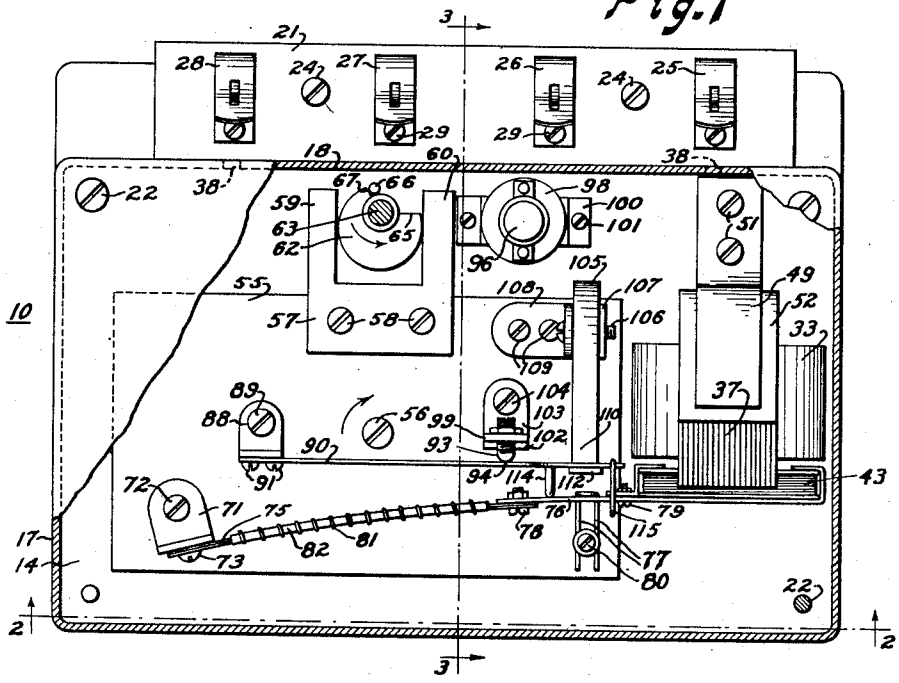
Dec. 24, 1940. L. M. PIGNOLET 2,226,514

ELECTROTHERAPEUTIC APPARATUS

Filed Dec. 13, 1937 3 Sheets-Sheet 1

Fig. 1



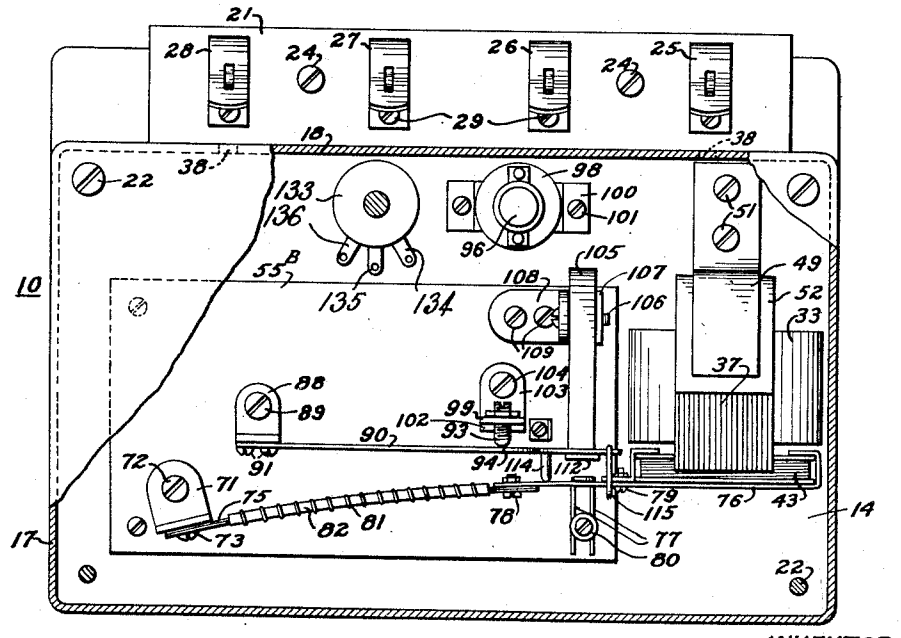


Fig. 8

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Dec. 24, 1940. L. M. PIGNOLET 2,226,514

ELECTROTHERAPEUTIC APPARATUS

Filed Dec. 13, 1937 3 Sheets-Sheet 2

Fig. 2

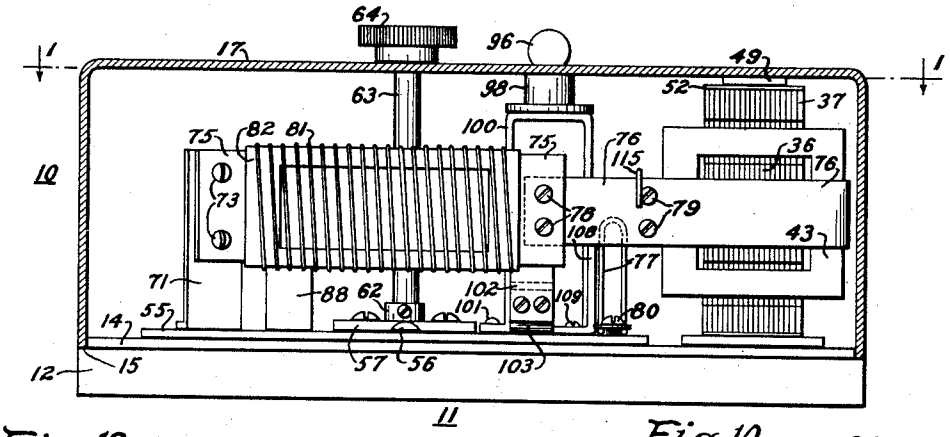


Fig. 12.

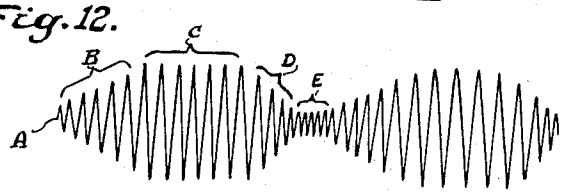


Fig. 10.

