Jan. 20, 1970 D. K. ALLISON 3,490,458

ELECTROTHERAPY DEVICE WITH SYNCHRONIZED PULSES AND SOUNDS

Filed Jan. 14, 1964

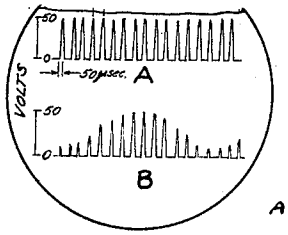

Fig. 1

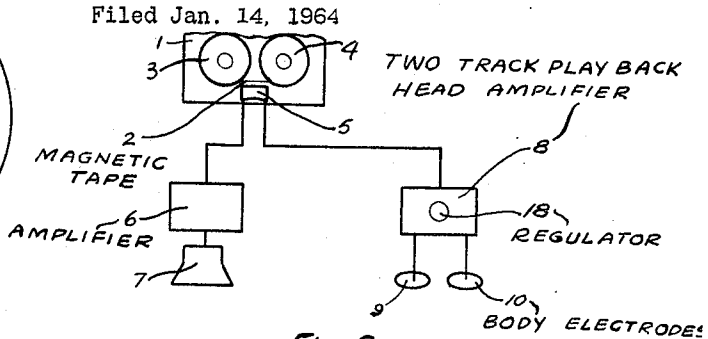

Fig. 2

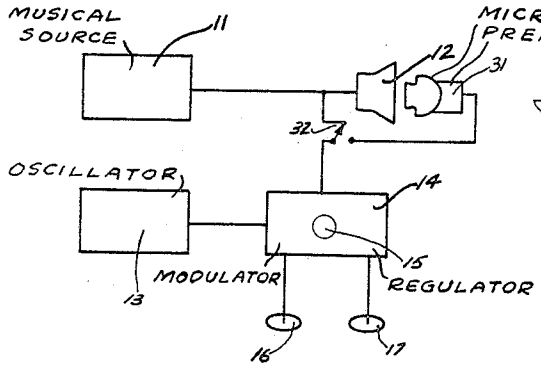

Fig. 3

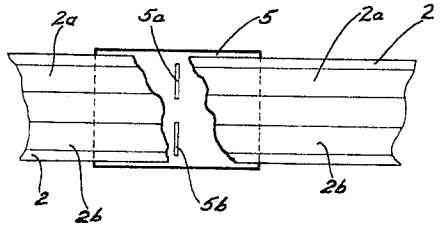

Fig. 5

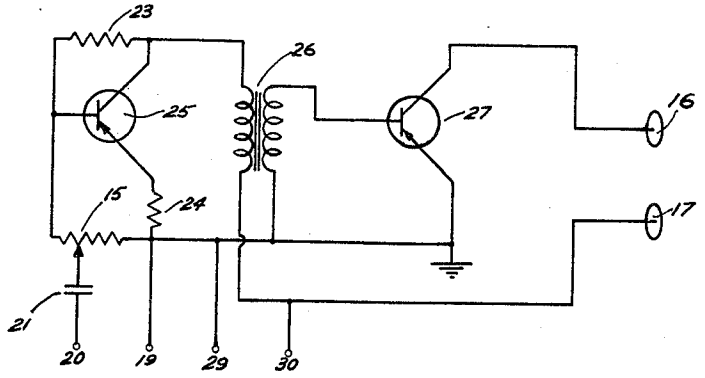

Fig. 4

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ELECTROTHERAPY DEVICE WITH SYNCHRONIZED PULSES AND SOUNDS

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U.S. Cl. 128—421 8 Claims

This invention relates to the electronic art, and more especially to the art of electrotherapeutic devices for the stimulation of muscles and tissue. This invention describes a device which combines effective electrotherapeutic stimulatory treatments, with esthetic and psychotherapeutic modalities, and which also may combine instructional material with the above modalities.

