

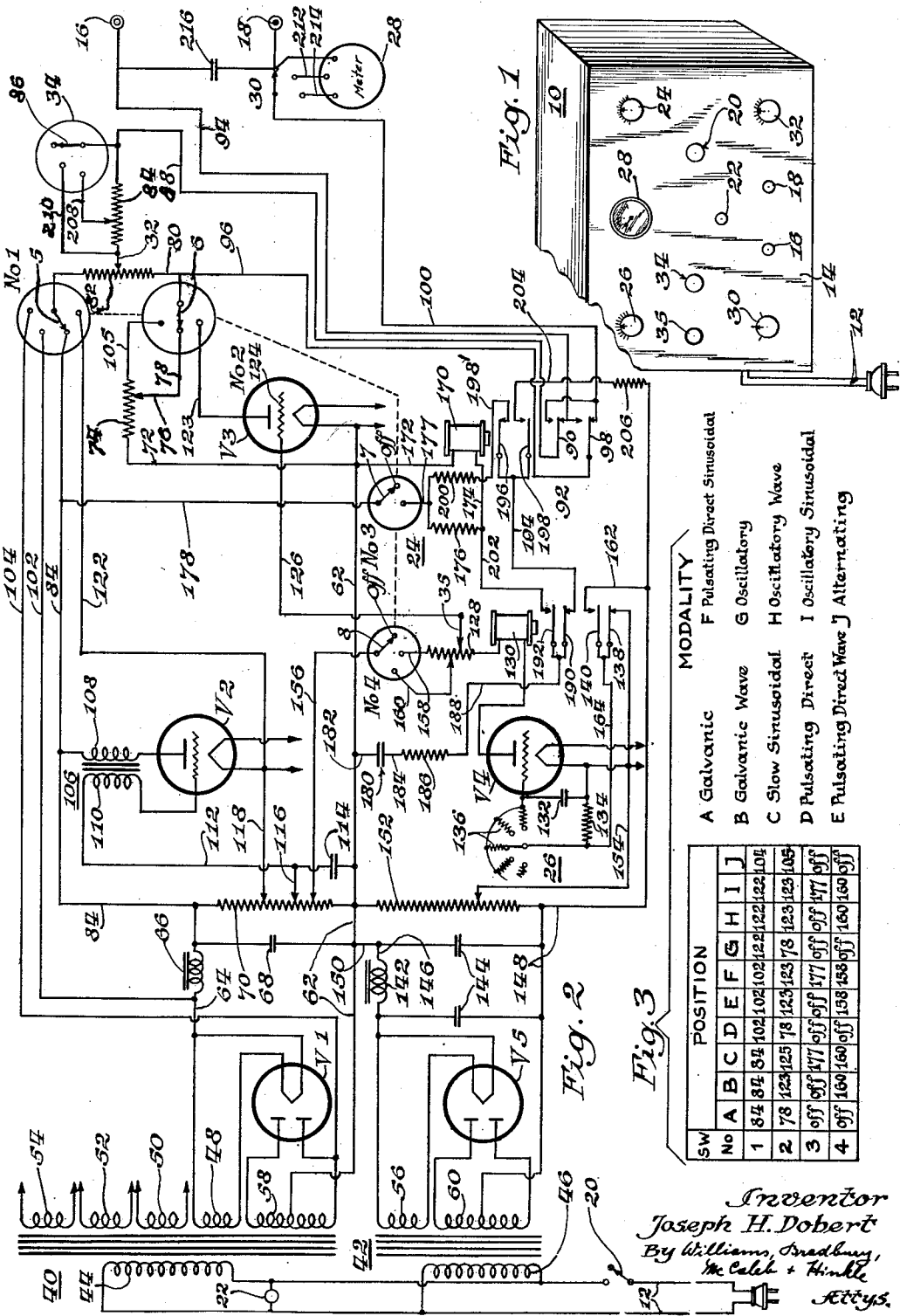
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ELECTRO-PHYSIOTHERAPEUTICAL APPARATUS

Filed March 13, 1939



- MODALITY
- A Galvanic
 - B Galvanic Wave
 - C Slow Sinusoidal
 - D Pulsating Direct
 - E Pulsating Direct Wave
 - F Pulsating Direct Sinusoidal
 - G Oscillatory
 - H Oscillatory Wave
 - I Oscillatory Sinusoidal
 - J Alternating

SW	No	A	B	C	D	E	F	G	H	I	J
1	84	84	84	102	102	102	102	102	102	102	102
2	78	123	125	78	123	123	123	123	123	123	105
3	off	off	off	off	off	off	off	off	off	off	off
4	off	160	160	off	158	158	off	160	160	160	off

UNITED STATES PATENT OFFICE

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ELECTROPHYSIOTHERAPEUTICAL
APPARATUS

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Application March 13, 1939, Serial No. 261,489

22 Claims. (Cl. 128—422)

The present invention relates to electro-physiotherapeutical apparatus, and has for its primary object, the provision of a new and improved apparatus for supplying various modalities of electro-physiotherapy to patients.

The present invention is an improvement over the apparatus disclosed and claimed in my co-pending application Serial No. 99,543, filed September 5, 1936, upon Electro-physiotherapeutical apparatus, now Patent No. 2,182,233 granted December 5, 1939.

One of the primary objects of the present invention is to provide a new and improved apparatus of the type described that is simple to build as compared to other apparatus utilized for the same purpose and reliable in operation.

Another object of the present invention is the provision of a new and improved apparatus of the type described, so constructed and arranged that the operator may, by simple manipulation of a single control, obtain galvanic and sinusoidal current, various modifications of either of these two current forms, and various combinations thereof for use in electro-therapy.

A further and more specific object of the invention is to provide a new and improved apparatus of the type described employing thermionic devices adapted preferably, but not necessarily, to be energized from a single source of power, and selector switches for selectively controlling the connections of the thermionic devices to each other and to other electrical apparatus, wherein the number of thermionic devices and selector switches are reduced to a minimum and are so constructed and arranged with respect to each other as to produce reliable operation.

