Feb. 7, 1933. H. P. PULLWITT 1,896,647

ELECTROTHERAPEUTIC SYSTEM AND APPARATUS THEREFOR

Filed Dec. 26, 1930 2 Sheets-Sheet 1

Fig. 2.

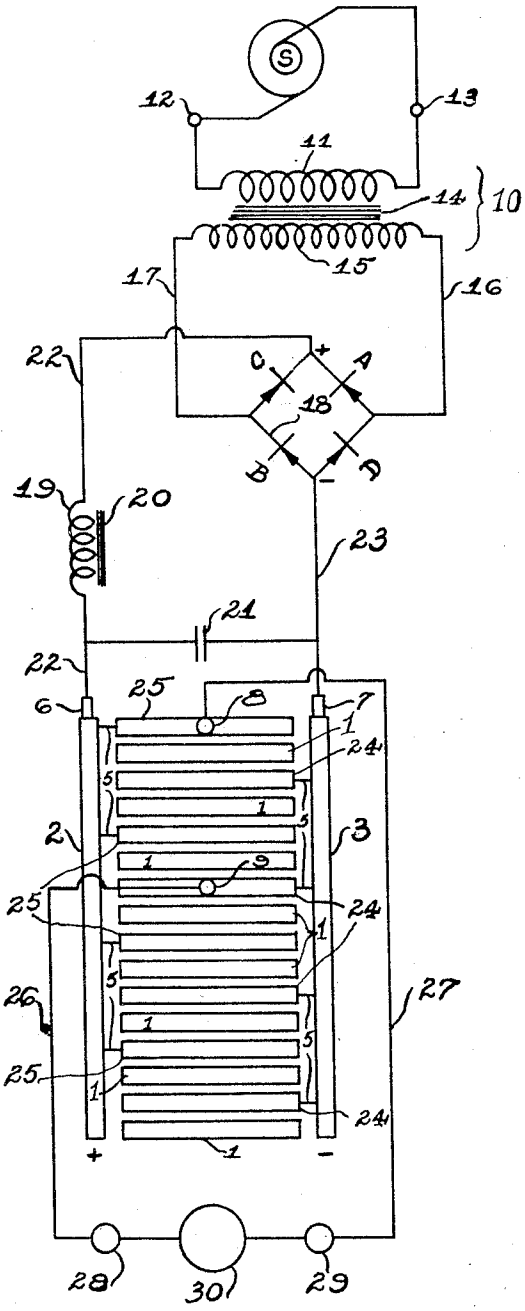


Fig. 1.

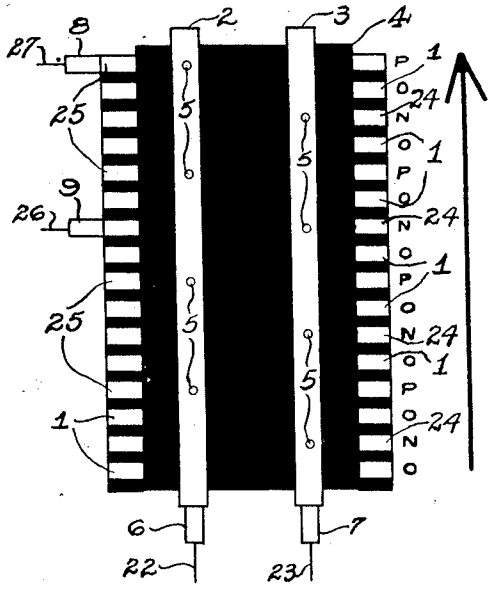
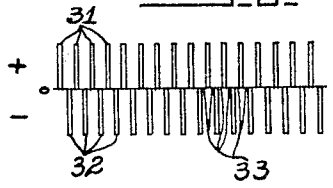


Fig. 3.



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ELECTROTHERAPEUTIC SYSTEM AND APPARATUS THEREFOR

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Fig. 4.