The electronic art is replete with electrical devices which induce contraction of selected muscles by application of rhythmically modulated electrical stimuli to the body surface, in proximity to the endings of the motor nerves which control these selected muscles. However, in the case of the majority of these devices, the waveform and frequency of the alternating current applied to the subject under treatment are such as to cause considerable burning or stinging discomfort to the patient, due at least partially to the fact that considerable current flows through the subject's body during the peaks of oscillation of the alternating current. Also, it has been found that the period of treatment required to effect the desired stimulated exercise is extremely tedious to the subject undergoing treatment, and in many cases it has been found to be virtually impossible to get the subject to continue the required course of treatments. Attempts have been made to overcome this tedium by combining a source of music, such as a radio, or record player, in the cabinet housing the treatment device, and although this approach may minimize the aggravation of the enforced treatment to some extent, it suffers from the defect that the rhythm or beat of the music from the radio or record player bears no relationship to the rhythmic modulation of the exercise stimuli, and this, too, can become annoying to the subject. It is therefore a primary object of my invention to provide a therapeutic exercise device which combines synchronized physical and esthetic stimuli.

Another object of my invention is to provide a muscle-stimulating pulsed-voltage, minimal current modality which is of the correct waveform and frequency to induce maximal muscular contractive response and minimal sensatory discomfort.

Still another object of this invention is to provide an electrotherapeutic exercise device which includes a series of synchronized programs of entertainment and exercise, to encourage the subject to complete each treatment session, and to continue the treatment sessions until the required number of sessions has been completed.

An additional object of my invention is to provide a device which can be used as an accessory or adjunct to a radio, record player, tape player, or television set, and which can employ the musical score emanating from such an entertainment device to provide the rhythmic modulation for the muscle-stimulatory modality generated by the device.

A still further object of my invention is to provide an electrotherapeutic stimulatory device which furnishes exercise programs, of which the duration, intensity, or tempo, can be varied or graduated, either during the course of a program, or in sequential programs.

These and other objects and advantages of my invention will be apparent from consideration of the specifications and drawings, in which:

FIGURE 1A depicts a typical waveform of the unmodulated electrical stimuli used in a preferred form of my invention;

FIGURE 1B shows a typical envelope of the modulated stimuli as applied to the subject, in the practice of a preferred form of my invention;

FIGURE 2 is a block diagram showing the interconnections between the elements of a preferred form of this invention;

FIGURE 3 is a block diagram of an alternative form of my invention;

FIGURE 4 is a circuit diagram of the modulator element of FIGURE 3; and

FIGURE 5 is a partially cut away elevational view showing the positional relationship of the magnetic tape to the playback head in FIGURE 2.

Referring now to FIGURE 1A, we see depicted here an oscilloscopic presentation of the unmodulated voltage waveform of the electrical signal employed for muscle stimulus in a preferred form of my invention. As will be seen in the figure, the waveform consists of a series of very sharp pulses, which exhibit short times of rise and fall of the voltage component. I have found that recurrence rates of 500 to 1500 pulses per second induces good contraction of the musculature to which these pulses are applied through motor nerve termini, and the effect is optimum for most subjects at approximately 1000 pulses per second. When the applied pulses have short times of rise and fall, as depicted in FIGURE 1, the current flowing through the body of the patient is minimal. I have found that it is the current flow that causes subjective discomfort in the form of stinging or burning sensation, and from determinations made on a number of subjects I have learned that a pulse base-width of approximately 50 microseconds is optimum. The voltage amplitude needed to induce the required muscle contraction varies with the subject, with the contact of the electrodes whereby the stimuli are conducted to the subject, and with the distance between the electrodes on the body of the subject. The requisite stimulatory peak voltage therefore may vary between 20 and 60 volts, and the value of 50 volts shown in FIGURE 1A is presented as an exemplary value.

FIGURE 1B shows a typical envelope of the modulated series of pulses as would be applied to a subject undergoing treatment. The modulation from minimum pulse amplitude to maximum amplitude is substantially sinusoidal, or at least gradual, to avoid the annoying sensation of sharp on-off modulation of the applied stimuli.