Another object of the present invention is to provide a new and improved apparatus for producing a wavy modality, i. e., one that fluctuates at a relatively low frequency from a predetermined value to predetermined values, either higher or lower, or both, than said one predetermined value.

Another object of the invention is to provide an apparatus of the type described in the preceding paragraph capable of providing a "rest" period between successive waves, during which rest period the current remains at its minimum value, and also an apparatus in which the rest period may be varied.

Another and more specific object of the present invention is to provide an apparatus of the type specified in the preceding paragraph comprising a patient's circuit having therein current

modifying means controlled by an independent timing circuit.

A further object of the present invention is to provide a simplified apparatus of the type described having an improved circuit arrangement for transforming the wave modalities of current into sinusoidal wave modalities.

Other objects and advantages of the present invention will become apparent from the ensuing description, in the course of which reference is had to the accompanying drawing in which:

Fig. 1 is a perspective view of an electro-physiotherapeutical apparatus embodying the features of the invention;

Fig. 2 is a schematic wiring diagram of the apparatus shown in Fig. 1; and

Fig. 3 is a chart listing the various modalities obtainable with the apparatus illustrated in the preceding figures and showing also the positions of the various switch blades comprising the selector means.

The multi-wave electro-physiotherapeutical apparatus of the present invention may be housed within a suitable cabinet 10 and provided with power, preferably from a sixty cycle alternating current source, through a single plug connector 12. The front panel 14 of the cabinet constitutes a control panel, upon which are mounted the various selector and control devices hereinafter described. In addition the control panel is provided with a pair of sockets 16 and 18 constituting output or patient's terminals adapted to receive suitable applicators (not shown).

The supply of power to the apparatus is controlled by a power switch 20 operable from an "off" to an "on" position to energize the equipment. The connection of equipment to the power supply is indicated by a pilot light 22 energized simultaneously with the equipment.

The selection of the desired current modality is effected through a manually operable multi-element selector means indicated generally by reference character 24. In the embodiment of the invention herein described and illustrated, the selector means comprises four rotatable switch blades (to be described in detail hereinafter), all simultaneously operable to make the circuit changes necessary to produce the desired current modality. The small number of switch blades comprising the selector means forms one of the important features of the present invention.

The frequency of the wavy modality currents is controlled by a controller indicated generally by the reference character 26, and the frequency

and polarity of the currents, as well as the magnitude thereof flowing in the patient's circuit, may be observed by a meter 28 of the multi-scale type. The connection of the meter in the patient's circuit and the selection of the desired scale is controlled by a switch 30.

The magnitude of the current supplied to the patient's terminals is controlled first by a potentiometer 32, and second by a switch 34 adapted to control the connection of a hereinafter to be described resistance in circuit with the patient's terminals. The length of the rest period between successive waves of the wavy modalities is controlled by a control means 35 which, as will be described more fully hereinafter, makes adjustable contact with a resistance.

The selector means comprises a plurality of switches indicated generally by the reference characters 1 to 4, inclusive, and illustrated schematically in Fig. 2. The switches may be of any well known type and comprise what is generally called a gang switch. A switch of this type generally includes a number of rotary switch blades equal to the number of switches, and a number of contacts equal to the number of positions to which the switch is operable. Such switches are well known in the art and further detailed description or illustration thereof is deemed unnecessary. The rotary switch blades of switches 1 to 4 are indicated by reference characters 5 to 8, inclusive.

The apparatus of the present invention is adapted to produce ten modalities of current, and consequently the selector means 24 is operable into ten different positions A to J, inclusive, as shown in Fig. 3. In each position the switch blades engage contacts so connected in various circuits that the selection of the desired modality and the supply thereof to the patient's terminals is controlled by a single selector means.

The ten current modalities are quite well known to those skilled in the art and these are listed in Fig. 3 of the attached drawing.

The various current modalities are derived from a single source of alternating current power which is transformed by suitable translating apparatus into currents which are utilized as sub-sources in the production of certain of the modalities. The sub-sources are the galvanic, pulsating direct, and oscillating currents, and these are translated into wave and sinusoidal wave modalities by means including thermionic devices and switches.

Referring now to the schematic wiring diagram illustrated in Fig. 2, it may be seen that the alternating current is supplied through the plug connector 12 and power control switch 20 to a pair of transformers 40 and 42 having primary windings 44 and 46, respectively. Current is supplied to the patient's terminals 16 and 18 through a patient's circuit including the transformer 40, and the frequency of the wave modality currents is controlled by an independent timing circuit energized through the transformer 42.

Transformer 40 is provided with four low voltage secondary windings 48, 50, 52 and 54 for supplying heating current to the filaments of the thermionic vacuum tubes V-1, V-2, V-3 and V-4, respectively. Transformer 42 is provided with a single low voltage secondary winding 56 for supplying heating current to the filament of the thermionic vacuum tube V-5. The

transformers 40 and 42 include secondary windings 58 and 60 providing a source of high potential for the anode circuits of vacuum tubes V-1 and V-5, which function as full-wave rectifiers.

Rectifier tube V-1 supplies pulsating direct current to conductors 62 and 64 connected, respectively, to the mid-point of the anode transformer winding 58 and to the filament of the tube. The current then passes through a filter, comprising a choke 66 in series with conductor 64 and a condenser 68 connected across the conductors 62 and 64, which serves to smooth the pulsations so that a galvanic current is supplied to the terminals of a high resistance voltage divider resistor 70.

Assuming for the time being that the selector means 24 has been operated to condition the apparatus for supplying galvanic current to the patient's terminals, then the switches 1 to 4, inclusive, occupy the positions in which they are shown in Fig. 2. As a result galvanic current is supplied, when the apparatus is energized, to the patient's terminals, through a circuit including the conductor 62, a conductor 72, a relatively low resistance resistor 74, a movable contact 76 associated therewith, a conductor 78 leading therefrom to switch No. 2, the movable blade 6 of which completes a circuit therefrom through conductor 80 to a high resistance potentiometer resistor 82. The circuit from the other terminal of resistor 70 to the other terminal of the potentiometer resistor 82 extends through conductor 84 and the movable switch blade 5 of switch No. 1.

