

[54] MANDIBLE STIMULATOR

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128/410

[56]

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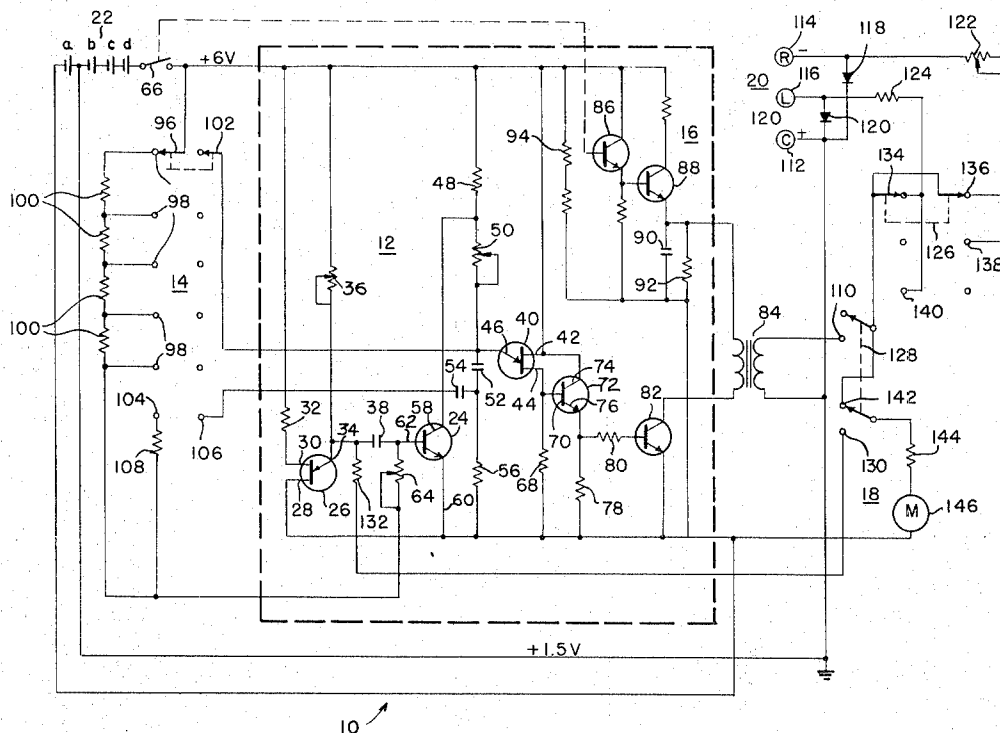
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ABSTRACT

