

Dec. 5, 1939.

J. H. DOBERT

2,182,223

ELECTROPHYSIOTHERAPEUTICAL APPARATUS

Filed Sept. 5, 1936

2 Sheets-Sheet 1

Fig. 1

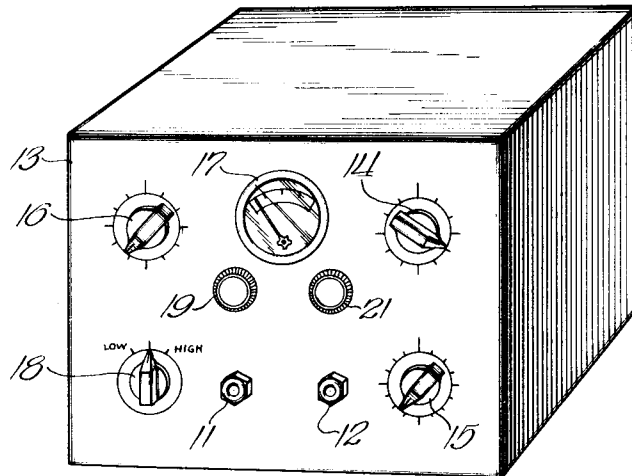


Fig. 2

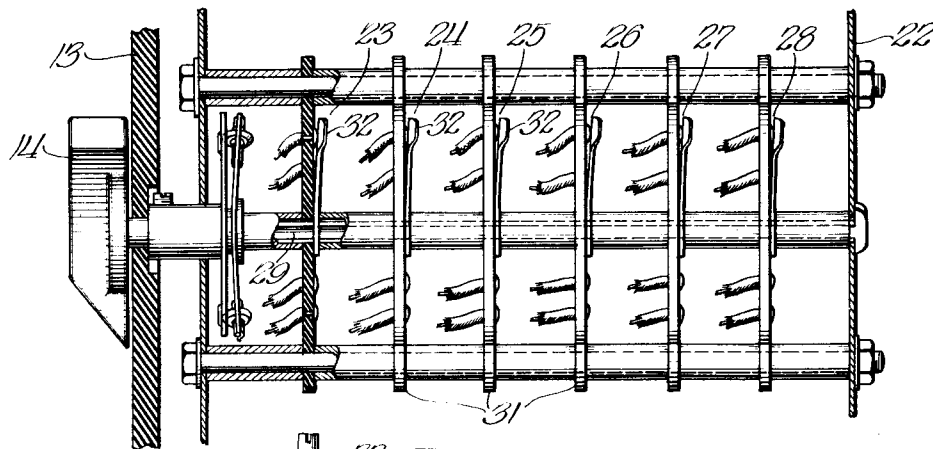
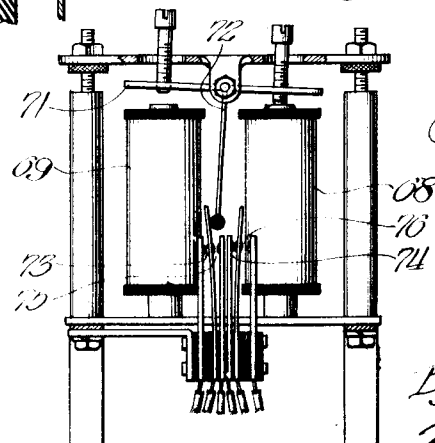