The current is led to the patient's terminal 16 from the potentiometer resistor 82 through the potentiometer contact 32, through all or a portion of a relatively low resistance 84, or directly, dependent upon the position of the movable switch blade 86 of switch 34, conductor 88, switch blade 90 of a relay operated reversing switch 92, the function and construction of which will be described fully shortly, and conductor 94. The lower terminal of potentiometer resistor 82 is connected to patient's terminal 18 through the conductors 80, 96, a second switch blade 98 of the reversing switch 92, conductor 100 and either directly to the terminal 18 through switch 30 (as indicated) or to the terminal through the meter 28.

Pulsating direct current is supplied to the potentiometer resistor 82 and thence to the patient's terminals through a circuit identical with that described above, except for the fact that the filter is by-passed and the pulsating direct current from the rectifier is conducted directly to switch No. 1 by a conductor 102 with which the switch blade 5 is in contact when this modality is selected (see the switch positions for modality D).

Alternating current of the same frequency as the power source is supplied to the potentiometer resistor 82 and the patient's terminals through a circuit that is substantially the same as the two described above, except for the fact that both the rectifier and filter are by-passed by a conductor 104 with which the switch blade 5 is in contact when this modality is selected (see the switch positions for modality J).

The last described connections result in the connection of the potentiometer resistor 82 to the lower half of the secondary winding 58 of the transformer 40. When the alternating current modality is selected, the whole of resist-

ance 74 is placed in series with the potentiometer resistor because switch blade 6 is in contact with conductor 105.

In the production of the oscillatory current modality, the vacuum tube V—2 is utilized as a source of oscillatory current that is supplied to the terminals of the potentiometer resistor 82 and thence to the patient's terminals. Tube V—2 has associated therewith a transformer 106 adapted to couple the output and input circuits of the tube in a well known manner. One winding 108 of the transformer is connected across conductor 84 and the anode of the tube. The other winding 110 of the transformer is connected to the grid and by conductor 112 to one terminal of a tuning condenser 114, the other terminal of which is connected to conductor 62. A branch conductor 116 connects the conductor 112 to the voltage divider 70. The filament of the tube is connected by conductor 118 to the voltage divider. The oscillatory current furnished by the oscillator is supplied to the lower terminal of potentiometer resistor 82 through conductors 62, 72, a portion of resistance 74, movable contact 76, conductor 78, switch blade 6 in contact with the latter, and conductor 80. It is supplied to the upper terminal of the resistor by conductor 122 and the switch blade 5, which is in contact therewith (see switch positions for modality G).

In the production of the various wave modalities (not the sinusoidal wave) the galvanic, pulsating direct and oscillatory currents are modified so that they gradually increase from a predetermined minimum value to a predetermined maximum value, and then decrease to the minimum value at substantially fixed relatively long time intervals. The modification is effected by the vacuum tube V—3, which is then connected in series with the potentiometer resistor 82 through conductor 123 connected to the anode of the tube and adapted to be connected to one terminal of resistor 82 by switch blade 6 of switch No. 2. The potential of the grid 124 of the tube is varied periodically and gradually to produce a similar change in the plate current of that tube, which current flows through the potentiometer resistor.

The desired variation in the potential of the grid of tube V—3 is obtained by connecting it by a conductor 126 to the previously mentioned movable contact 35 associated with resistance 128 forming part of the previously mentioned independent timing circuit. The potential applied to the grid 124 at any particular time is dependent upon the value of the current flowing through resistance 128 having a value intermediate the low and high resistance values mentioned above. The flow of current through the resistance 128 is gradually varied from a minimum to a maximum and then back to a minimum value by timing means including the vacuum tube V—4, a marginal relay 130 connected to the anode of the tube and to one terminal of the resistance 128, and a condenser 132 connected across the grid and filament of the tube and adapted alternately to be charged and discharged through a circuit including a selected one of a plurality of resistances 136. The resistances 136 each have a different value and they, together with the condenser 132, form part of the frequency control means 26. The alternate charging and discharging is controlled by a pair of switch blades 138 and 140 operated by the relay 130.

Before proceeding further with the details of

the circuit connections of the elements just enumerated, it may be well to describe briefly the manner in which they are supplied with energy from the transformer 42.

The transformer secondary windings 56 and 60 are connected in accordance with usual practice to the filament and anodes of the rectifier tube V—5, and the pulsating direct current output thereof is smoothed by a filter comprising the choke coil 142 and a pair of condensers 144 connected in parallel across the conductors 146 and 148. The conductor 146 is the positive conductor and the conductor 148 negative. The positive conductor 146 is tied to the negative conductor 62 of the patient's circuit by a conductor 150. The output from the filter is supplied across the terminals of a voltage divider 152 having an intermediate value of resistance. The filament of the vacuum tube V—4 is connected by conductor 154 to a point on the voltage divider 152 having a potential more positive than the potential of the conductor 148, and the anode of the tube is connected to a point more positive than the one to which the conductor 154 is connected, and more positive than conductor 62, by a conductor 156 leading to the voltage divider 70. The conductor 156 is adapted to be connected to the anode of the tube through switch No. 4 and solenoid 130. The switch blade 8 of switch No. 4 is operable from an off position in which it is indicated into two positions to connect the anode to the voltage divider. In one position the connection is through the whole of resistance 128. This connection is through conductor 158. In the other position the connection is through a part of resistance 128 and the connection is made through conductor 160.

When the relay 130 is de-energized, as it is when the apparatus is disconnected from the power source, the switch blades 138 and 140 occupy the positions indicated wherein the resistance-condenser circuit and grid of tube V—4 are connected to conductor 154 so that the grid is at a potential that is more positive than if connected to conductor 148 through switch blade 140 and branch conductor 162. In the position indicated, the condenser 132 is adapted to discharge through the resistances 134 and 136 and the grid rendered most positive through conductor 154, switch blade 138 and conductor 164. Consequently, when the apparatus is energized the tube V—4 is in its most conductive condition because of the more positive potential applied to its grid, and the relay 130 is designed to be energized at this time.