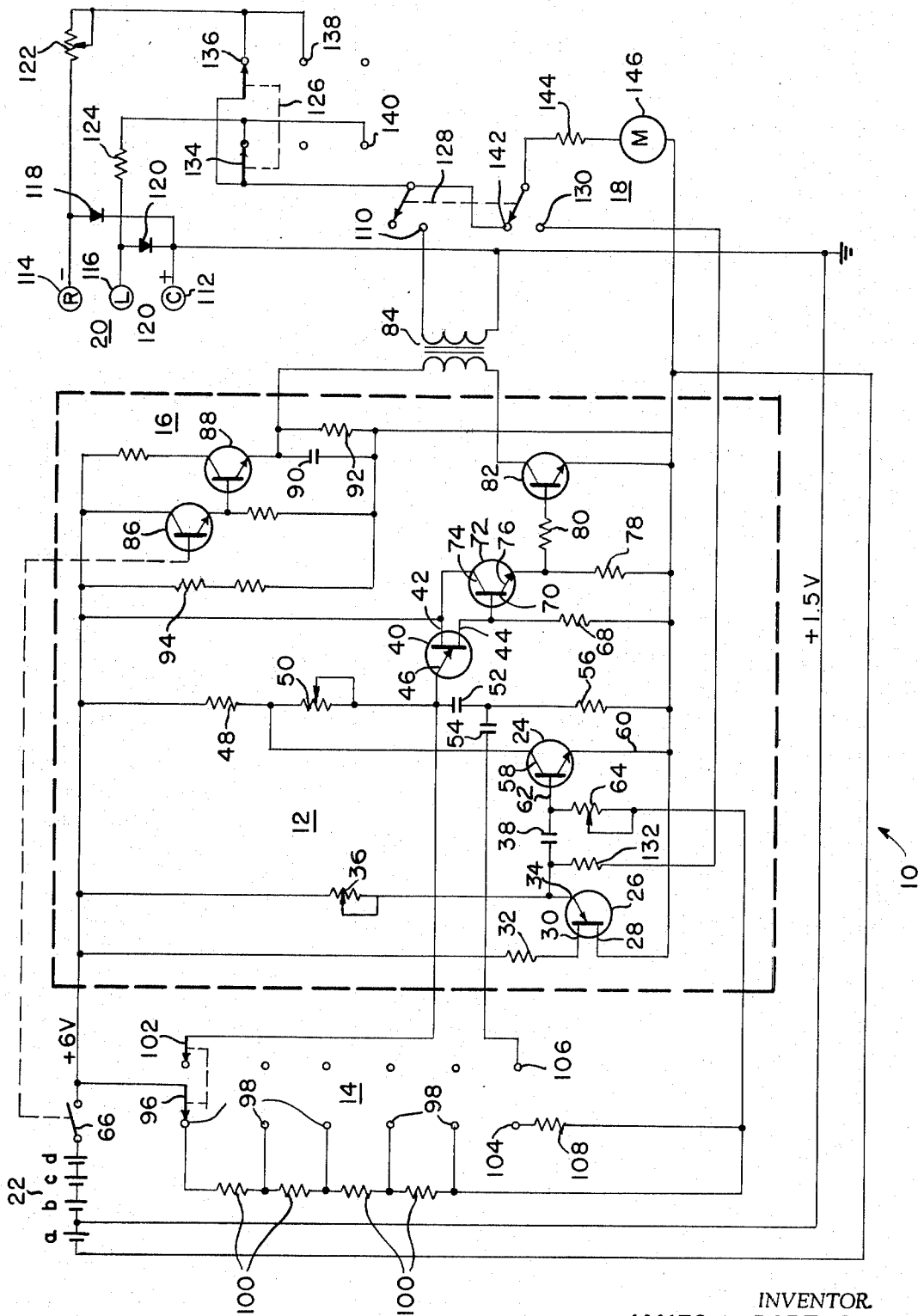
The mandible stimulator includes a pulse burst generator including a first solid state oscillator which modulates a second solid state oscillator. A coupling switch device between the two oscillators is connected to a pulse control circuit to vary the number of pulses in each output burst. The pulse generator controls the output from an amplitude control circuit through an output transformer to an output electrode assembly. A test circuit is connected to measure the current flow through the output electrodes.

14 Claims, 1 Drawing Figure



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MANDIBLE STIMULATOR

The stimulation of muscles in the human body by electrical stimuli to provide involuntary muscular response has become a useful remedial, diagnostic and clinical technique; and in some instance, as with a cardiac stimulator, electrical stimulation has been substituted for normal electro chemical nerve signals. However, the direct, repetitive electrical stimulation of muscles by evenly timed electrical pulses fed from a simple oscillator to a single electrode pair is not practical in some instances where electronic stimulation is required. For example, in techniques producing involuntary mandibular closure, it is clinically important that contraction of the nerve fibers be effected through the motor nerves rather than by controlling the mandible by the individual stimulation of the muscles per se. Direct stimulation of the muscles is impractical due to the number of electrodes which would be required, and stimulation of the motor nerves ensures stimulation of the entire muscle complex. Also, it requires from six to eight times less electrical energy to effectively stimulate the motor nerves than would be required for direct muscle stimulation.

In the electrical stimulation of the motor nerves controlling the masticatory and facial muscles, muscularly balanced closure of the mandible may be achieved by simultaneously and evenly stimulating the motor roots of the mandibular and facial nerves on both sides of the face. If only one muscle group on one side of the face contracts, the mandible will deviate to that side as it closes. Thus, for smooth physiologic closure to occlusion, the entire muscle complex of each side of the face must contract simultaneously in group action.

If simultaneous and bilateral stimulation to produce group action of all the masticatory and facial muscles can be achieved, a number of clinical and diagnostic techniques are possible. For example, controlled stimulation may be employed to diagnose the comparative degree of relaxation or contracture of the muscle groups on each side of the face; to cause the mandible to close to the horizontal myocentric position of occlusion; to determine the vertical position of occlusion; to take denture impressions; to relax muscle spasms associated with Temporomandibular Joint Syndrome; and to reduce post-operative swelling and discoloration by causing gentle massage as the muscles contract.