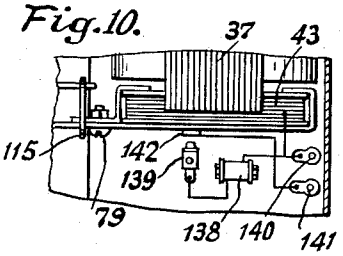


Fig. 3

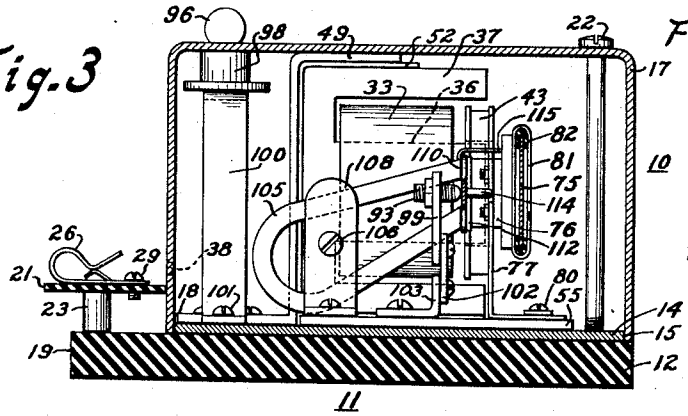
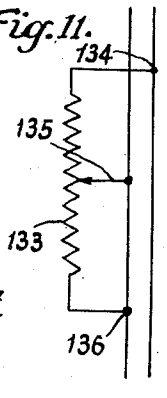


Fig. 11.



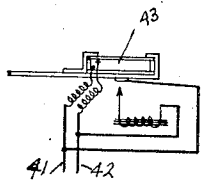


Fig. 9

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Dec. 24, 1940. L. M. PIGNOLET 2,226,514

ELECTROTHERAPEUTIC APPARATUS

Filed Dec. 13, 1937 3 Sheets-Sheet 3

Fig. 5

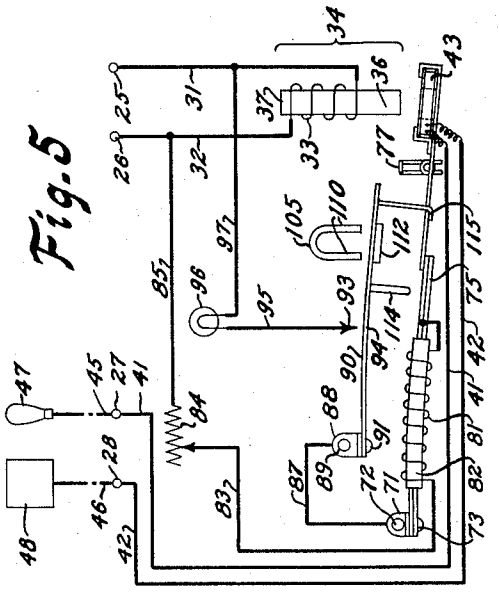


Fig. 7

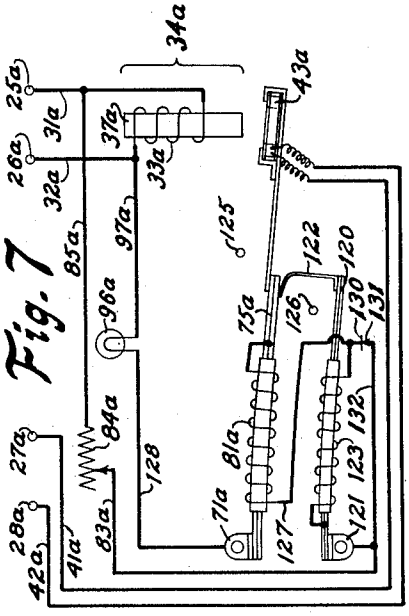


Fig. 4

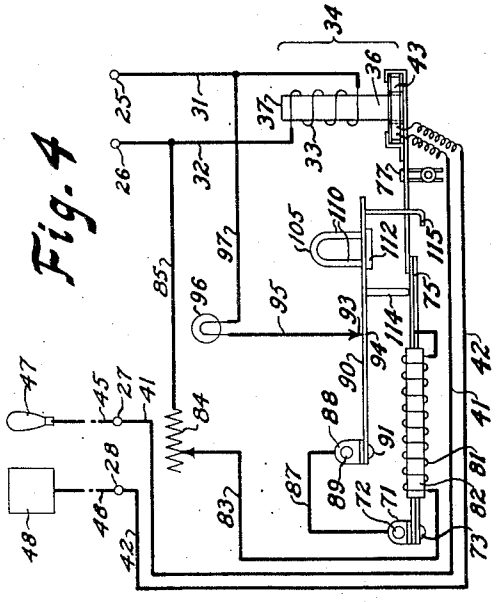
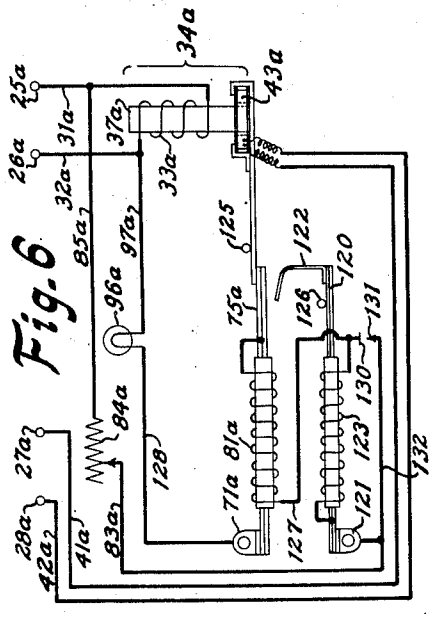


Fig. 6



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Patented Dec. 24, 1940

2,226,514

UNITED STATES PATENT OFFICE

2,226,514

ELECTROTHERAPEUTIC APPARATUS

Louis M. Pignolet, Chatham, N. J.

Application December 13, 1937, Serial No. 179,408

12 Claims. (Cl. 128—421)

My invention relates to electrotherapeutic apparatus, and particularly to means of this character for effecting muscular treatments with the concomitant benefits thereof.

Ordinary electric light current, such as generally available in homes, if passed through a muscle, causes a vigorous muscular contraction, even with a current value of as small as four or five milliamperes. However, such treatment has little effect in promoting growth and vigor of the muscle and especially if, as ordinarily available, it is applied suddenly and directly. In such case, disagreeable shock is felt by the patient, the value of the treatment is reduced or destroyed, and continuance of the treatment is discouraged.

To be effective for the desired purposes, the current should be gradually built up from a minimum to a maximum selected to suit any given patient or condition, and as gradually reduced, in repeated, rhythmic cycles, whereby to produce slowly alternating periods of contraction and relaxation of the muscles. By such treatment, circulation of the blood is stimulated and the muscle developed and strengthened in a natural way.

Among the benefits of such treatment are the relief of muscular pains, the exercise of muscles in cases of infantile paralysis, massaging muscles of broken limbs during the convalescing period, relieving constipation by increasing the action of the peristaltic muscles, removing excess fat through increased circulation, and beneficial results in numerous other cases.