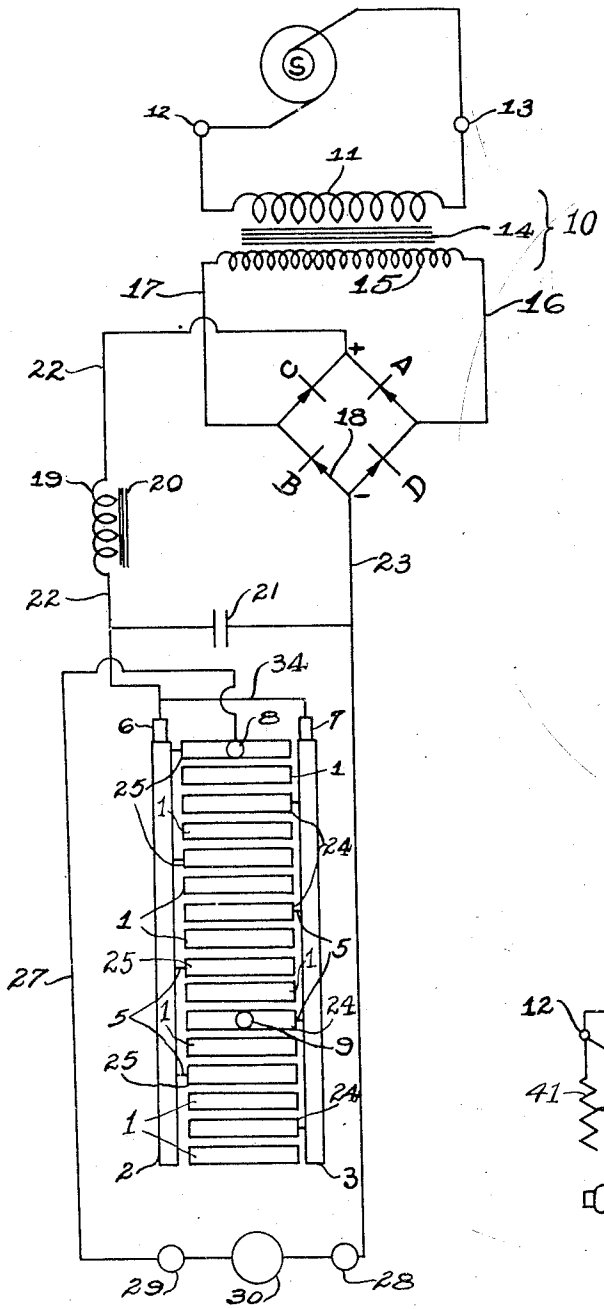


Fig. 5.

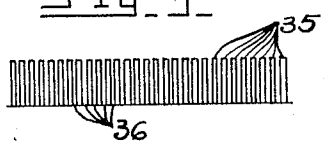


Fig. 6.

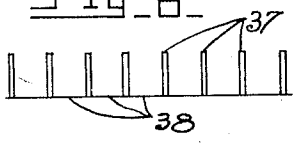
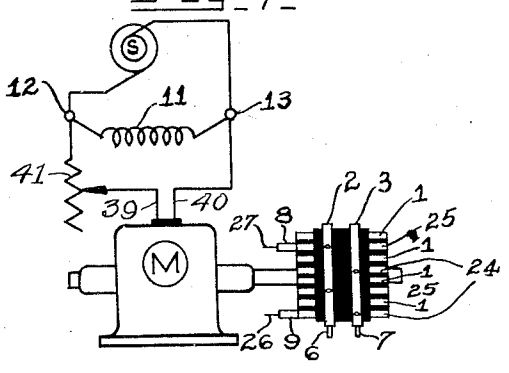


Fig. 7.



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Patented Feb. 7, 1933 1,896,647

UNITED STATES PATENT OFFICE

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ELECTROTHERAPEUTIC SYSTEM AND APPARATUS THEREFOR

Application filed December 26, 1930. Serial No. 504,814.

The invention relates to a therapeutical low tension current converting system, comprising novel means for changing the current characteristics of an alternating or direct current for the purpose of increasing the therapeutic effect of such a current.