The above values and limits for waveform, frequency, voltage, and modulation are set forth as exemplary values for optimum results. Stimulatory electrical impulses having values falling outside of these optimum regions can be employed, though with somewhat degraded efficacy, for the practice of my invention.

In FIGURE 2, a tape transport deck **1** provides substantially constant speed transport of a magnetic tape **2** from a reel **3** to a reel **4**, passing over a 2-track playback head **5**. The output from one track of the playback head is amplified in an audio amplifier **6**, and then made audible by a speaker **7**. The output from the other track of the playback head **5** is amplified in an amplifier **8**, which is provided with an amplitude control **18**. The output of the amplifier **8** is conducted to contact elements **9** and **10**, which are placed in contact with the selected motor nerve terminal regions of the body of the subject.

FIGURE 3 illustrates an alternative form of my invention in which a musical source **11** provides entertainment music through a speaker **12**. The musical source **11** may be a radio, record player, tape player, television receiver, or any source which provides musical or rhythmic audio entertainment. A portion of the musical audio output is conducted to a modulator **14** either directly by electrical connection through a switch **32** or by sound link through a microphone-preamplifier **31**, and thence through

the switch **32** to the modulator **14**. The modulator **14** is provided with an amplitude control potentiometer **15**. An oscillator **13** is a source of oscillatory electrical energy having the general waveform characteristics depicted in FIGURE 1A, and this energy is conducted to the modulator **14**, wherein it is amplitude modulated by the amplitude peaks of the musical tempo, or beat. The oscillator **13** can be any of several types of audio oscillator capable of delivering the desired approximately 1000-cycle signal having the required waveform and voltage, or alternatively, the oscillator **13** may utilize a tap playback, or a vibratory pulse generator to provide the required form and frequency of pulses. The output of the oscillator **13** can be positive-going pulses as shown in FIGURE 1, or the output can provide negative-going pulses, without detracting from the efficacy of the device.

FIGURE 4 presents one of several possible circuits for the amplitude modulation of the stimulatory pulses in synchronism with the tempo of the music from the musical source **11** of FIGURE 3. In FIGURE 4, the musical input from the source **11** is connected to terminals **19** and **20**. From the terminal **20**, the pulse energy passes through a capacitor **21** to the slidable contact of a potentiometer **15**. The high-potential side of the potentiometer **15** connects directly to the base of a transistor **25**, and through a resistor **23** to the collector of the same transistor. The emitter of transistor **25** is connected through a resistor **24** to the common ground bus, which is also connected to the ground side of the potentiometer **15**, and to the music input terminal **19**. The collector of transistor **25** connects to one of the primary terminals of a transformer **26**, and the other terminal of transformer **26** is connected to the modality output terminal **17** and to a pulse input terminal **30**. The other pulse input terminal **29** is connected to common ground, and to the emitter of a transistor **27**. The collector of transistor **27** is connected to the modality output terminal **16**, and the base of the transistor **27** connects to one terminal of the secondary of the transformer **26**, of which the other secondary terminal connects to the common ground.

FIGURE 5 shows an enlarged, partially cut away, elevational view illustrating the cooperative relationship of the magnetic tape **2** and the playback head **5** of FIGURE 2. The magnetic tape **2** carries the amplitude-modulated stimulatory pulses, having the waveform and envelope configuration substantially as depicted in FIGURE 1B, recorded on a longitudinal track area **2***a*. Tape **2** also carries recorded music on a track area **2***b*. The playback head **5** includes two magnetic transducer pickups, **5***a* and **5***b*. Linear translatory motion of the magnetically recorded tracks **2***a* and **2***b* on the tape **2**, across the face of the playback head **5** causes an electrical voltage having substantially the waveform shown in FIGURE 1B to appear across the terminals of pickup **5***a*, and simultaneously, a waveform representative of the recorded music of track **2***b* appears across the terminals of pickup **5***b*.