Fig. 3



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2 Sheets-Sheet 2

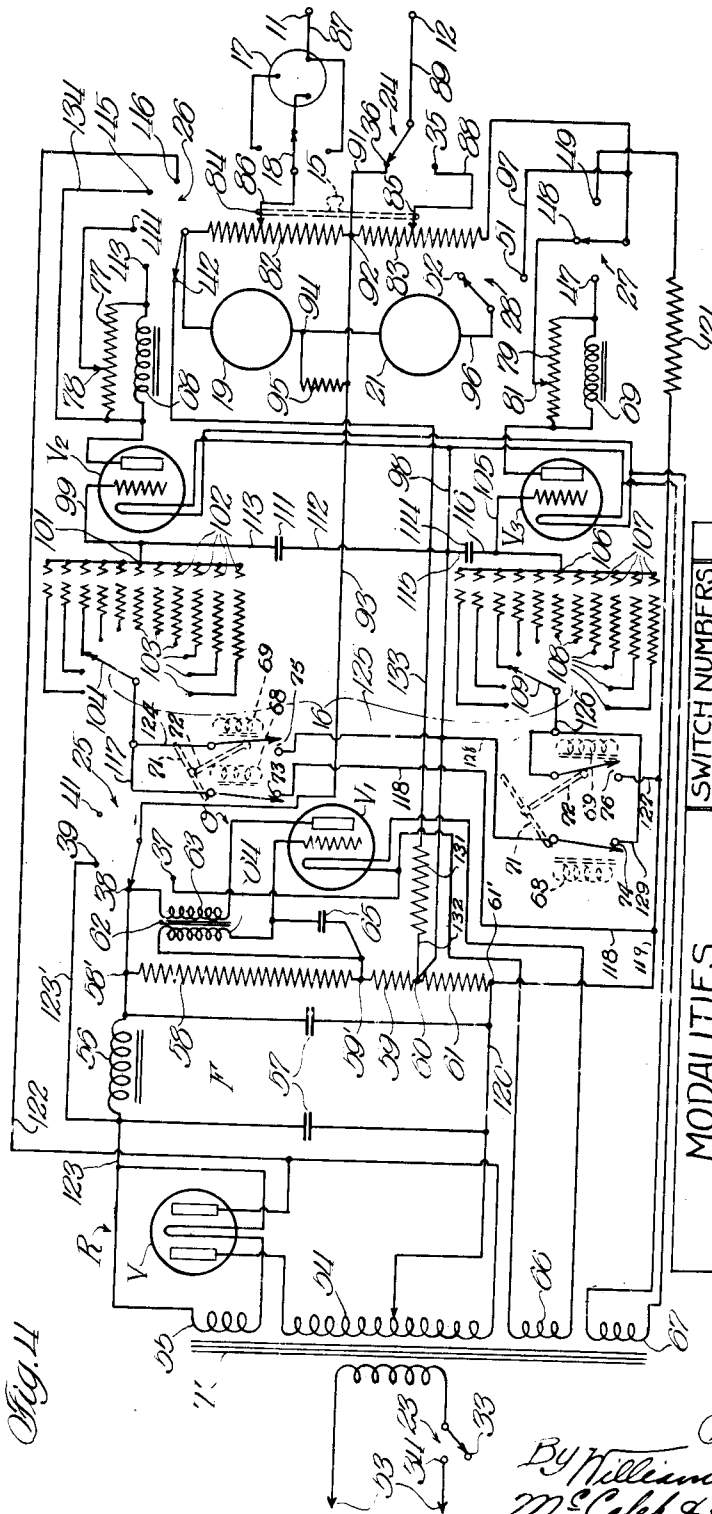


Fig. 11

MODALITIES	SWITCH POSITIONS									
	23	24	25	26	27	28	29	30	31	32
Off Position	33	36	38	42	48	52	53	56	58	62
a Galvanic	34	36	38	42	48	52	53	56	58	62
b Galvanic Wave	34	36	38	42	48	52	53	56	58	62
c Slow Sinusoidal	34	35	38	44	48	51	53	56	58	62
d Pulsating Direct Current	34	36	39	45	48	52	53	56	58	62
e Pulsating Direct Current Wave	34	36	39	44	48	52	53	56	58	62
f Pulsating Sinusoidal Wave	34	35	39	44	48	51	53	56	58	62
g Oscillating Current	34	36	37	45	47	52	53	56	58	62
h Oscillating Wave	34	36	37	44	47	52	53	56	58	62
i Oscillating Sinusoidal Wave	34	35	37	44	47	51	53	56	58	62
j Alternating Current	34	35	41	46	49	51	53	56	58	62

Fig. 5

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UNITED STATES PATENT OFFICE

2,182,223

ELECTROPHYSIOTHERAPEUTICAL
APPARATUS

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Application September 5, 1936, Serial No. 99,543

15 Claims. (Cl. 128—420)

This invention relates in general to electro-physiotherapeutical apparatus, and has more particular reference to multi-form energy supply sources for supplying various modalities of electrophysiotherapy to patients.