The accomplishment of these techniques requires a versatile apparatus adapted to simultaneously provide timed bursts of pulses of equal amplitude to either side of the face. This electrical stimulus must constitute current pulses of a number and duration which is optimum for the stimulation of muscle repeatedly without fatigue. Generally, intermittent or pulsing current having a duration of about 2 milliseconds and a frequency of about 40 pulses per minute has been found to be of a duration approximating that of normal stimuli and a frequency below that which would cause muscle exhaustion. However, the pulsing apparatus must be able to provide variations from these preferred standards.

The amount of stimulus provided by the electrodes to the motor nerves depends upon the skin resistance of an individual. As this resistance differs from patient to patient, the pulsing apparatus must include means to measure the relative impedance of the current from each electrode to a common dispersal electrode.

It is a primary object of the present invention to provide a novel and improved mandible stimulator for use in closing the human mandible by stimulating group action of all the masticatory and facial muscles by an electric current. This stimulator is adapted to simultaneously provide timed bursts of pulses of equal amplitude to either side of the face of a patient by providing pulses from a common source to two output electrodes.

Another object of the present invention is to provide a novel and improved mandible stimulator which includes a solid state pulse generator formed by a timing relaxation oscillator which modulates a pulse producing oscillator to provide timed pulse bursts. A solid state switch couples the two oscillator circuits and the off time of the switch governs the number of pulses in each pulse burst. A pulse control circuit is connected to vary the switch off time and thus the number of pulses in each burst.

BRIEF DESCRIPTION OF THE DRAWING

Shown in a circuit diagram of the mandible stimulator of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, the mandible stimulator indicated generally at 10 includes a pulse generator circuit 12, a pulse control circuit 14, an amplitude control circuit 16, an output switching and test circuit 18 and an output assembly 20. The mandible stimulator is fully transistorized and is operated from a battery power supply 22.

The pulse generator circuit 12 includes two solid state relaxation oscillators connected by a coupling and switching transistor 24. The first oscillator is formed by a unijunction transistor 26 having a base-one electrode 28 and a base-two electrode 30 connected with a resistor 32 to form a series base circuit. The transistor 26 also includes an emitter electrode 34 which is connected to a variable load resistor 36 and a capacitor 38. The capacitor and variable load resistor control the repetition rate of the first solid state oscillator.

The second solid state oscillator includes a unijunction transistor 40 having a base-one electrode 42, a base-two electrode 44 and an emitter electrode 46. Emitter load resistor 48 and variable load resistor 50 connected in series with the emitter electrode 46 determine the pulse rate of the output pulses from the second solid state oscillator while capacitors 52 and 54 and resistor 56 determine the width of the output pulses. More specifically, the pulse rate is determined by the RC time constant of resistors 48, 50 and capacitors 52, 54 and other circuit impedances. Pulse width is directly proportional to the capacitance and inversely proportional to the resistance. The capacitors set the approximate pulse width while the resistor is a fine adjustment for pulse width and may be of a resistance value sufficient to determine a specific desired pulse width.

The transistor 24 controls the relative operation of the unijunction transistors 26 and 40 so that the first solid state oscillator modulates the second. The transistor includes a collector electrode 58 which is connected between load resistor 48 and variable load resistor 50, an emitter electrode 60 and a base electrode 62 connected to the capacitor 38. When the transistor 24 is nonconductive, output pulses are produced by the

second solid state oscillator and thus the off time of this transistor governs the number of output pulses occurring in each output pulse group from the pulse generator 12. The transistor off time is governed by the capacitor 38 and the variable resistor 64 connected to the base 62 and the pulse control circuit 14. Adjustment of the pulse control circuit and the variable resistor 64 results in a corresponding variation in the number of output pulses contained in each pulse burst from the pulse generator.

The power supply 22 includes a plurality of serially connected batteries 22a-d which, for purposes of illustration, will be designated as 1.5 volt batteries connected to provide a 6 volt output to an on-off switch 66. It is obvious that any combination of batteries may be employed to provide a power supply of a desired value.

The power supply operates when the on-off switch 66 is closed to supply power to the pulse generator circuit 12 across the resistors 36, 48 and 50 and to the base-one electrode 42.