The tracks **2***a* and **2***b* have been pre-recorded in such a manner that the peaks of maximum voltage and amplitude of the envelope of track **2***a* substantially coincide with the amplitude peaks of the tempo, or beat, of the music recorded on track **2***b*. This can be accomplished during the pre-recording by manual control of the amplitude of the stimulatory pulses in time with the tempo of the music, or it likewise can be performed automatically during the pre-recording of the tape through the use of a modulator element similar to the modulator **14** of FIGURE 3, of which the operation will be described hereinafter. Consequently, as the tape **2** is transported longitudinally across the playback head **5**, two synchronized signals appear as the outputs of the tape playback head, as hereinbefore stated. The output of the pickup **5***b* is amplified in the audio amplifier **6**, which can be any of the many suitable audio amplifiers so well-known in the art as not to require description here. The output of the modulated pulse track, sensed by pickup **5***a*, is amplified in an audio-frequency amplifier **8**, which again is of conventional type, and of which the principal requirements are a maximum voltage output of 60 volts, peak, and a sufficiently high frequency response that the sharp stimulatory pulses depicted in FIGURES 1A and 1B are not seriously rounded or degraded during the amplification process. The amplifier **8** is provided with the amplitude control **18**, which serves to regulate the amplitude of the output voltage to that optimum value at which maximum muscular response and minimum discomfort are experienced by the subject under treatment. The output of the amplifier **8** is connected to the conductive electrodes **9** and **10**, which serve to conduct the stimulatory pulses to selected areas of the subject's body.

The rhythmic contractions induced in the selected muscles of the subject's body have been found to be therapeutically beneficial, both for weight reduction through the electrically paced program of exercise, and additionally for the toning and nourishment of selected body areas through the increase of blood circulation to these areas. The duration of each exercise session is adjusted to fit the duration of the musical score which accompanies the exercise stimulating signal track on the tape, and the esthetic appeal of the musical score to the subject insures that each treatment session will be continued to the end. The musical score can be accompanied with verbal instructions as to proper placement of the conductive electrodes on the subject's body, or, as added incentive for continuation of the treatment session, the musical score can serve as background for a narrative calculated to entertain and hold the attention of the subject. It is obvious that the tempo and intensity of treatments can be increased by recording the corresponding stimulatory and audio material on the magnetic tape, thereby enhancing the effectiveness of the therapy, and the esthetic benefits to the subject.

Referring now to FIGURES 3 and 4, the operation of this form of my invention is as follows: A portion of the audio signal from the radio receiver **11**, in passing to the radio speaker **12**, is by-passed through the switch **32** to the modulator **14**. The output signal from the oscillator **13**, which has substantially the waveform shown in FIGURE 1A, also is delivered to the modulator **14**. Transistor **27** is biased "off" under the no-signal condition at terminals **19** and **20**. When a signal, in this case music from the radio receiver **11**, is applied to the terminals **19** and **20**, it is amplified by the transistor **25** and applied through the transformer **26** to the base of the transistor **27**. Proper adjustment of the sensitivity control potentiometer **15** will so regulate the amplitude of the pulse output from the terminals **16** and **17** that the modulated envelope will be quite similar to that shown in FIGURE 1B. The amplitude of the maximum voltage delivered to the conductive electrodes **17** and **18** reaches the value required to maximize muscle response, and to minimize discomfort. When this form of my invention is operated in accordance with the foregoing description, the subject experiences exhilarating exercise of muscular contractions, in time with the beat of the music, emanating from the speaker **12**.

Various other forms of my invention will be readily apparent to persons skilled in the art. For example, the modulator **14** of FIGURE 3 need not be electrically connected to the speaker output terminals of the radio **11**, but can obtain its modulatory synchronizing signal from the microphone-preamplifier combination **31**, of which the output can be connected to the modulator by actuation of the switch **32**. The amplitude of the muscle-stimulatory pulses is then modulated in time with the beat of the music emanating from the speaker **12** in the manner described above.

In another obvious form of my invention, the 2-track tape playback head **5** can be replaced by a 2-channel stereo disc record player, from which the one channel provides the musical accompaniment, and the other chan-

nel supplies the amplitude-modulated synchronized exercise stimulating pulses.