An object of my invention is to avoid the above-mentioned disadvantages, and to permit the rhythmic application of electrical charges of only sufficient value to produce effective results in each particular case and in apparatus that may be used safely by the general public, as well as the medical profession.

Another object of the invention is to provide electrotherapeutic apparatus that shall not require an electric motor or its appurtenant elements and that shall be accordingly simpler, less expensive, less likely to get out of order, and that shall encourage and extend the use of such apparatus.

Another object of the invention is to utilize the principle of space effect, such as electromagnetic induction, whereby to simplify and reduce the cost of the apparatus, to more effectively separate the primary source of energy from the patient, and to obtain other advantages.

Another object of the invention is to provide apparatus of the above-indicated character that shall operate on standard household supply or other electric lines.

Another object of the invention is to utilize means, such as non-electrical, reciprocable, or thermo-responsive means, or a device other than an electric motor of the rotatable type, for operating electrotherapeutic apparatus to vary the voltage and/or current charges employed in treating a patient.

With such objects in view, as well as other advantages which may be incident to a utilization of the improvement the invention comprises the parts and combinations thereof hereinafter set forth and claimed, with the understanding that the several necessary elements may be varied in proportion, arrangement and texture, without departing from the nature and scope of the invention.

In order to make the invention more clearly understood, means are shown in the accompanying drawings for carrying the same into practical effect, without limiting the improvements in their useful applications to the particular constructions which, for the purpose of explanation, are made the subject of illustration.

Figure 1 is a view, partially in top plan, and partially taken along the line 1—1 of Fig. 2, of an electrotherapeutic device constructed in accordance with the invention; certain circuit conductors being omitted;

Fig. 2 is a view partially in side elevation, and taken partially along the line 2—2 of Fig. 1;

Fig. 3 is a sectional view, taken substantially along the line 3—3 of Fig. 1;

Fig. 4 is a diagram of the apparatus of Figs. 1 and 2, and of the circuit conductors and electrodes associated therewith; showing the parts as related at one stage of operation;

Fig. 5 shows the parts of Fig. 4 as related at another stage of operation;

Fig. 6 is a diagram similar to Fig. 4 of a modified form of the invention, illustrating the parts as related in a corresponding stage of operation;

Fig. 7 illustrates the parts of Fig. 6, as related during a stage of operation corresponding to that of Fig. 5.

Fig. 8 is a plan view, with the top cover broken away, of a modified form of apparatus embodying my invention;

Fig. 9 is a diagrammatic showing of choke coil and associated circuits which may be used to eliminate possibilities of sudden distress to the patient;

Fig. 10 is a fragmentary view of the electro-

magnet showing an application of the arrangement of Fig. 9;

Fig. 11 is a modification of the circuit of Fig. 4 showing the use of a potentiometer; and

Fig. 12 is a curve of voltage changes approximately as they occur in the apparatus shown.

In exemplary apparatus for practicing the invention, a device such as an electromagnet including a primary element or coil is associated with, or connected to, a source of electromotive force, which may be a standard alternating-current circuit, or a direct-current circuit rendered pulsating or alternating by converting means, such as a vibrator. The element or coil is associated with a laminated iron core, mounted on a main base, and connected to the source, as through terminals, binding posts or clips, also on the base with the electromagnet, to which coil a secondary element or winding is inductively and movably related.

The secondary winding is moved by non-electrical means, such as a thermo-responsive bimetallic strip fixed at one end to a post on a normally stationary support or sub-base that is movably mounted on the main base. The strip carries the above referred to secondary winding at its other, or free, end opposite a pole of the primary-circuit electromagnet.

Alternate heating and cooling of the bimetallic strip, causes oscillatory or reciprocable movement of the secondary winding toward and away from the pole of the electromagnet, whereby to induce in the winding slowly rising and slowly falling or pulsating voltage values, as distinguished from alternations or reversals of usual frequency without regard to value or rate of rise and fall, as in the primary coil.

In other words, although the voltages in both the primary and secondary circuits may be constantly alternating at the relatively high frequency of the primary circuit, the value of the voltage in the secondary circuit is slowly built up from substantially zero, or a negligible minimum, to a maximum selected to suit any given case or the desires of the patient and slowly reduced to the minimum. This cycle of slow rise and fall of the voltage value is automatically and regularly repeated so long as the apparatus is connected to the power supply.

The sub-base, mentioned above, supporting the bimetallic strip and the movable secondary winding, also supports an element, such as an elongated spring of the leaf or strip variety fixed at one end on a post near the fixed end of the bimetallic strip and extending approximately parallel to the latter, in slightly spaced relation thereto, to a position near the secondary winding by which the bimetallic strip is controlled or limited in movement toward the primary-circuit electromagnet by an adjustable stop on the sub-base.

Heating means for the bimetallic strip may take the form of a resistor wound on the strip over a thin flexible insulating envelope or sleeve and grounded at one end to the strip. The other end of the resistor is connected to one terminal of the primary circuit.

From the ground connection on the bimetallic strip, the resistor circuit extends through the strip and a conductor to the spring, which at a point between the ends thereof operates a circuit interrupter or contact making and breaking device including a contact member carried by the spring, for cooperation with a contact member stationarily mounted on the sub-base. From the latter contact member, the resistor circuit for heating the bimetallic strip is completed through a signal device, such as a lamp or other electro-responsive means, to the other primary circuit terminal.

The spring, a section thereof, or an element disposed thereon, beyond the contact member from the fixed end of the spring, may be constructed of non-magnetic material opposite the poles of a permanent or other magnet, and provided on its side toward the bimetallic strip, away from the permanent magnet, with an armature for the permanent magnet. Thus, the armature is attracted to the permanent magnet. Thus, the armature is attracted to the permanent magnet through the non-magnetic element to prevent sticking of the armature to the poles of the permanent magnet.

ments on the spring are provided to limit the movement of the bimetallic strip relative to the spring. One of these elements, on the side of the armature nearer the fixed end of the spring, may be in the form of a pin projecting laterally to the flat side of the spring toward the near side of the bimetallic strip. The other element, beyond the permanent magnet armature on the spring toward the free end of the spring, may be on the order of a hook-like projection extending laterally from the spring to a position beyond the far side of the bimetallic strip, and having its hook portion adapted to impinge against this far side.

The distance laterally of the spring and the bimetallic strip between the points at which the above-mentioned elements impinge against the bimetallic strip at opposite sides thereof, determines the operating range of the strip as controlled by the spring. When the bimetallic strip moves the secondary winding away from the primary-circuit electromagnet, the permanent magnet holds the spring, by cooperation with the permanent-magnet armature, until the strip engages the hook, thereby ensuring quick break of the contact members controlled by the spring and maintaining the resistor energized for a substantial period of time to ensure proper gradation of the voltage value to be applied to, and consequently, of the current value to be passed through, the affected parts of the patient.