In the treatment of impaired nerve and muscle by means of an electric current it has been found that application of the negative pole of the treatment circuit increases the irritability of the nerves and that application of the positive pole decreases the irritability of the nerves. It has also been found that it is not the time during which the current is applied to a nerve that produces the therapeutical effects, but that these effects are produced by sudden reversals in the polarity of the applied current and abrupt closures and openings of the circuit supplying the current flow.

Alternating currents in which the polarity reverses several hundred times per second have been used, but the reversals of polarity of an alternating current, regardless of frequency, are not sudden reversals but are gradual, due to correspondingly gradual potential changes in either direction. These current characteristics of alternating current render it undesirable for the treatment of impaired nerve and muscle, and it is the purpose of this invention to provide a current converting system which produces a current which is free from these objections.

One object of this invention is to produce a current in which the polarity reverses rapidly and suddenly and in which the current increases and decreases abruptly. Each of the current impulses produced by this invention, changes from one of its limiting values to the other, whether the impulses be unidirectional or reversed in kind, without the accompanying voltage variations which are characteristic of the usual alternating current, thereby increasing the therapeutic value of the electric current delivered by my system, above anything possible in applying the usual alternating current to a patient.

Another object of the invention is to provide means for increasing and decreasing the frequency of the reversals without changing the potential of the current. To accomplish this I provide a substantially non-inductive current converter, which is driven by a variable speed motor. By this means it becomes possible to change the frequency of the reversals for varying the therapeutic effect, without changing the voltage of the current.

Another object of the invention is to provide rest periods between the current reversals, as it is not the length of time during which the current is applied to a nerve or muscle, which determines its therapeutic effect, but it is the sudden change in the polarity and the abrupt closures and openings of the current flow that produce intense therapeutic effects.

Another object of the invention is to produce low tension current impulses in which the time of current flow per impulse, is of a shorter duration than the corresponding period of the impulses would indicate.

A further object of the invention is to reduce the effects which the polar properties of the electric current have on the nerves; namely, the negative pole increases the irritability of a nerve, whereas the positive pole decreases the irritability of a nerve. In order to reduce the irritability which is produced by the negative pole, without raising the frequency to a point where artificial stimulation of nerve and muscle is impaired, I have found that by interposing rest periods between the current pulsations, the time during which the current is flowing can be reduced to a point where irritation is reduced to a minimum or abolished altogether. For instance, with the commercial 60-cycle alternating current, the current is in a negative or positive direction, as the case may be, for 1/120th of a second. In using my converting system this time can be reduced to any desired value; for instance if a rest period of one-half of the closure period is provided, the time during which the current flows is then reduced by one-half or to 1/240th of a second. Making the rest periods longer reduces the closure periods without changing the frequency of the reversals.

Another object of the invention is to pro-

duce interrupted currents, in which the interruptions are so rapid as to reduce the period of current flow to a value where irritation which is caused by the negative pole is eliminated. Such currents are of value when it is desired to retain the physiological effects which the positive and the negative poles have on the human body. For example, the positive pole is physiologically sedative and the negative pole is physiologically stimulative.

The currents which I have found to be very effective in the treatment of human ailments are as follows:

For impaired nerve and muscle, a current which reverses its direction about 680 times per second, with rest and closure periods of equal duration, produces the desired results. With this type of current, the time during which the current is either in a positive or negative direction is only 1/1360 of a second.

For treatment where the physiological effect of the current is desirable, a continuous current which is rapidly interrupted produces the desired results without the irritation which is present when the current value remains constant during the treatment. These current interruptions must occur with extreme rapidity, or electrical shock is experienced by the patient. Interruptions occurring from about 250 to 1,000 times per second appear to be most effective.

The absence of skin irritation seems to be, as far as I am able to ascertain at this time, due to the short duration of current flow which is accomplished by my invention.

The novel means and features which I believe to be characteristic of this invention will best be understood by reference to the following description taken in connection with the accompanying drawings, in which

Fig. 1 illustrates in developed view, one form of current converter which I employ.