The pulse output from the unijunction transistor 40 is developed across a base-two resistor 68 and is fed to the base 70 of a transistor current driver 72. This transistor current driver includes a collector electrode 74 connected to the on-off switch 66 and an emitter electrode connected to an emitter load resistor 78 and a base resistor 80 for a transistor switch 82. The transistor switch includes a collector-emitter circuit connected to the primary of an output transformer 84, and the transistor current driver 72 provides a high drive to enable the transistor switch 82 to switch the output transformer.

The positive voltage supply for the output transformer 84 is supplied by the amplitude control circuit 16 which constitutes a pair of transistors 86 and 88 connected in emitter-follower configuration to charge a supply capacitor 90. The supply capacitor and a shunt resistor 92 therefor are connected to the primary of the output transformer 84.

Power for the amplitude control circuit 16 is provided from the on-off switch 66 to the base of the transistor 86 by way of a variable load resistor 94. The amplitude of the change on the capacitor 90 and thus the amplitude of the output from the output transformer 84 is determined by adjusting the resistance of the variable load resistor 94. This resistor may be ganged to the on-off switch as indicated in FIG. 1.

The pulse control circuit 14 operates to control the number of pulses in each pulse group emitted from the pulse generator 12 by alternating the off time of the switching transistor 24. This is accomplished by selectively moving a movable contact 96 connected to the on-off switch 66 between taps 98 interposed between a plurality of serially connected resistors 100 to connect varying amounts of resistance in series with variable resistor 64. As more resistance is added to the base circuit of the transistor 24, the number of pulses in each output pulse group from the pulse generator 12 will increase.

The movable contact 96 may be ganged with a second movable contact 102, and when these contacts complete a connection with taps 104 and 106 respectively, a resistor 108 is connected in series with the resistor 64 and the capacitor 54 is connected with the capacitor 52 to control the pulse width of the output from the pulse generator. The resistors 108 and 64 cause a

single pulse to be generated by the pulse generator circuit during each off period of the transistor 24 and the capacitors 52 and 54 cause the width of this pulse to be greater than that of the multiple pulses generated when the resistors 100 are connected in the base circuit of the transistor 24. For example, the pulse width of the single output pulse may be 2 milliseconds while that of the multiple output pulses may be six tenths of a millisecond.

The secondary winding of the output transformer is directly connected to a pulse tap 110 and to a dispersal electrode 112 in the output circuit 20. The output circuit also includes a right electrode 114 and a left electrode 116 for use in applying electrical impulses to the right and left sides respectively of a patient's face. Diodes 118 and 120, connected between the right and left electrodes respectively and the dispersal electrode, clip and positive output signals on the right and left electrodes so that they are always negative with respect to the dispersal electrode. Also resistors 122 and 124 are connected to the right and left electrode circuits as current limiting resistors. Resistor 122 is made variable so that the current in the right and left electrodes can be equalized or unbalanced.

Switches 126 and 128 operate to selectively connect the electrodes 114 and 116 to receive an output from the output transformer 84 or to operate the test circuit 18. For providing a pulse output, the switch 128 is moved into contact with taps 110 and 130. The tap 130 is connected to a resistor 132 which is in the circuit between the capacitor 38 and the emitter 34 of the unijunction transistor 26.

When the switch 128 contacts the tap 110, a circuit is completed from the secondary of the output transformer 84 to the contacts of the switch 126. This switch may then be activated to engage taps 134 and 136 to simultaneously complete a circuit through the resistors 122 and 124 to the right and left electrodes 114 and 116. On the other hand, the switch 126 may be moved to contact a tap 138 to complete a circuit to only the right electrode or a tap 140 to complete a circuit to only the left electrode. The switch 126 is operative in this manner in both the pulse and test positions of the switch 128.

To activate the test circuit 18, the switch 128 is moved from a pulse position contact with the taps 110 and 130 to make a test position contact with a tap 142. This connects the switch 126 in series with a load resistor 144 and a current measuring meter 146. To test the amount of current flowing by means of the electrodes 114 and 116 through the tissues and skin of a patient 1.5 volt D.C. power is provided by the battery 22a to the secondary circuit of the output transformer 84.

The operation of the muscle stimulator 10 will be apparent from the description of the circuit to this point and will be briefly summarized utilizing pulse values found to be preferred values for the electrical stimulation of the motor nerves for the masticatory and facial muscles. It should be obvious, however, that other values can be employed.