Upon the return movement of the bimteallic strip, during the cooling thereof, the strip disengages the hook, but the spring remains away from the magnet with the contact members separated until the thermo strip moves sufficiently to press against the post and thus to push the spring to a position where the armature is attracted forcibly by the permanent magnet and held firmly against its poles. Now the resistor circuit is closed and the parts are in position to automatically repeat the above-mentioned cycle of operations. The strength and position of the spring and the attraction between the permanent magnet and armature are such that the armature remains out of contact with that magnet until pushed close thereto by the pressure of the thermostatic strip against the post.

In one form, an operating member or handle, movably mounted on the main base, operates, as through an eccentric or cam, against a spider or the like on the sub-base, whereby the nearest position which the secondary winding is to occupy with respect to the primary-circuit electromagnet, and thereby the voltage range of the secondary circuit, may be adjusted to suit the patient, since it is this position of the secondary winding in which the highest value of the secondary-circuit voltage is induced.

In another form, a potentiometer or rheostat

may be employed in either the primary or secondary circuit, or like devices may be employed in both circuits, for effecting the above-mentioned voltage-value adjustment, or other setting of the device.

As set up in the described embodiment, when the circuit through the heating resistor is closed, a signal device or lamp indicates this fact by its illumination or other manifestation, and opening of the circuit is indicated by lack of a signal or illumination of the lamp.

There may be different sets or pairs of electrodes of a size, shape and character for selective application or use according to different ailments to be treated, or different parts of the body to be treated, according to any other condition.

For example, one electrode connected to the secondary winding circuit may have the form of a plate upon which the patient sits, or otherwise applies to his body, and the other electrode may be smaller and formed according to the part or parts of the patient's body to which it is to be applied. In the case of treatment of any particular muscle the electrodes are applied near the opposite ends of the muscle.

In operation, after adjusting the apparatus to suit any given case or condition, as above indicated, the electrodes are applied to the patient, by himself or another, as prescribed or desired, and the treatment continued in accordance with desire or direction, during which time, the affected parts or muscles are subject to the stimulating effect and natural exercise as set forth.

In a modified form, generally like that above set forth, the invention, instead of employing a spring for the purposes indicated, may employ an auxiliary bimetallic or thermostatic strip, similarly disposed parallel to the main bimetallic strip in spaced relation thereto, but of thinner metal than the main strip, whereby, when heated by a comparable resistor, it will heat and cool faster than the main strip, and consequently oscillate or flex to and fro more rapidly than the main thermostat.

Contact members are so arranged relative to the main and auxiliary bimetallic strips, in this latter form of the invention, that an effect similar to that of the apparatus first above indicated is obtained. That is, as in the apparatus employing the spring, the heating current is maintained in the resistor of the main bimetallic strip carrying the secondary-circuit winding longer than if it broke its own circuit through contact members like those on the spring, and the voltage derived by the secondary winding from the primary-circuit electromagnet is more slowly built up and reduced, in accordance with a primary aim of the invention.

Referring to Figs. 1 and 2 for a more detailed description of the invention in the form first above generally outlined, the device may be enclosed in a small compact cabinet or box **10** comprising a main base **11** including a bottom panel **12**, as of wood or Bakelite composition, and a top plate **14** of metal, or of insulating material, constituting a raised portion of the panel **12**. The top plate **14** may be spaced inwardly slight distances from the end and rear edges of the panel, the latter shown at the bottom of Fig. 1 and at the right hand side of Fig. 2, to provide a shallow substantially rabbet groove **15**, Figs. 2 and 3 in which three of the edges of a cover **17** of rectangular inverted cup-shape are seated. The cover may also be of thin sheet-like character, as indicated, made of composition or the like.

As viewed in Fig. 1, the front edge **18** of the plate, at the top of the figure, and at the left in Fig. 3, is disposed a substantial distance from the adjacent parallel edge **19** of the panel **12** to provide a rabbet groove seating edge **18** for the adjacent side of the cover **17**, and also to provide a ledge or shoulder **20** outside the cover, on which a terminal board **21** is disposed. Any other disposition of terminals may be provided. The cover is removably mounted in position, as by relatively long vertical screws **22** at the upper left and lower right hand corners of the cover, as viewed in Fig. 1, which have heads over the top of the cover and lower end screw threaded portions extending into the base **11**.

The terminal board **21** may be an insulating plate, as of Bakelite composition or the like, or be constructed and arranged otherwise to receive, in insulated relation thereto, terminal clips, binding posts or the like. It may be mounted over the ledge **19** in spaced relation thereto on posts **23**, Fig. 3, as by screws **24**, Fig. 1.

As shown in Fig. 1, a pair of primary-circuit terminal clips **25** and **26**, and a pair of secondary-circuit terminal clips **27** and **28** are secured to the terminal board **21**, as by screws **29**. The primary-circuit terminal clips **25** and **26** are for connection to a source of electromotive force, such as a standard electric light alternating-current circuit, or to a vibrator or other converting means deriving its energy from a direct-current source and changing the direct current into alternating or pulsating current. This connection (not shown) may be of usual and well-known character.

The terminals **25** and **26**, are connected by conducting leads **31** and **32**, respectively indicated diagrammatically in Figs. 4 and 5, but not shown in Figs. 1, 2 and 3, to a primary-circuit coil **33** of an electromagnet **34** surrounding the middle leg or pole portion **36** of a laminated iron core **37**. Slots **38**, Figs. 1 and 3, are provided in the bottom front edge of the cover **17**, through which the conductors **31** and **32** extend to the clips **25** and **26**, and arranged to permit removal and replacement of the cover, without disturbing the connections. Similar slots **38** are provided for connecting secondary-circuit conductors **41** and **42**, Figs. 4 and 5, from the clips **27** and **28**, respectively, to a movable secondary-circuit winding **43** of relatively thin flat rectangular loop form.

Conductors **45** and **46** extend away from the secondary-circuit clips **27** and **28** to electrodes **47** and **48**, respectively, indicated diagrammatically in Figs. 4 and 5. As indicated, one of the electrodes, in this instance the electrode **48**, may be in the form of a plate upon which the person employing the apparatus sits or otherwise engages a portion of his body, and the electrode **47** may have any shape best adapted for application to a particular part of the patient's body. Of course, the electrodes will vary in shape, size and construction according to the use to be made thereof.