Upon the energization of the relay 130, the switch blade 138 is moved upwardly to disconnect the resistance-condenser circuit and grid from the more positive conductor 154, and the switch blade 140 is adapted to be moved upwardly to connect the resistor-condenser circuit and grid to the more negative conductor 148 through the conductors 162 and 164. As a result of this last-mentioned operation the grid potential is gradually made more negative at a rate dependent upon the proportions of the resistance 136, and the condenser 132, in a manner well known to those skilled in the art. The gradual application of a more negative potential to the grid decreases the plate current flowing through the tube V—4 to a minimum value at which the relay 130 is de-energized, and the switch blades 138 and 140 return to the positions indicated, and the condenser 132 gradually discharges into the resistances and the grid again made more positive. The relay 130 is, as has been mentioned above, a marginal

relay, that is, it is adapted to be energized when a current of predetermined value flows therethrough and remains energized until the current decreases to a value below the aforesaid predetermined value.

The flow of current through the resistance 128 thus varies from a predetermined maximum to a predetermined minimum value at recurring periods, dependent upon the setting of the frequency control means 26. When the current flowing through the resistance 128 is at a maximum, the voltage drop across the portion of resistance 128 included between the conductor 156 and the switch blade 8 is a maximum, and consequently the grid is most negative with respect to the filament which is connected directly to conductor 62. When the current flowing through the resistance is a minimum, that is, when the relay 130 is deenergized, the voltage drop is least and the grid potential is more positive. It is desirable that the negative potential applied to the grid of tube V-3 be made substantially zero in order to obtain a desirable maximum value for the wavy modality currents, and it is for this reason that the conductor 156 is connected to a point on the voltage divider 70 having a potential above that of conductor 62. The effect of connecting the conductor 156, as indicated, is the application of a potential bucking the negative potential in resistance 128 resulting from the flow of current therethrough.

Since the vacuum tube V-3 is interposed in series with the potentiometer resistor 82 and the latter is adapted selectively to be connected to the sources of galvanic, pulsating direct and oscillatory currents, it may be seen that the latter current modalities can readily be modified to produce the galvanic, pulsating direct and oscillatory wave modalities, and that the frequency of the waves may be controlled as desired by the frequency control means 26.

A "rest" period may be interposed between the successive waves by adjusting the movable contact 35 connecting the grid 124 of tube V-3 to the resistance 128, so that the tube is biased to cut-off before the current flow through relay 130 reaches its maximum value. If this be done, no current flows through the potentiometer resistor during the time that the tube is biased to cut-off.

The wave modalities above described are transformed into sinusoidal wave modalities by reversing the connections of the terminals of the potentiometer resistor 82 with respect to the patient's terminals 16 and 18. This reversing operation is effected by the previously mentioned reversing switch 92.

In order to prolong the life of the reversing switch, the reversals effected thereby should take place when the current flowing to the patient's terminals is at a minimum (this minimum value is ordinarily zero because the maximum negative potential applied to the grid of the tube V-3 is sufficient to bias it to its cut-off point).

Therefore, it is necessary that the reversing switch be tied in with the operation of the timing circuit, and this is accomplished by placing the reversing switch operating relay 170, which is of the marginal type, under the control of the relay 130.

The relay 170 and its associated circuits are, therefore, rendered operative when the sinusoidal wave modalities are selected. When these are selected, switch No. 3 is operated from the position in which it is shown to connect relay 170 across conductors 62 and 84, through conductor 172 and

through conductor 174, resistance 176, conductor 177, switch blade 7 of switch No. 3 and conductor 178, respectively.

The relay 170, being as heretofore mentioned a marginal relay, is adapted to be energized when the current flowing therethrough reaches a predetermined value, and remains energized until the current decreases below a value less than the predetermined value. The resistance 176 in series therewith is so proportioned that the current flowing through the relay and resistance is insufficient initially to energize the relay, but is sufficient to maintain the relay energized when the latter is once energized. It may be seen, therefore, that according to the present invention the relay must be provided with additional current for its energization, and that the normal current flow therethrough must be decreased in order to de-energize the relay.

The increase and decrease in the normal current flow through the relay 170 is obtained by a condenser which is selectively positively and negatively charged with respect to the direction of flow of current through the relay, thereby to add to or subtract from the normal current flowing through the relay by amounts sufficient, respectively, to effect energization and de-energization of the relay. The condenser which is so charged is indicated by the reference numeral 180, one terminal of which is connected by conductor 182 to the conductor 62, and the other terminal of which is connected by conductor 184 to a resistance 186. The latter is connected by a conductor 188 to switch blades 190 and 192 adapted to be raised upwardly from the positions shown in Fig. 2 whenever the relay 130 is energized.

When the switch blades are in the positions indicated, the condenser is adapted to be charged positively through a circuit including the switch 190, a conductor 194 leading therefrom to a pair of interconnected switch blades 196 and 198 operable simultaneously with switch blades 90 and 98, for a purpose to be described shortly, by the relay 170, through switch blade 196, conductor 198, resistance 200, conductor 177, and switch blade 7 of switch No. 3, and conductor 178 leading to conductor 84. When the switch blade 7 is in circuit making position and the equipment energized, the terminal of the condenser connected to conductor 184 is charged positively.

When the relay 130 is energized, the charge from the condenser is impressed across the relay 170 in a direction such as to increase the flow of current therethrough to a value sufficient to energize the relay. The charge is impressed through a circuit including switch blade 192, now in engagement with a conductor 202 connected by conductor 174 to the relay 170. The energization of relay 170 effects a reversal of the connections of the potentiometer resistor terminals to the patient's terminals by operation of the switch blades 90 and 98 from their lowermost to their uppermost positions. The relay 170 once energized remains energized even after the condenser charge is dissipated and the relay 130 de-energized. However, the circuit arrangement is such that upon re-energization of the relay 130, the relay 170 is de-energized by impressing the charge from condenser 180 thereon, the condenser at this time having a charge that is negative with respect to the direction of flow of current in the relay. The condenser 180 is provided with a negative charge in the following manner:

Once the relay 170 is energized, switch blades

186 and 198 are moved upwardly and the latter is connected through conductor 204 and resistance 206 to the negative conductor 148. Thus, the negative conductor 148 is conditioned for connection to charge the condenser negatively when the relay 130 is de-energized, at which time switch blade 198 is connected to the condenser through conductor 184, resistance 186, conductor 188, switch blade 190, and conductor 194.