Fig. 2 illustrates diagrammatically a system of electrical connections which I employ for producing rapid current reversals,

Fig. 3 is a diagrammatical view of the current impulses which are produced by the system of connections illustrated in Fig. 2,

Fig. 4 illustrates diagrammatically a system of electrical connections which I employ for producing a rapidly interrupted current.

Fig. 5 is a diagrammatical view of the current impulses which are produced by the system of connections illustrated in Fig. 4,

Fig. 6 is a diagrammatical view of the current impulses which are produced by the system of connections illustrated in Fig. 4 with wire 34 removed, and

Fig. 7 is a diagrammatical view of illustrative means for driving the current converter at variable speed.

Similar numerals refer to similar parts throughout the several views.

In Fig. 1, I show one form of current converter which I employ. 1, 24 and 25 indicate segments of a commutator of standard construction, consisting for example of copper segments which are insulated from each other. Rings 2 and 3 are of metal and are pressed over the segments with insulation 4 separating the rings from the segments. Connecting pins 5 are so positioned as to electrically connect the rings to the indicated segments. Brushes 6 and 7 are in contact with the rings 2 and 3 and are used for connecting the current converter to an input circuit. Brushes 8 and 9 are in contact with the segments and are used for connecting the current converter to a load or output circuit. The input and ouput circuit connections may be interchanged, but I prefer to connect the input circuit to brushes 6 and 7. The commutator described, as illustrated in Fig. 7, may be mounted for rotation on the shaft of a variable speed motor M supplied with current from the terminals 12 and 13 below described, of a source of current S, through wires 39 and 40 and variable resistance 41, so that by changing the amount of the resistance 41 in circuit with the motor, any desired speed of rotation of the commutator and frequency of the current impulses delivered from the commutator, may be secured. It will be understood that the commutator may be similarly rotated and the same result secured, in any other desired manner.

In Fig. 2, I show the circuit connections of a system for producing a highly effective low tension therapeutic current in which the current converter shown in Fig. 1, is used for converting a continuous current into a rapidly reversing current in which rest periods are interposed between the reversals. To accomplish this by means of the usual alternating current supply, I use a transformer 10, having a magnetic core 14, primary winding 11 and secondary winding 15. Primary winding terminals 12 and 13 are connected to an alternating current supply S. The secondary 15 delivers an ungrounded current by means of wires 16 and 17 to a full wave rectifier 18. Any of the well known full wave rectifiers, for example, a copper oxide rectifier of the electronic dry contact type, may be used. Output wires 22 and 23 of rectifier 18 carry a unidirectional current. Wire 22 carries a positive charge and wire 23 is negatively charged. Reactance coil 19 wound on a magnetic core 20 is inserted in the positive wire 22 which is connected with brush 6 and in turn with ring 2. Wire 23 is connected with brush 7 and in turn with ring 3. Segments 24 and 25 thereby become negatively and positively charged respectively at a constant potential by means of the connecting pins 5. Brush 8, when it is in contact with a segment 25 as shown, supplies a positive charge through wire 27 to the output terminal 29.

Brush 9, when it is in contact with a segment 24 as shown, establishes a negative condition of output terminal 28 through wire 26. A load 30 is connected with terminals 28 and 29, which may represent a human body being treated. A condenser 21 is connected between wires 22 and 23.

Connecting the current converter Fig. 1, in the manner just described, produces in load 30, current pulsations which are diagrammatically shown in Fig. 3, as follows:

Since brush 6 is connected with the positive pole of rectifier 18, and brush 7 is connected with the negative pole of said rectifier, all segments 25, through their connecting pins 5, are positively charged, and all segments 24, through their connecting pins 5, are negatively charged. Brushes 8 and 9 are positioned to be in contact for each current impulse, with oppositely charged segments. With brushes 8 and 9 in contact as shown and described, a current impulse flows through the load 30 in a positive direction, as indicated at 31 in Fig. 3. Rotating the current converter in the direction of the arrow shown in Fig. 1, brings the next following segments 1 into contact with brushes 8 and 9 and as these segments are not connected with rings 2 and 3 and no current then flows through the load 30 in Fig. 2, a rest period indicated at 33 in Fig. 3, is produced. Rotating the current converter still further, brings a negatively charged segment 24 into contact with brush 8 and a positively charged segment 25 into contact with brush 9, with the result that a current impulse then flows through load 30 in a negative direction, as indicated at 32. Rotating the current converter still further, brings another pair of segments 1 into contact with brushes 8 and 9, thereby producing another rest period 33. Further rotation of the current converter repeats the cycle of operation described.