As better seen in Figs. 1 and 3, the electromagnet core member **37** may be secured to the plate **14** by a nonmagnetic bracket **49** of the Z-profile held to the base, as by screws **51**, and made of flat-strap brass or the like, laid over a sheet **52** of insulating material between the bracket and the core member.

An auxiliary or sub-base **55**, in the form of a plate of brass or the like, is pivotally mounted on the main base plate by a single pivot screw or pin **56**, and provided with an insulating spider **57** fixed to the sub-base, as by screws **58**. The spi-

der 57, as illustrated, is in the form of a flat plate of substantially U-shape having a closed or base end secured to the sub-base 55 by the screws 58 and arms 59 and 60 Fig. 1, projecting from the base.

An eccentric disc or cam 62, between the arms 59 and 60, is fixed to a vertical shaft 63 having its lower end journaled in the main base, and its upper end projecting through the top wall of the cover 17, and carrying a knob or handle 64, Fig. 2.

By turning the handle 64 to turn the shaft 63 counterclockwise, as indicated by the arrow on the cam 62 in Fig. 1, the cam engages the spider arm 60 to turn the sub-base 55 clockwise about its pivot pin 56, as indicated by an arrow near this pin in Fig. 1. This movement of the cam, which may be effected by any desired amount, may be, ultimately limited by engagement of a shoulder 65 on the cam 62 with a stop pin 66 fixed to the main base plate 14.

Reverse movement, or clockwise movement of the shaft 63, as viewed in Fig. 1, engages the cam 62 against the arm 59 of the spider 57 to move the sub-base 55 counterclockwise about its pivot pin 56. The latter movement may be ultimately limited by engagement of a shoulder 67 of the cam 62 with the pin 66.

Both of the above-described movements are for adjusting the starting and stopping position of movement of the secondary-circuit winding 43 relative to the middle leg 36 of the E-shaped electromagnet core member 37, and thereby for setting or determining the maximum voltage value induced in the secondary circuit and across the electrodes 47 and 48, as will hereinafter more clearly appear.

An non-magnetic strap-metal post 71 of substantially L-shape is fixed to the sub-base 55, adjacent to the lower left hand corner thereof, as viewed in Fig. 1, and has fixed thereto adjacent to the upper end thereof (Fig. 2) a bimetallic thermostatic strip 75 disposed flat side in a vertical plane, and extending horizontally from the post 71 toward the secondary-circuit winding 43 to which it is connected by a non-magnetic strap-metal element 76, as by screws 78. This strap element 76, as better indicated in Figs. 1 and 2, is return bent about the secondary-circuit winding 43 and is secured on itself, as by screws 79 whereby to fixedly embrace, and securely hold, the winding 43.

A stop 77, secured to the sub-base 55, engages the side of the strap element 76 next to the electromagnet 34.

A resistor 81, in the form of nichrome wire, is wound about an insulating envelope or sleeve 82, which surrounds the bimetallic strip 75 from a position near the post 71 to a position short of the near end of the strap element 76. The sleeve 82 is flexible and of single layer or thin construction to avoid interference with flexing of the strip 75. The end of the resistor 81 farthest from the post 71 is grounded to the bimetallic strip 75, as better seen in the diagrams of Figs. 4 and 5. The other end of the resistor may be connected by a conductor 83 through an adjustable rheostat 84, shown only diagrammatically, and a conductor 85 to the primary-circuit conductor 32. The rheostat 84 is optional equipment, as indicated above.

In the opposite direction, the circuit of the resistor 81 extends from its ground connection on the bimetallic strip 75 through the strip, the post 71 and a conductor 87 to a vertical post 88, like the post 71, fixed to the sub-base 55, as by a screw 89.

A non-magnetic leaf spring 90, of material such as phosphor bronze, is disposed flat side in a vertical plane, fixed to the post 88, as by screws 91, and extending horizontally along the bimetallic strip 75 in laterally spaced relation thereto, with the longitudinal center line of the spring substantially in a horizontal plane with the corresponding center line of the bimetallic strip. This spring extends to a position near the secondary-circuit winding 43.

At an intermediate position along the spring, a contact element or member 93 fixed to the sub-base 55 cooperates with a contact portion or element 94 of the spring, whereby the circuit of the resistor 81, from its ground end on the bimetallic strip, is completed through the spring, the contact elements 93 and 94, a conductor 95, a signal device or lamp 96, and a conductor 97 to the opposite primary-circuit conductor 31. The lamp 96 may be mounted in an opening in the top of the box 17 in a usual insulating socket 98 on a strap-metal post 100 that is of inverted substantially U-shape having laterally extending feet through which screws 101 extend to secure the post to the main base 11.

The contact element 93 may be in the form of a screw fixed to a short metal strap element 99 secured to an insulating plate 102 that is secured to an angle member 103 fixed, as by a screw 104, to the sub-base 55. By this structure, the contact element 93 and the strap 99 are insulated from the sub-base.

A permanent horse-shoe magnet 105, at a position longitudinally of the spring 90 between the contact element 94 and the free end of the spring next to the winding 43, is adjustably mounted, as by a screw 106 and a washer-like nut 107, on a strap metal post 108 secured to the sub-base 55, as by screws 109. This magnet has pole ends 110 adjacent to the near side thereto of the non-magnetic spring, or to a non-magnetic section of this spring, or a non-magnetic element secured to the spring if it be desired to have the spring of magnetic metal.

At the far side of spring 90, opposite the permanent magnet pole ends 110, a magnetic armature plate or element 112 is secured flat side against the spring, so that the flux of the magnet must pass through the non-magnetic portion to pass through the armature. This arrangement, with the non-magnetic spring portion, or its equivalent, between the permanent magnet pole ends 110 and the armature 112, prevents sticking of the armature against the pole ends.

A pin 114, disposed on the spring 90, between the contact element 94 and the permanent magnet armature 112, is fixed to the spring and projects horizontally, normal to the flat vertical side thereof, to act as a stop for the bimetallic strip 75 by impinging against the near side of the extension strap 76 of the strip.

An element 115, in the form of a hook disposed longitudinally of the spring between the armature 112 and the free end of the spring, is fixed to the spring and adapted to project from the spring over and about the upper edge of the strap 76, so that its outer hook end is opposite the far side of the strap 76.

The horizontal distance normal to the flat vertical sides of the spring and the strap between the outer free end of the pin 114 and the outer hook end of the hook 115, determines the distance the bimetallic strip can flex after disengaging the

pin and engaging the hook, and regulates the amplitude of the back and forth movement of the strip.

In operation, with the primary circuit of the electromagnet 34 having been disconnected from the energy source for sufficient period of time for the bimetallic strip 75 to become thoroughly cool, the parts are related as indicated in Figs. 1, 2, 3 and 4, with the secondary winding 43 surrounding but not touching, or frictionally engaging, the middle-leg pole portion 36 of the electromagnet and in substantially parallel plane relation to the plane pole face of this leg.