With the on-off switch 66 closed, the switch 128 in the pulse position, and the switch 126 connected to the taps 134 and 136, the first solid state oscillator including the unijunction transistor 26 will establish a basic repetition rate which is approximately 40 pulses per minute. This rate may be altered by the variable resistor 36 and modulates the second solid state oscillator

including the unijunction transistor 40 so that the output therefrom is a recurrent burst of pulses with from one to twenty or more pulses in each burst. These pulses are generated during the off time of the switching transistor 24 when the unijunction transistor 26 5 conducts and opens the switching transistor. The number of pulses in each output burst are determined by the off time of the switching transistor which is established by the capacitor 38, the variable resistor 64 and the pulse control circuit 14. Pulse rate within the output burst is determined by the variable resistor 50 while pulse width is established by the capacitors 52 and 54 and the resistor 56. When the resistor 108 and capacitor 54 are switched into the pulse generator circuit, a single pulse is provided at approximately 1.5 second 15 intervals and with a 2 millisecond pulse width. However, when the resistors 100 are switched into the circuit, pulse bursts of from two to ten or more pulses occurring at 1.5 second intervals are produced with the pulse in each burst having a width of approximately .6 20 milliseconds.

The output pulses are fed to the current driver 72 which operates the switching transistor 82 to control the output signal across the output transformer 84. This output signal is developed by emitter followers 86 and 88 which form a charging circuit for a capacitor 90. The amplitude of the charge on the capacitor 90 and thus the signal applied to the primary of the output transformer 84 is limited by the variable resistor 94. 25

The output transformer steps up the output signal to a level which could allow 20 volts to be applied across a 600 ohm load in parallel with a 1 micro farad capacitor. This output is applied to the output circuit 20 under the control of switches 126 and 128. In the test position of the switch 128, a 1.5 volt D.C. potential 30 from the battery 20a is applied across the electrodes of the output circuit and a patient in series with a micro-amp meter 146. This is employed to test the electrode resistance on the patient.

In use, the electrodes 114 and 116 are placed on the right and left sides of a patient's face and the dispersal electrode 112 is placed along the spine. In order for the electrodes to function properly, they must intimately contact the skin of the patient.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A mandible stimulator for providing controlled electrical stimulation of the multiplicity of muscles innervated by the fifth and seventh cranial nerves, comprising:

a power source,

pulsing means connecting to the power source operative to provide output pulse signals, said pulsing means including pulse generator means operative to selectively provide successive spaced pulse bursts including one or more pulses,

pulse control means connected to said pulse generator means to control the number of pulses in each said pulse burst,

output means for receiving and transmitting said output pulse signals from said pulsing means to the body of a patient including a common output source, said output means further including a dispersal electrode connected to said common output source, right and left electrodes also connected to said common output source for applying electrical 65

impulses to the right and left sides of the face of a patient and adapted to complete a circuit with the dispersal electrode through the body of the patient, and variable resistor means connected between said common output source and one of said right and left electrodes so that the current output through the electrode can be equalized or unbalanced.

2. The mandible stimulator of claim 1 wherein said pulsing means includes amplitude control means operative to provide an output signal of a predetermined amplitude to said output means and switching means connected to control the passage of said output signal from said amplitude control means, said switching means being controlled by the pulse bursts from said pulse generator means.

3. The mandible stimulator of claim 2 wherein said pulse generator means includes a first oscillator means operative to provide timing pulses having a first repetition rate, said first oscillator means including a first unijunction transistor having an emitter electrode and a timing capacitor connected to said emitter electrode to control the timing pulse repetition rate of said first oscillator means, second oscillator means operative to provide output pulses having a repetition rate greater than that of said timing pulses, said second oscillator means including a second unijunction transistor having an emitter electrode, an emitter load circuit connected to supply power to said emitter electrode, and timing capacitor means connected to said emitter electrode, said timing capacitor means operating with said emitter load circuit to control the repetition rate of said output pulses, and pulse control switching means connected between said first and second oscillator means and rendered alternately conductive and nonconductive by said timing pulses to activate and deactivate said second oscillator means, said control switching means including a switching transistor having a collector-emitter circuit connected to said emitter load circuit for the second unijunction transistor, and a base electrode connected to the timing capacitor for said first oscillator means, said switching transistor operating when conductive to deactivate said second oscillator means. 40

4. The mandible stimulator of claim 3 wherein said pulse control means is connected to the base electrode of said switching transistor to vary the nonconduction time of said switching transistor.