Having described and shown my invention in several forms, I do not wish to be limited in the scope of the protection afforded to my invention, except as limited by the appended claims.

I claim:

1. An electrotherapy device including in combination:
a source of electrical impulses capable of inducing muscular response when applied to a motor nerve of a patient;
a source of audio frequency electrical signals;
means for modulating the amplitude of said electrical impulses by said audio frequency signals;
means for transducing said audio frequency signals into sound audible to the patient; and
means for applying the modulated electrical impulses to selected motor nerves of the patient which said sound is being heard by the patient.

2. An electrotherapy device including in combination:
a source of electrical impulses capable of inducing muscular response when applied to a motor nerve of a patient;
a source of audio frequency electrical signals;
means whereby the amplitude of said audio frequency signals modulates the amplitude of said electrical impulses;
means for transducing said audio frequency signals into sound audible to the patient; and
electrode means for applying the modulated electrical impulses to selected points on the patient's body while said sound is being heard by the patient.

3. An electrotherapy device including in combination:
a source of electrical impulses capable of inducing muscular response when applied to a motor nerve of a patient;
a source of musical audio frequency electrical signals;
means for transducing said audio frequency signals into music audible to the patient;
means for modulating the amplitude of said electrical impulses in accordance with the amplitude of said musical signals; and
electrode means for applying the modulated electrical impulses to the patient to stimulate selected motor nerves.

4. An electrotherapy device including in combination:
a source of electrical impulses capable of inducing muscular response when applied to a motor nerve of a patient;
a recorded musical score;
means for transducing said musical score into music audible to the patient;
means for modulating the amplitude of said electrical impulses by the amplitude of said musical score; and
means for conducting the modulated electrical impulses to the body of a patient to synchronize the effective application of the electrical impulses with the musical score.

5. An electrotherapy device including in combination:
a source of sharp electrical pulses having a frequency between 500 and 1,500 pulses per second;
means for modulating said electrical pulses; a source of modulating signals for said modulating means, said modulating signals modulating said electrical pulses from a minimal non-effective voltage to a maximum voltage of between 20 and 60 volts, said modulating signals further producing a gradual and rhythmic

modulation of said electrical pulses to prevent sharp on-off of the applied pulses; and
means for conducting said modulated electrical pulses to the body of a patient.

6. An electrotherapy device including in combination:
a source of sharp electrical pulses having a frequency between 500 and 1,500 pulses per second and having a pulse base of substantially 50 microseconds;
means for modulating said electrical pulses;
a source of substantially sinusoidal modulating signals for said modulating means, said modulating signals modulating said electrical pulses from a minimal non-effective voltage to a maximum voltage of between 20 and 60 volts, said modulating signals further effecting a substantially sinusoidal change in the amplitude of said electrical pulses from a minimum non-effective voltage to a maximum of between 20 and 60 volts; and
means for applying said modulated electrical pulses to selective motor nerves of a patient.

7. An electrotherapy device including in combination:
a source of sharp electrical pulses having the frequency between 500 and 1,500 pulses per second and having a pulse base of substantially 50 microseconds;
means for modulating said electrical pulses from a minimal non-effective voltage to a maximum voltage of between 20 and 60 volts;
means providing a source of audio frequency signals;
means transducing said signals into sound audible to the patient;
means feeding said audio frequency signals to said modulating means to modulate said electrical pulse; and
means for applying the finally modulated electrical pulses to selective motor nerves of a patient while said sound is being heard by the patient.

8. An electrotherapy device including in combination:
a source of sharp electrical pulses having the frequency between 500 and 1,500 pulses per second and having a pulse base of substantially 50 microseconds;
means modulating said electrical pulses from a minimal non-effective voltage to a maximum voltage of between 20 and 60 volts;
means providing a source of audio frequency signals;
means transducing said signals into sound audible to the patient;
means feeding said audio frequency signals to said modulating means to synchronize the application of electrical stimulus with the sound heard by the patient; and
wherein said source of audio frequency signals is a musical score and said electrical impulse application is synchronized with the rhythm of the musical score.

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