The path of the current through the system of connections illustrated in Fig. 2, is as follows: The current supply S, is connected with terminals 12 and 13 of transformer primary winding 11. The secondary current flows, when wire 16 is positive with respect to wire 17, through section A of the rectifier, wire 22, reactance coil 19, brush 6, ring 2, segment 25, brush 8, wire 27, terminal 29, load 30, terminal 28, wire 26, brush 9, segment 24, ring 3, brush 7, wire 23, section B of rectifier, and through wire 17 back to the transformer. When wire 17 is positive with respect to wire 16, the current flows from wire 17 through section C of rectifier to wire 22 and thence through the path above traced to wire 23, and thence through section D of the rectifier and wire 16, back to the transformer.

The rectifying action of the rectifier prevents the passage of the current through the wires 22 and 23 differently than described. Condenser 21 although connected between the output wires of the rectifier 18, offers a high resistance to the flow of direct current, but offers a low impedance to any current pulsations which may pass through reactance coil 19, thereby preventing undesired current pulsations from entering the current converter.

From the description of the path of the current it will be seen that the rings 2 and 3 of the current converter Fig. 1, are always at constant polarity when connected as in Fig. 2, but as the current converter is rotating when in use, the brushes 8 and 9 and their associated output connections will be charged, first in one direction, then remain at zero potential, then become charged in the opposite direction and then remain at zero potential for a similar period, after which the cycle of operation described occurs repeatedly.

In Fig. 4 I show the circuit connections of a system for producing a highly effective low potential therapeutic current in which the current converter shown in Fig. 1, is used for interrupting the flow of current in a circuit of constant polarity. To accomplish this by means of the usual alternating supply current, I use devices of the kind above described, and connected as above described in connection with Fig. 2, excepting as follows: as shown in Fig. 4, the wire 23 extends from the rectifier 18 and is connected with the terminal 28 instead of being connected with the brush 7; the brush 7 is connected by wire 34 with wire 22 and thus with brush 6; and the brush 9 is disconnected from the rest of the wiring of the system. As before, the wires 22 and 23 are always positively and negatively charged respectively, and in this case, the brushes 6 and 7 are always positively charged, and the terminal 28 is always negatively charged. In this way, all of the segments 24 and 25 are positively charged, the segments 1 being neutral as before. While either of the brushes 8 and 9 may be used to intermittently supply positive charges to the terminal 29, I show the brush 8 so connected, it being understood that whichever one of said brushes is so used, the other of said brushes may be in disconnected condition, as shown for the brush 9.

As a result of the circuit connections and paths of current flow above described, when the connections of Fig. 4 are employed, each time the brush 8 rests upon a segment 25 or 24, a positive current impulse is communicated to the terminal 29, through the load 30 to terminal 28, and then through wire 23 to rectifier 18; rotation of the current converter to move the next segment, which is a neutral segment 1, into contact with the brush 8, interrupts the current flow and produces a rest period; further rotation of the current converter moves the next segment 24 or 25 into contact with the brush 8 and communi-

cates another positive current impulse to the terminal 29, followed by alternate rest periods and positive current impulses as shown in Fig. 5, where the current impulses and rest periods are designated 35 and 36 respectively. Where, as illustrated, the segments are all of the same width and equally spaced, and the rotation is uniform, the current impulses and rest periods will be of equal duration. It will be understood that any desired segment proportions and arrangement may be employed, and that the frequency of the current impulses delivered by any particular construction of current converter or commutator is determined by its speed of rotation.