This is the position at which, when the primary circuit is closed, the secondary winding 43 inductively derives its greatest voltage value, so that, by turning the handle 64 counterclockwise, and consequently, turning the sub-base 55 clockwise about its pivot pin 56, as viewed in the figures, the highest voltage value desired to be impressed on the muscles between the electrodes 47 and 48, may be adjusted. Turning the sub-base 55, as stated, causes the latter to turn with it all the parts mounted thereon, whereby the position at which the secondary winding 43 starts to move away from the electromagnet 34 may be adjusted to suit the patient, or any desired condition.

This adjustment may be effected before the bimetallic strip 75 becomes sufficiently heated to appreciably move the secondary winding, during which time also, the fact of energization of the apparatus is indicated by the lamp 96. The adjustment may also be made, with the apparatus deenergized, from experience with the values received at certain positions of the secondary winding, or by the use of a suitable index (not shown) having the values indicated thereon.

With the bimetallic strip constructed, as of brass and iron as its components, with the more highly expansive side next to the spring 90, upon sufficient heating thereof by the resistor 81, the strip will begin to flex about its fixed end on the post 71 as a pivot, whereby the secondary winding starts to move away from the electromagnet 34 and thereby the voltage value induced in the winding starts to decrease.

Near the beginning of this movement, the strap extension 76 of the thermostatic strip 75 disengages from the pin element 114 on the spring 90 and starts to move toward the hook element 115. After a period of time, in which the bimetallic strip is flexing as stated, and carrying the secondary winding 43 away from the electromagnet, the strap extension 76 engages the hook element 115. By reason of the attraction between the permanent magnet 105 and the armature 112 on the spring 90, flexure of the bimetallic element is retarded, while sufficient force is built up against the hook 115 to pull the armature 112 away from the permanent magnet 105. When the armature pulls away, it does so suddenly whereby to effect a quick break between the contact elements 93 and 94. Thereafter the bending torque of the spring is imposed on the bimetallic strip 75, which with this added load and the time lag in the cooling of the resistor causes the strip to move slightly farther from the electromagnet to a position similar to that indicated in Fig. 5, and then to start flexing back toward starting position.

Upon separating the contact elements 93 and 94, the circuit of the resistor 81 and the signal lamp 96 is broken, and remains broken during the time thereafter that the parts are positioned as in Fig. 5, and until the bimetallic strip cools sufficiently to return to its starting position.

During such return the spring 90 remains practically stationary till the bimetallic strip by pressure on the post 114 pushes the spring 90 towards the permanent magnet 105 and into its field when the magnet suddenly again attracts the armature 112 to quickly engage the contact elements 93 and 94 to each other. This action properly positions the bimetallic strip 75 and the resistor 81 and the lamp 96 so that they are energized for the purposes above set forth and the secondary winding 43 begins again its gradual movement toward the electromagnet as above described.

Automatic repetition of the gradually increased and decreased voltage values in the secondary or electrode circuit is effected so long as the terminal clips 25 and 26 are connected to the primary voltage source.

With the pin 114 located on the spring 90 at the side of the contact elements 93 and 94 away from the fixed end of the spring on the post 88, pressure of the strap 76 on the pin 114 improves the contact between the elements 93 and 94.

Also, the hook 115 is located between the permanent magnet armature 112 and the free end of the spring 90, or substantially at this free end, so that the pull by the strap 76 on the hook 115 will not pull the spring away from the contact element 93 before the armature 112 is separated from the permanent magnet 105.

The stop 77 prevents backward or return movement of the bimetallic strip 75 beyond the desired starting position; this feature being important because, when operation of the device is discontinued, the thermostatic strip 75 cools to a lower temperature than its lowest temperature during operation, and thus would flex farther in the return direction which would disarrange the adjustments of the device.

The above arrangement and operation of the bimetallic strip engaging the hook 115 and the combination with the spring 90, causes the alternate periods of heating and cooling of the strip to be substantially longer than if the spring and the magnet were omitted and the contact element 94 mounted on the bimetallic strip for direct movement or control thereby. This action is very important in preventing sudden reversals of voltage values in the secondary circuit of the winding 43 and the attached electrodes 47 and 48, and in providing voltage-value changes of sufficiently gradual and rhythmic nature to be of proper benefit to the patient.

Also by obtaining these changes by the space effect set forth, and without the use of an electric motor of the rotative type, the danger of short circuit between the primary and secondary circuits, and of excessive voltage to the patient, are substantially eliminated and many other advantages are obtained.

Fig. 12 illustrates somewhat the voltage changes and periods thereof which occur in the secondary coil of the electromagnet, in any of the forms shown in this application. Starting from a point of zero voltage indicated at A, the voltage builds up gradually, to a selected, and pre-determined maximum, over a period indicated at B. This maximum voltage is maintained over a period indicated at C and then the voltage decreases to a minimum over a period indicated at D. The minimum voltage is maintained for a brief period indicated at E and then the voltage builds up gradually in a repetition of the cycle

just described. It will be noted that the period of voltage build up B and the period of maximum voltage C are about equal, while the period of decreasing voltage D is about half the duration of the time of the voltage build up. The duration of the period of minimum voltage E is less than the period of decreasing voltage and the combined periods D and E are less than the period of voltage build up B. Both the voltage build up and voltage decrease are gradual with, however, the difference in gradients just referred to.

Referring to Figs. 6 and 7, in which corresponding parts are designated by corresponding reference numerals having the suffix "*a*," the modified form of my invention therein diagrammatically shown, is similar to the form first above described in structural detail, from which the structure of the form of Figs. 6 and 7 should be understood.

The main distinction in the modified form of apparatus is the means for obtaining increased and retarded movement of a main bimetallic strip **75***a* by a secondary bimetallic strip **120**, which takes the place of the spring **90**.

In this form, primary terminal clips **25***a* and **26***a* are similarly connected by conductors **31***a* and **32***a* to a primary electromagnet coil **33***a* on a core member **37***a* of an electromagnet **34***a*.

Secondary-circuit or electrode terminal clips **27***a* and **28***a* are connected by conductors **41***a* and **42***a*, respectively, to a secondary circuit winding **43***a* that is mounted at the free end of the main bimetallic strip **75***a*. The latter is mounted on a post **71***a* that is fixed on a sub-base (not shown) similar to the sub-base **55**. The secondary bimetallic strip **120** is fixed at one end to a post **121** to be mounted on the sub-base, and carries a flexible contact element **122** adjacent to its free end for contact with the main bimetallic strip **75***a*. Resistors **81***a* and **123** are provided on the strips **75***a* and **120**, respectively, for heating the same.