Reviewing the operation of the energization and de-energization of relay 170, it may be seen that it is alternately energized and de-energized each time that the relay 130 is energized.

Before reviewing the operation of the apparatus, it should be noted that the magnitude of the current supplied to the patient's terminals may be controlled not only by the potentiometer 32, but also by the switch 34, the switch blade 86 of which is adapted to be operated from the position shown in which the whole of resistance 84 is in the patient's circuit into engagement with conductor 208 to decrease the amount of the resistance in the circuit or into engagement with a conductor 210 to cut the resistance out of circuit entirely.

The meter 28 may be inserted in the patient's circuit, if desired, by operating the switch 30 from the position in which it is shown into engagement with either of conductors 212, 214. When operated into engagement with the former, the low reading scale of the meter is rendered effective, and when operated into engagement with the latter the high reading scale of the meter is rendered effective. A low capacity blocking condenser 216 is connected directly across the patient's terminals 16 and 18.

It is believed that while the operation of the apparatus in its entirety is fairly comprehensible from the above detailed description, a brief review of the operation of the system in the production of the various modalities of current will serve a useful purpose. The various modalities will, therefore, be considered in the order in which they are alphabetically listed in Fig. 3.

(A) Galvanic

In the description of the operation of the apparatus for the production of this modality as well as the other modalities, it is assumed that the plug connector 12 is connected to a sixty cycle alternating current source, switch 20 is closed to energize the transformers, and control devices 26, 30, 32, 34 and 35 are in the positions indicated. The pilot light 22 is energized to give an indication that power is being supplied to the apparatus. The selector switch 24 is operated into position A, conditioning the apparatus for the supply of galvanic current to the patient's terminals. In position A switch No. 1 establishes a circuit from conductor 84 to the potentiometer resistor 82, and switch No. 2 establishes a circuit from conductor 62 to the other end of the potentiometer resistor 82 through conductor 72, a portion of resistance 74, movable contact 76 and conductors 78 and 80. Switches Nos. 3 and 4 are in their off position at this time so that the time control and reversing means are inoperative. As previously explained, the conductors 62 and 84 are connected to the terminals of the voltage divider resistor which is supplied with a galvanic current from the rectifier in a manner that need not be described again. The galvanic current is supplied from the potentiometer resistor 82 to the patient's terminals through switch blades 90

and 98 of the reversing switch 92, which are maintained in the position indicated by reason of the fact that the relay 170 is inoperative. The amount of current flowing in the patient's circuit may be determined by observation of meter 28 which may be included in the circuit by operation of switch 30 into contact with conductors 212 or 214.

The magnitude of the current flowing in the patient's circuit may be controlled in the first instance by switch 34, which may be operated from its off position into contact with conductors 208 or 210, thereby increasing the current from a minimum to an intermediate or to a high value.

Close adjustment of the current is had by means of the potentiometer movable contact 32, and a further adjustment of the current may be obtained by adjustment of the movable contact 76, but ordinarily it is not necessary to resort to this and, therefore, the contact is ordinarily placed within the cabinet 10 where it is relatively inaccessible. The use of the meter and the adjustment of the current to low, intermediate and high values by switch 34 is the same for all modalities and the operation thereof will not be described again.

(B) Galvanic wave

When this modality is selected, switch No. 1 remains in engagement with conductor 84, switch No. 2 is operated so that switch blade 6 engages conductor 123, thereby placing the current modifying tube V-3 in circuit, switch No. 4 is brought into contact with conductor 160, thereby rendering effective the time control means controlling the potential applied to grid 124, and switch No. 3 remains in its open position, thereby maintaining the reversing means inoperative.

The change in the position of switch No. 2 merely cuts out the resistance 74 and places the vacuum tube V-3 in place thereof so that the filament of the latter is connected to conductor 62 and the anode to conductor 84 through conductor 123, switch blade 6, conductor 80 and switch blade 5.

Relay 130 having been de-energized, the potential applied to the grid of the time control tube V-4 is most positive because the grid is connected to conductor 154 through switch blade 138, conductor 164 and the selected resistance 136. Consequently, the tube is in its most conductive condition and the relay 130 is immediately energized connecting the resistor-condenser circuit to the most negative conductor 148 through conductor 162, switch blade 140, and conductor 164. A negative charge is built up in the condenser 132 at a rate dependent upon the value of the selected resistance 136, and the potential of the grid consequently becomes more negative gradually at a rate dependent upon the proportions of the resistance and condenser. After the grid potential reaches a certain negative value, the current flowing in the output circuit of the tube decreases to a point where the relay 130 becomes de-energized and the switch blades 138 and 140 are returned to the positions indicated, wherein the condenser-resistance circuit is connected to the more positive conductor 154, again to make the grid more positive and in time to increase the current in the anode circuit thereof to a value sufficient to energize the relay. It may be seen, therefore, that the current flowing through the

resistance 128 varies from a maximum to a minimum value periodically. The potential of the point to which the movable contact 35 is attached, therefore, varies, being most negative when the current is at a maximum and least negative when the current is at a minimum. The resistances are so proportioned that the variation is great enough to make the grid 124 of tube V—3 sufficiently negative to bias the tube to cut-off so that the current flowing through the potentiometer resistor 82 is reduced to zero. If desired the contact 35 may be so adjusted that the point of cut-off is reached before the current flow in resistance 128 reaches its maximum value so as to provide rest periods between the successive waves.