Current pulsations 37 and rest periods 38 as shown in Fig. 6, are produced with the system of connections shown in Fig. 4 when the wire 34 is removed. In this case, the current pulsations are only produced by contact of the segments 25 with the brush 8. When segments 1 and 24 contact with brush 8, no current then flows through brush 8 and the periods of current flow are shorter than the rest periods, the effect being the same as providing the current converter with narrow charged segments and wider neutral segments.

If no alternating current is available, direct current supply may be applied directly to the input brushes 6 and 7 for the connections shown in Fig. 1, or to the brush 6 and terminal 28 for the connections shown in Fig. 4. The rest and closure periods may be changed by changing the thickness of the segments, as for instance thin segments for current closures and thick segments for the rest periods, produce shorter durations of the current closures and longer periods of rest; or reversing the connections, that is, connecting the thick segments for current closures and the thin segments for rest periods, increases the durations of current closures and reduces the length of time of the rest periods.

From the above, it will be observed that the devices employed to produce the current impulses and interruptions, and the circuit connections used to apply said impulses to a patient, may be of substantially constant impedance, since they may readily be substantially free from inductance and capacity, as a result of which, for any selected potential impressed upon the impulse producing devices, the effective potential of the current impulses produced may be maintained practically constant for different frequencies of said impulses produced by the frequencing changing devices.

While the arrangements of the system which I have shown and described, illustrate the invention in detail, it will be understood that modifications may be made in the particular apparatus used and the circuit arrangement employed without departing from the scope of my invention.

What I claim is:

1. In a system of the class described, the combination of alternating current rectifying means having alternating current supply terminals and unidirectional current delivery terminals, first circuit connections extending from said delivery terminals, pulsation suppressing means in said circuit connections, high frequency circuit changing contacts connected with said first circuit connections, and output circuit connections extending from said contacts, whereby rapid current impulses are abruptly and repeatedly communicated to said output circuit connections.

2. In a system of the class described, the combination of alternating current rectifying means delivering unidirectional current, pulsation suppressing means, delivery circuit connections extending from said rectifying means and connected with said pulsation suppressing means, circuit closing and opening mechanism in said circuit connections, and devices operating said circuit closing and opening mechanism at a desired frequency.

3. In a system of the class described, the combination of alternating current rectifying means delivering unidirectional current, pulsation suppressing means, delivery circuit connections extending from said rectifying means and connected with said pulsation suppressing means, circuit closing and opening mechanism in said circuit connections, devices operating said circuit closing and opening mechanism at a desired frequency, and speed changing mechanism controlling said operating devices.

4. In a system of the class described, the combination of alternating current rectifying means delivering unidirectional current, pulsation suppressing means, delivery circuit connections extending from said rectifying means and connected with said pulsation suppressing means, circuit closing and opening mechanism in said circuit connections, and devices operating said circuit closing and opening mechanism at a desired frequency, said circuit closing and opening mechanism comprising cooperating electric contacts having an open circuit relation for an appreciable part of each cycle of their operation.

5. In a system of the class described, the combination of alternating current rectifying means delivering unidirectional current, pulsation suppressing means, delivery circuit connections extending from said rectifying means and connected with said pulsation suppressing means, circuit closing and opening mechanism in said circuit connections, and devices operating said circuit closing and opening mechanism at a desired fre-

quency, said circuit closing and opening mechanism comprising cooperating electric contacts having an open circuit relation for a longer time interval than the time interval of their closed circuit relation for each cycle of their operation.

6. In a system of the class described, the combination of an inductive current converting unit, an electronic current converting unit, a mechanical current converting unit, circuit connections between said units, and a source of supply current for said inductive converting unit, said mechanical current converting unit comprising a source of current impulses of constant potential and desired sign for delivery to a patient's circuit.

7. In a current converting system, the combination of an inductive, an electronic and a mechanical current converting unit, each unit having input and output circuit connections, a source of alternating current connected to the input connections of the inductive converting unit, said output and said input connections of said inductive and said electronic units respectively being connected, said output and said input connections of said electronic and said mechanical units respectively being connected and supplying unidirectional current to said mechanical converting unit.

In witness whereof, I hereunto subscribe my name this 15th day of December, A. D. 1930.

HERMAN P. PULLWITT.