In the deenergized condition of the apparatus, the parts are disposed as indicated in Fig. 6, in which the secondary winding **43***a* is closest to the electromagnet **34***a*, the main bimetallic strip **75***a* is in engagement with a stop **125** and the auxiliary bimetallic strip **120** is in engagement with a stop **126**.

The circuit of the resistors **81***a* and **123** extends from the primary-circuit conductor **31***a*, through a conductor **85***a*, a rheostat **84***a*, a conductor **83***a*, the post **121**, the resistor **123**, a flexible conductor **127**, the resistor **81***a*, a ground connection of the resistor **81***a* on the strip **75***a*, through the strip **75***a*, the post **71***a*, a conductor **128**, a signal device or lamp **96***a*, and a conductor **97***a*, to the other primary-circuit conductor **32***a*. A contact member **130**, carried by the auxiliary bimetallic strip **120**, is connected to the resistor **123** and is adapted to engage a stationary contact member **131** that is connected by a conductor **132** to the post **121**.

The auxiliary bimetallic strip **120** is of thinner metal than the main bimetallic strip **75***a* and the resistor **123** is of comparable value to the resistor **81***a*, or these parts are otherwise constructed, proportioned or related, such that the auxiliary bimetallic strip **120** heats and cools faster than the main bimetallic strip **75***a*. It is desirable to have the auxiliary bimetallic strip **120** operate at a higher temperature than the main strip **75***a*, which may be obtained by increasing the resistance of the resistor **123** or other means.

In operation, when the terminal clips **25***a* and **26***a* are connected to the source of primary energy, and the parts are conditioned as indicated in Fig. 6, current flows from the clip **25***a*, through the primary winding **33***a*, the conductor **97***a*, the lamp **96***a*, the conductor **128**, the main bimetallic strip **75***a*, the resistor **81***a*, the flexible conductor **127**, the auxiliary resistor **123**, the conductor **83***a*, the rheostat **84***a*, the conductor **85***a*, and the conductor **32***a* to the primary-circuit terminal clip **26***a*.

This circuit causes simultaneous heating of the two heating coils or resistors **81***a* and **123**, whereby the main and auxiliary bimetallic strips **75***a* and **120**, respectively, heat in unison and start to flex downwardly at the right-hand free ends, as viewed in the drawings.

However, the auxiliary bimetallic strip, being thinner, heats faster than the main strip **75***a*, thereby moving faster than the main strip, until its movement is arrested by engagement of the contact member **130** with the stationary contact member **131**. This action short circuits the secondary resistor **123** and prevents overheating of the latter.

After engagement between the contact members **130** and **131**, as indicated in Fig. 7, the main bimetallic strip continues its movement until it engages the flexible contact element **122**, whereupon the main heating coil or resistor **81***a* is also short circuited, and both strips now cool. This action causes the strips to move backwardly toward the starting position of Fig. 6, during which, by reason of movement of the auxiliary strip **120** faster than the movement of the main bimetallic strip, contact is maintained between the flexible contact element **122** and the main strip **75***a* until movement of the auxiliary strip **120** is arrested by the stop **126**.

The strips **75***a* and **120** then separate, current flows in both resistors **81***a* and **123** again, and the forward and backward movement described is repeated. This cycle continues so long as the clips **25***a* and **26***a* are connected to the primary voltage source. The stop **125** prevents the main bimetallic strip **75***a* from moving too far in its return movement toward the electromagnet **34***a*.

In the above-described operation, the secondary winding **43***a* is alternately slowly moved from and toward the electromagnet **34***a*, as in the form of the invention first above described, whereby, to similarly affect the electrodes **47** and **48** connected to the secondary terminal clips **27***a* and **28***a*, respectively, and similarly applied to parts of a patient's body.

Fig. 8 illustrates a further modified form of device embodying my invention wherein the sub-base **55B** is stationary, and not movable as in the other forms. The adjustment of voltage applied to the patient is here controlled by a potentiometer **133** the circuit connections of which are shown in Fig. 11. Terminal **134** is connected to the circuit extending from one end of the coil **43** to electrode terminal **27**. The movable center tap **135** is connected to the electrode **28** and the third terminal **136** is connected to the other end of coil **43**. By this arrangement, as will be understood by those in the art, the voltage between electrodes **27** and **28** will depend upon the position of the movable top of the potentiometer. This method of control has several advantages over the movable subbase control of the previously described forms of my device.

To safeguard the patient from any undue shocks due to any build-up of static voltage, the arrangement shown in Figs. 9 and 10 may be provided, although the same arrangement may be

applied also to the form shown in Fig. 8. This consists of providing a choke coil 138 through which secondary coil 43 is short-circuited when the coil is in its outermost position from the electromagnet core 37.

One end of the choke coil 138 is connected to contact 139, mounted on base 11, and the other end thereof is connected to terminal 140 to which lead wire 42 is also connected. The other lead wire 41 is connected to terminal 141 which in turn is connected to contact 142 that is carried by coil 43 and cooperates with contact 139 when the coil 43 is in its outer position.

As will be understood, the choke coil 138 may be replaced by a resistor or other means to accomplish the same purpose.

In either form, the apparatus is greatly simplified in construction and operation, is rendered substantially more economical in manufacture than former devices, eliminates troubles and hazards, operates better on the patient and in the hands of the patient, and is an improvement generally in the electrotherapeutic art to which it relates.

Although particular forms of the invention have been shown and described, this has been done by way of example of practical application of the apparatus, which may be changed in various features to obtain equivalent results, without departing from the spirit and scope of the invention, as set forth herein and in the accompanying claims.

I claim:

1. Electrotherapeutic apparatus comprising electrode means, means for energizing the electrode means including electroresponsive means embodying a thermo-responsive bimetallic strip fixed adjacent to end end, and means for controlling the circuit of the electroresponsive means and movement of the strip including a spring parallel to the strip fixed at one end adjacent to the fixed end of the strip, a contact element carried by the spring, a cooperating contact member, and means on the spring for limiting movement of the strip relative thereto.

2. Electrotherapeutic apparatus comprising electrode means, means for energizing the electrode means including electroresponsive means embodying a thermoresponsive bimetallic strip fixed adjacent to one end, and means for controlling the circuit of the electroresponsive means and movement of the strip including a spring parallel to the strip fixed adjacent to one end adjacent to the fixed end of the strip, a contact member carried by the spring, a cooperating contact member, a magnet between the contact members and the free end of the spring, an armature on the spring opposite, and for cooperation with the magnet, a member carried by the spring between the armature and contact members thereon for limiting movement of the strip in its contracting movement, and a member carried by the spring adjacent to the free end thereof for limiting movement of the strip in its expansion movement.