As stated above in the detailed description of the circuit arrangement, the conductor 156 is connected to a point on voltage divider 70 sufficient to render the bias upon grid 124 of tube V—3 substantially zero, thereby to determine the most conductive condition of the tube.

The frequency of the waves is controlled by the frequency controller 26, which is adapted to be rotated to place various resistances 136 in circuit with the condenser 132 and grid of the tube V—4. Ten resistances have been found ample for ordinary purposes.

(C) Slow sinusoidal

The selector control means 24 is operated into position C and the switches remain in the positions described under the previous heading, with the exception of switch No. 3 which is adapted to complete a circuit across conductors 177 and 178, thereby rendering effective the reversing switch 92. It is believed sufficient to state at this point that the relay 170 is energized for every alternate energization of relay 130, and similarly de-energized upon the other alternate energizations of relay 130. The energization of the relay 170, it may be remembered, is effected by discharging condenser 180, when positively charged, into the relay 170, and the de-energization of the relay is effected by discharging the condenser, when negatively charged, into the relay. The alternate charging and discharging of the condenser positively and negatively is effected through switch blades 196 and 198 under the control of relay 170, and switch blade 190 under the control of relay 130. The discharge of the condenser into the relay is effected by switch blade 192 under the control of relay 130. The operation of the system, except for the reversing switch, remains the same as in the previously described modality, and the reversing switch is effective merely to reverse the connections of the patient's terminals 16 and 18 with respect to the potentiometer connection 32 and the lower resistor terminal, which is connected to conductor 80. The reversals are effected as described above at a time when the current flowing in the patient's terminals is at a minimum (ordinarily zero), because of the fact that the reversal is effected whenever relay 130 is energized, that is, when maximum current flows through the resistance 128, at which time the bias applied to tube V—3 is most negative.

(D) Pulsating direct

When the apparatus is conditioned for the supply of pulsating direct current, the selector means 24 is operated into position D, at which time switch No. 1 is connected to conductor 102, switch No. 2 to conductor 78, and switches Nos.

3 and 4 are open. The circuit, therefore, is quite similar to the circuit existing when modality A is selected. Pulsating direct current is thus supplied to the output terminals through a previously described circuit including conductor 102, which is connected directly to the output of the rectifier tube V—1.

(E) Pulsating direct wave

When this modality is selected, switch No. 1 remains connected to conductor 102, switch No. 2 is operated to connect the vacuum tube V—3 in the patient's circuit, switch No. 3 remains in its off position, and switch No. 4 renders effective the time control circuit. The potential applied to the grid 124 of the tube V—3 is periodically varied in the manner described in detail in connection with modality (B) and the pulsating direct current is transformed into a pulsating direct wave modality.

(F) Pulsating direct sinusoidal

When this modality is selected, switches Nos. 1, 2 and 4 remain connected in the manner last described and switch No. 3 is connected to conductor 177, thereby to render effective the current reversing means. The operation of the system at this time is substantially the same as for modality (C) and the pulsating direct current supplied to the potentiometer resistor 82 and tube V—3 is transformed into a pulsating direct sinusoidal modality.

(G) Oscillatory

When the oscillatory modality is selected, switch No. 1 is connected to the output of the oscillator tube V—2 by conductor 122, switch No. 2 is connected to conductor 78, and switches Nos. 3 and 4 are in their off positions. The operation of the system at this time is the same as when modalities (A) and (D) are selected, the only difference being that oscillatory current is supplied to the potentiometer resistance instead of the galvanic or pulsating direct.

(H) Oscillatory wave

When this modality is selected, switch No. 1 is connected to conductor 122, switch No. 2 to conductor 123, switch No. 3 is in its off position, and switch No. 4 is connected to conductor 100. Switch No. 4 thus again renders effective the time control circuit and a gradually varying potential is applied to the tube V—3, which is now in circuit with the potentiometer resistance, thereby to transform the oscillatory current supplied thereto into an oscillatory wave modality in a manner previously described.

(I) Oscillatory sinusoidal

When this modality is selected, switches Nos. 1, 2 and 4 remain in the positions they occupy when the oscillatory wave modality is selected, and switch No. 3 is connected to conductor 177, thereby to render effective the current reversing means. The operation of the apparatus at this time corresponds to the operation when current modalities (C) and (F) are selected, and consequently further description of the operation is not deemed necessary at this point.

(J) Alternating

When the alternating current modality is selected, the lower half of transformer 58 is connected to the potentiometer resistor 82 through a previously described circuit that includes conductor 104 to which switch blade 5 of switch No.

1 is connected. Switch No. 2 connects in the circuit the whole of resistance 74. Switches Nos. 3 and 4 are in their off positions to render ineffective the wave frequency control and reversing means.

While a preferred embodiment of my invention has been described, many modifications may be made without departing from the spirit of the invention, and I do not wish to be limited to precise details of the construction set forth.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. An electro-therapeutic apparatus, including in combination, output terminals, a source of current and means interconnecting said source and terminals for transforming said current into a wavy modality of electro-physiotherapy, said means including a circuit interconnecting said source and terminals, a single thermionic device having a plurality of electrodes, two of which are permanently connected in said circuit, and periodically acting means operating independently of said device for varying the potential applied to another of said electrodes.

2. An electro-therapeutic device, including in combination, output terminals, a source of current and means interconnecting said source and terminals for transforming said current into a wavy modality of electro-physiotherapy, said means including a circuit interconnecting said source and terminals, a single thermionic device having a cathode, anode, and another electrode, said anode and cathode being permanently connected to said circuit, periodically acting means operating independently of said device for varying the potential applied to said other electrode and means for varying the period of operation of said last mentioned means.

3. An electro-therapeutic apparatus, including in combination, output terminals, a source of alternating current, means co-operatively associated with said source for providing sub-sources of galvanic, pulsating direct, or oscillatory current modalities, and means interconnecting said source and terminals for transforming selected ones of said modalities into wavy modalities, said means including a circuit adapted to interconnect said source and terminals, a single thermionic device in said circuit and having a control electrode, and periodically operating means for varying the potential applied to said control electrode, and single manually operable control means for establishing circuit connections between the sub-sources of current and the transforming means for supplying the selected modality to the output terminals.