5. The mandible stimulator of claim 1 wherein said pulse generator means includes first oscillator means operative to provide timing pulses having a first repetition rate, second oscillator means operative to provide output pulses having a repetition rate greater than that of said timing pulses, and pulse control switching means connected between said first and second oscillators and rendered alternately conductive and nonconductive by said timing pulses, said pulse control switching means operating when conductive to deactivate said second oscillator means, and when nonconductive to permit operation of said second oscillator means.

6. The mandible stimulator of claim 3 wherein said pulse control means is connected to vary the nonconduction time of said pulse control switching means.

7. The mandible stimulator of claim 1 including test means adapted for selective connection to said output means, said test means including circuit means to provide D.C. power from said power source to said output

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means and being operative upon connection to said output means to indicate the external resistance by the body of a patient to pulse transmission by said output means.

8. The mandible stimulator of claim 7 wherein said test means includes current indicator means, circuit means to provide D.C. power from said power source to said dispersal electrode and current indicator means, and switching means for connecting said current indicator means to said right and left electrodes.

9. A mandible stimulator for providing controlled electrical stimulation of the multiplicity of muscles innervated by the fifth and seventh cranial nerves, comprising:

a power source,

pulsing means connecting to said power source operative to provide output pulse signals, said pulsing means including (1) a first oscillator means operative to provide timed pulses having a first repetition rate, said first oscillator means including a first unijunction transistor having an emitter electrode and a timing capacitor connected to said emitter electrode to control the timing pulse repetition rate of said first oscillator means, (2) second oscillator means operative to provide output pulses having a repetition rate greater than that of the said timing pulses, said second oscillator means including a second unijunction transistor having an emitter electrode, (3) an emitter load circuit connected to supply power to said emitter electrode, said timing capacitor means operating with said emitter load circuit to control the repetition rate of said output pulses, and (5) pulse control switching means connected between said first and second oscillator means and rendered alternately conductive and non-conductive by said timing pulses to activate and deactivate said second oscillator means, said control switching means including (a) a switching transistor having a collector-emitter circuit connected to said emitter load circuit for the second unijunction transistor, (b) a base electrode connected to the timing capacitor for said first oscillator means, said switching transistor operating when conductive to deactivate said second oscillator means; said pulsing means further including amplitude control means connected to said power source operative to provide an output signal of a predetermined amplitude, said amplitude control means including an output capacitor, a transistor pair connected in common emitter-follower configuration to provide charging current from said power source to said capacitor, a variable resistor means connected to said power source and said transistor pair to control the charge on said output capacitor, an output transformer having a primary winding connecting to said output capacitor, and a

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secondary winding connected to said output means, and a controlled transistor means having a collector-emitter circuit connected to said primary winding and a base electrode connected to receive output pulse signals, said control transistor means operating to control the current flow from said output capacitor through said primary winding, pulse control means connected to said pulsing means to control the number of pulses in each said pulse burst,

output means connected to said secondary winding for receiving and transmitting said output pulse signals from said pulsing means to the body of a patient, the output means including an electrode circuit adapted for applying electrical impulses to the right and left sides of the face of a patient to stimulate the fifth and seventh cranial nerves thereof.

10. The mandible stimulator of claim 9 wherein said pulse control means includes a plurality of control resistors connected in series with the base electrode of said switching transistor, electrical terminals between each of said control resistors, and switching means for connecting one of said electrical terminals to said power source to alter the resistance at the base of said switching transistor to vary the off time thereof.

11. The mandible stimulator of claim 9 wherein said pulse control means includes a second capacitor connected to the timing capacitor in the emitter circuit of said second unijunction transistor, said switching means being operative to selectively connect said second capacitor to the emitter of said second unijunction transistor.

12. The mandible stimulator of claim 9 wherein said output means includes a dispersal electrode connected to receive signals from the secondary winding of said output transformer, right and left electrodes adapted to complete a circuit with said dispersal electrode through the body of a patient, and switching means connected between said secondary winding and said first and second electrodes.

13. The mandible stimulator of claim 12 wherein a test means is provided and includes current indicator means, circuit means to provide D.C. power from said power source to the secondary winding of said output transformer and current indicator means, said switching means being operative to disconnect said first and second electrodes from said secondary winding and connect said first and second electrodes to said current indicator means.

14. The mandible stimulator of claim 13 wherein said switching means is selectively operative to complete a circuit to both said first and second electrodes simultaneously or to either of said first and second electrodes individually.

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