3. Electrotherapeutic apparatus comprising electrode means, means for energizing the electrode means including electroresponsive means embodying a thermo-responsive bimetallic strip fixed adjacent to one end, and means for controlling movement of the strip including a spring fixed adjacent to one end of the strip, an armature on the spring, and a magnet for cooperation with the armature.

4. Electrotherapeutic apparatus comprising a pulsating-current electromagnet, a bimetallic strip fixed adjacent to one end and carrying a winding for inductive relation to the electromagnet, electrode means for energization by the winding, means for heating the strip, a spring parallel to the strip fixed at one end, a contact member on the spring, a cooperating contact member, a circuit through the heating means and the contact members, a permanent magnet, an armature on the spring for the permanent magnet, means for limiting movement of the strip, and means for adjusting the winding relative to the electromagnet.

5. Electrotherapeutic apparatus comprising an electromagnet for connection to a source of pulsating electromotive force, an electroresponsive signal device, a bimetallic strip fixed adjacent to one end and carrying adjacent to its other end a winding for inductive relation to the electromagnet, electrodes for energization by the winding, a resistor for heating the strip, a spring paralleling the strip fixed at one end adjacent to the fixed end of the strip, a contact member on the spring, a cooperating stationary contact member, a circuit from said source through the resistor and through the contact members and the signal device back to the source, a stop for limiting movement of the strip toward the electromagnet, a permanent magnet, an armature on the spring for the permanent magnet, means on the spring for limiting movement of the strip, and means for adjusting the winding relative to the electromagnet.

6. Electrotherapeutic apparatus comprising a base, an electromagnet fixed to the base for connection to a source of pulsating electromotive force, an electroresponsive signal device, a support movably mounted on the base, a bimetallic strip fixed adjacent to one end to the support and carrying adjacent to its other end a winding for inductive relation to the electromagnet, electrodes for energization by the winding, electroresponsive means for heating the strip, a spring parallel to the strip fixed to the support adjacent to one end adjacent to the fixed end of the strip, a contact member on the spring, a cooperating contact member on the base, a circuit from said source through said heating means and through said contact members and the signal device back to the source, a stop on the base for limiting movement of the winding toward the electromagnet, a permanent magnet on the base, an armature on the spring for the permanent magnet, means carried by the spring for limiting movement of the strip in opposite directions, and an operating member movably mounted on the base for moving the support to adjust the winding relative to the electromagnet.

7. Electrotherapeutic apparatus comprising a base, an electromagnet including a coil fixed to the base, a pair of primary terminals on the base connected to the coil for connection to a source of pulsating electromotive force, an electroresponsive signal device on the base, a support movable on the base, a bimetallic strip fixed adjacent to one end to the support and carrying adjacent to its other end an armature winding for inductive relation to the electromagnet, electrodes for affecting a patient, means including a pair of secondary terminals on the base for connecting the winding to the electrodes, a heating resistor insulatingly surrounding the bimetallic strip having one terminal connected to one of the primary-circuit terminals and another terminal grounded to the strip, a spring parallel

to the strip fixed adjacent to one end to the support adjacent to the fixed end of the bimetallic strip and carrying a nonmagnetic element, a contact member on the spring, a cooperating contact member on the base, means providing a circuit from the strip to the spring through the contact members and the signal device to the other primary terminal, a stop on the base cooperating with the strip adjacent to the winding for limiting movement of the winding toward the electromagnet, a permanent magnet on the base between the contact members and the free end of the spring, an armature on the spring opposite, and for cooperation with, the permanent magnet through said nonmagnetic element, a member carried by the spring between the armature and contact members thereon for limiting movement of the strip toward the spring, a member carried by the spring adjacent to the free end thereof for limiting movement of the strip away from the spring and an operating member movably mounted on the base for moving the support to adjust the winding relative to the electromagnet.

8. Electrotherapeutic apparatus comprising an electromagnet having inductively related primary and secondary coils movable relatively to each other, a thermo-responsive bi-metallic strip fixed at one end and carrying one of said coils at its free end, means for heating the strip intermittently to cause the free end and said coil to move to and fro to vary the current induced in said coil, and patient's electrodes energized by the current induced in said coil as it moves to and fro.

9. Electrotherapeutic apparatus comprising an electromagnet having inductively related primary and secondary coils movable relatively to each other, a thermo-responsive bi-metallic strip fixed at one end and carrying one of said coils at its free end, a resistance element operatively associated with said strip, means for intermittently energizing said element to cause the free end of said strip and said coil to move to and fro to vary the current induced in said coil, and patient's electrodes energized by the current induced in said coil as it moves to and fro.

10. Electrotherapeutic apparatus comprising an electromagnet having inductively related primary and secondary coils movable relatively to each other, a thermo-responsive bi-metallic strip fixed at one end and carrying one of said coils at its free end, a heating element operatively associated with said strip, and connected to a source of electric current, a pair of contacts in the circuit to said heating element and normally closed, connections whereby movement of the bi-metallic strip and associated coil caused by energization of the heating element will also open the circuit through said contacts and whereby further movement of the bi-metallic strip and associated coil responsive to de-energization of the heating element will reclose the circuit through said contacts, such movements of the coil varying the current induced in said coil, and patient's electrodes arranged to be energized by the current in said coil.

11. Electrotherapeutic apparatus comprising an electromagnet having inductively related primary and secondary coils movable relatively to each other, one of said coils moving and fitting over one pole of the magnet, a thermo-responsive bi-metallic strip fixed at one end and carrying the last mentioned coil at its free end, means for heating the strip intermittently to cause its free end and said coil to move to and fro along the pole and at least partially off said pole, and patient's electrodes connected to said coil.

12. Electrotherapeutic apparatus, comprising an electromagnet having inductively related primary and secondary coils movable relatively to each other, a thermo-responsive bi-metallic strip fixed at one end and carrying one of said coils at its free end, means for heating the strip intermittently to cause the free end and said coil to move to and fro to vary the current induced in said coil, said means including a resistor connected with a source of electricity for heating the strip, a spring fixed at one end and having an armature at its free end, a pair of contacts actuated by said spring, a magnet cooperating with the armature to cause the spring to firmly close the contacts whereby the resistor is connected with the source of electricity, a hook on the spring by which the bi-metallic strip in its movement when heated pulls the armature away from the magnet and causes the spring to open the contacts, thus interrupting the electric current through the resistor, and a connection on the spring against which said strip pushes when cooling, thus pushing the armature against the magnet to reclose the circuit through the resistor.

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