4. An electro-therapeutic apparatus, including in combination, output terminals, a source of alternating current, means associated therewith for providing sub-sources of galvanic and pulsating direct current, means associated with the source of galvanic current for providing a sub-source of oscillatory current, means interconnecting said various sub-sources and terminals for transforming said current of a selected sub-source into a wavy modality, said means including a circuit adapted to interconnect said selected sub-sources and terminals, a thermionic device having an anode and cathode in said circuit and another electrode, periodically acting means operating independently of said device for varying the potential applied to said other electrode, and single manually operable control means comprising a plurality of simultaneously operable

switches for establishing circuit connections between the sub-sources of current and the transforming means for supplying the selected modality to the output terminals.

5. An electro-therapeutic apparatus, including in combination, output terminals, a source of current, means interconnecting said source and terminals for transforming said current into a wavy modality of electro-physiotherapy, said means including a circuit interconnecting said source and terminals, a thermionic device having a plurality of electrodes, at least two of which are connected to said circuit, a resistance, a connection from another of said electrodes to a predetermined point on said resistance, and means for supplying current to said resistance through another circuit and for periodically varying the current flowing through said resistance, and thereby the potential of said point and the potential applied to said other electrode.

6. An electro-therapeutic apparatus, including in combination, output terminals, a source of current, means interconnecting said source and terminals for transforming said current into a wavy modality, said means including a circuit interconnecting said source and terminals, a thermionic device having a plurality of electrodes, at least one of which is connected to said circuit, a resistance, a connection from the second of said electrodes to predetermined point on said resistance, and means for periodically varying the current flowing through said resistance and thereby the potential of said point and the potential applied to said electrode, the connection of said second electrode to said resistance being adjustable and the current flow being so regulated that the thermionic device is rendered substantially non-conductive before the current flow through said resistance is changed to vary the potential in a direction to render the device more conductive, thereby to provide adjustable "rest" periods between successive waves.

7. An electro-therapeutic apparatus, including in combination, output terminals, a source of current, and means interconnecting said source and terminals for transforming said current into a wavy modality of electro-physiotherapy, said means including a circuit interconnecting said source and terminals and a wave frequency control means for controlling the conductivity thereof, said circuit including a thermionic device, and said frequency control means including a second thermionic device, and a periodically charged and discharged condenser for controlling the conductivity of said device, said second mentioned device controlling the action of the first mentioned one.

8. An electro-therapeutic apparatus, including in combination, output terminals, a source of current and means interconnecting said source and terminals for transforming said current into a wavy modality of electro-physiotherapy, said means including a circuit interconnecting said source and terminals and a wave frequency control means, said circuit including a thermionic device having an electrode for controlling the conductivity thereof, and said control means including a thermionic device having an anode and an electrode controlling the conductivity thereof, means connected to the anode circuit of said device connected to the electrode of said first mentioned device and operative to vary the potential of said electrode responsive to the flow of current in said anode circuit, and means including a condenser connected to the electrode

of said device, resistance means in circuit therewith, and a relay in said anode circuit responsive to the current flowing therethrough adapted alternately to charge or discharge said condenser through said resistance means.

9. An electro-therapeutic apparatus, including in combination, output terminals, a source of alternating current, a first transformer, means interconnecting said transformer and output terminals for transforming current derived from the transformer into a wavy modality of physiotherapy, said means including a circuit interconnecting said source and terminals, and a wave frequency control means, said circuit including a thermionic device having an electrode for controlling the conductivity thereof and said control means including a thermionic device having an anode, and an electrode controlling the conductivity thereof, a second transformer, and means energizing said second thermionic device from said second transformer, means connected to the anode circuit of said second thermionic device for varying the potential of the electrode of said first-mentioned thermionic device responsive to the flow of current in said anode circuit, and means including a condenser connected to the electrode of said second-mentioned thermionic device, resistance means in circuit therewith, conductors connected to points of different potential, and a relay in said anode circuit responsive to the current flowing therethrough for alternately connecting said condenser, resistance means and electrodes to said conductors, whereby said condensers are alternately charged and discharged through said resistance means and the potential of the electrode of said second-mentioned thermionic device gradually and periodically varied between predetermined maximum and minimum limits at a rate determined by the value of said resistance means.

10. An electro-therapeutic apparatus, including in combination, output terminals, a source of current, means including a circuit interconnecting said source and terminals having therein a single thermionic device having a plurality of electrodes, at least one of which is included in said circuit, and periodically operating means for varying the potential applied to another of said electrodes for transforming said current into a wavy modality of electro-physiotherapy, and periodically operating current reversing means interposed between the output of said thermionic device and the output terminals.

11. An electro-therapeutic apparatus, including in combination, output terminals, a source of current, means including a circuit interconnecting said source and terminals having therein a single thermionic device having a plurality of electrodes, at least one of which is included in said circuit, and periodically operating means for varying the potential applied to another of said electrodes for transforming said current into a wavy modality of electro-physiotherapy, and current reversing means interposed between said thermionic device and output terminals controlled by said periodically operating means.

12. An electro-therapeutic apparatus, including in combination, output terminals, a source of current, means including a circuit interconnecting said source and terminals having therein a single thermionic device having a plurality of electrodes, at least one of which is included in said circuit, and periodically operating means for varying the potential applied to another of said electrodes for transforming said current into

a wavy modality of electro-physiotherapy, and current reversing means including switch means and a relay controlled by said periodically operating means interposed between said thermionic device and the output terminals.

13. An electro-therapeutic apparatus, including in combination, output terminals, a source of alternating current, and means connected to said source for transforming the current into sub-sources of galvanic, pulsating direct, and oscillatory modalities of electro-physiotherapy, and means interposed between said sub-sources and output terminals adapted selectively to be rendered effective to transform said modalities into wavy modalities, and single selector means manually operable into a plurality of positions for supplying said output terminals with current directly from said sub-sources or through said transforming means, said selector means comprising three switches, one adapted to control the connection of the output terminals to the sub-sources, and a second and third to control the effectiveness of the means for transforming the selected sub-source into a wavy modality.

14. An electro-therapeutic apparatus, including in combination, output terminals, a source of alternating current, and means connected to said source for transforming the current into sub-sources of galvanic, pulsating direct, and oscillatory modalities of electro-physiotherapy, and means interposed between said sub-sources and output terminals adapted selectively to be rendered effective to transform said modalities into wavy modalities, reversing means adapted selectively to be connected between said last-mentioned means and the output terminals for transforming said wavy modalities into sinusoidal wavy modalities, and single selector means manually operable into a plurality of positions for supplying said output terminals with current directly from said sub-sources, through said first-mentioned transforming means or through both said transforming and reversing means, said switch means comprising four switches, one adapted to control the connection of the output terminals to the sub-sources, a second and third to control the effectiveness of the means for transforming the selected sub-source into a wavy modality, and a fourth for controlling the effectiveness of the reversing means.

15. An electro-therapeutic apparatus, including in combination, output terminals, a source of galvanic current, means including circuit connections and a single thermionic device having an electrode the potential of which is adapted to be periodically varied for transforming the galvanic current into a galvanic wave modality, thermionic means for periodically varying the potential applied to said electrode, and a single manually operable selector means so constructed and arranged with respect to said output terminals, device, thermionic means and circuit connections that it can be operated into one position to condition the apparatus for supplying galvanic current to the output terminals and render ineffective the thermionic means and into a second position to render effective said thermionic means, thereby to condition the apparatus for supplying a galvanic wave modality to the output terminals, said selector means comprising a single switch blade for controlling the effectiveness of the thermionic means.

16. In combination, a relay, means for nor-

normally supplying said relay with current insufficient to operate but sufficient to maintain the same in operated position when it is once operated, and means operable selectively to increase or to decrease the current normally flowing through said relay for controlling the operation thereof, said last mentioned means including a condenser adapted periodically to be discharged through said relay and alternately to be charged in such manner that the discharge temporarily increases or decreases the flow of current through the relay, and a periodically operating relay for controlling the charging and discharging of said condenser.

17. An electro-therapeutic apparatus, including in combination, output terminals, a source of current, means including a circuit interconnecting said source and terminals having therein thermionic means of the type having an electrode the potential of which is adapted to be varied to control the conductivity thereof, periodically operating means for varying the potential applied to said electrode for transforming said current into a wavy modality of electro-physiotherapy, and current reversing means interposed between said thermionic means and the output terminals, said last-mentioned means including a first relay controlling circuit connections to the output terminals, a second relay controlled by said periodically operating means, means normally supplying said first-mentioned relay with current insufficient to operate but sufficient to maintain the same in operated position when it is once operated, and means controlled by said second-mentioned relay for periodically increasing or decreasing the current flowing through said first-mentioned relay sufficiently to operate and return the same to non-operated position.

18. An electro-therapeutic apparatus, including in combination, output terminals, a source of current, means including a circuit interconnecting said source and terminals having therein thermionic means of the type having an electrode the potential of which is adapted to be varied to control the conductivity thereof, periodically operating means for varying the potential applied to said electrode between predetermined limits for transforming said current into a wavy modality of electro-physiotherapy, one of said limits having a value such that the current is reduced to substantially zero, and current reversing means interposed between said thermionic means and the output terminals, said last-mentioned means including a first relay controlling circuit connections to the output terminals, a second relay controlled by said periodically operating means adapted to be energized when said current is substantially zero, means normally supplying said first mentioned relay with current insufficient to operate but sufficient to maintain the same in operated position when it is once operated, a condenser, sources of positive and negative potential, and switch means conjointly controlled by said relays for alternately connecting said condenser to said sources and discharging said condenser through said first relay, the discharge being effected upon each energization of said second relay, whereby the current reversals are effected when the current supplied to the output terminals is substantially zero.

19. An electro-therapeutic apparatus, including in combination, output terminals, a source of current and means interconnecting said source and terminals for transforming said current into a wavy modality of electro-physiotherapy, said means including a circuit interconnecting said source and terminals, a single thermionic device in said circuit having a control electrode, and means including a periodically operating thermionic tube operating independently of said device for varying the potential applied to said control electrode.

20. In combination, a relay, means including a direct current circuit for normally supplying said relay with current insufficient to operate but sufficient to maintain the same in operated position when it is once operated, and means normally disconnected from the relay operable periodically and alternately to supply said relay with a current charge of one polarity to increase momentarily the current flowing through said relay for operating it and to supply said relay with a current charge of an opposite polarity to decrease momentarily the current normally flowing through said relay for effecting return thereof to its non-operated position, whereby said relay is periodically operated between its operated and non-operated positions.

21. In combination, a relay, means including a direct current circuit for normally supplying said relay with current insufficient to operate but sufficient to maintain said relay in operated position when it is once operated, and means operable selectively to supply said relay with an electric charge of one polarity for momentarily increasing the normal current flow through said relay for operating said relay to its operated position and with an electric charge of an opposite polarity for momentarily decreasing the normal current flow through said relay for returning said relay from its operated position, said last mentioned means including a second circuit normally disconnected from said first mentioned circuit.

22. In combination, a relay, means including a direct current circuit for normally supplying said relay with current insufficient to operate but sufficient to maintain said relay in its operated position when it is once operated, and means operable selectively to supply said relay with an electric charge of one polarity for momentarily increasing the normal current flow through said relay for operating said relay to its operated position and with an electric charge of an opposite polarity for momentarily decreasing the normal current flow through said relay for returning said relay from its operated to its non-operated position, said last mentioned means including a condenser normally disconnected from said relay, means for periodically connecting said condenser to said relay to effect discharge of the condenser therethrough, and means for providing said condenser with charges of opposite polarity each time it is disconnected from the relay, whereby the normal current flow through the relay is alternately increased and decreased to effect operation of said relay between its operated position and non-operated position.

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