The invention has as an object, the provision of a novel low voltage multi-wave apparatus which at the will of an operator, and by the manipulation of simple controls, will produce galvanic current for its thermal and chemical effects, sinusoidal current for muscular stimulation and action, and various modifications of either galvanic or sinusoidal currents and combinations thereof for use in electrotherapy.

Another object of the invention is the provision of such therapeutical apparatus which may be aptly described as thermionic as distinguished from electrotherapeutic apparatus employing vibrating or other mechanical devices for generating a desired modality, or for converting current of a usual or predetermined wave form into current of a desired wave form, whereby to obtain substantially noiseless operation, a minimum of maintenance, and a generally simplified and compact multi-wave apparatus.

Other objects of the invention will be apparent from the following description and from the accompanying drawings, in which similar characters of reference indicate similar parts throughout the several views.

Referring to the drawings:

Fig. 1 is a perspective view of an electrophysiotherapeutic apparatus embodying the features of the invention;

Fig. 2 is a detailed side view, partially in section, of a suitable selector to select the desired modality produced by the apparatus shown in Fig. 1;

Fig. 3 is an elevational view, partially in section, of a suitable relay employed as a control means in the novel apparatus;

Fig. 4 is a schematic wiring diagram of the apparatus shown in Fig. 1; and

Fig. 5 is a schedule of the modalities and the corresponding positions of the selector for producing the same.

As illustrated in the drawings, a multi-wave electrophysiotherapeutic apparatus for accomplishing the foregoing objects may be provided with a suitable casing or housing having a pair of sockets 11 and 12, or other suitable patient's or output terminals, which are electrically connectible to suitable applicators, not shown. The terminals 11 and 12 may be carried at some convenient location about the casing, for example,

by a control panel 13 at one side of the casing.

The control panel 13 is adapted to carry the various control and indicating devices for the multi-wave apparatus in the casing, including selector operating means 14 operable to select the desired modality to be supplied to the patient's terminals 11 and 12, voltage control means 15 for varying the voltage applied to the sockets 11 and 12, frequency control means 16 for varying the frequency of the current variations employed in certain treatments, a multi-scale meter 17 for indicating the current supplied to the patient's terminals, a multi-point switch 18 for switching to the desired scale of the meter 17, and a pair of lights or other suitable means 19 and 21, for indicating the polarity and frequency of the output current.

Inside the casing, a selector is employed which is operatively connected with the selector operating means 14 to facilitate selecting the desired modality. Various types of selector may be employed for that purpose, a suitable type being a well known gang switch illustrated in Fig. 2. While the gang switch itself forms no part of the invention, it might be well by way of explanation, to point out briefly that it comprises a framework 22 which carries a plurality of spaced multi-point switches 23, 24, 25, 26, 27, and 28, and a switch operating shaft 29 common to all of the switches and journaled in the framework 22. The shaft 29 extends through the control panel 13 for operable connection with the selector operating means 14. Each of those switches includes a stationary contact carrying member 31 suitably fixed on stationary members of the framework, and a movable contact member 32 fixed on to rotate with the shaft 29.

Each contact carrying member 31 has suitably secured thereon a plurality of stationary contacts arranged concentrically about the shaft 29 for electrical contact with the corresponding movable contact member 32 as the shaft is rotated from the selector operating means 14. The stationary contacts of each contact carrying member 31 are electrically grouped by electrical connections whereby, as shown in Fig. 4, the switch 23 is an "off and on" switch provided with switch points or contacts 33 and 34; the switch 24 is provided with switch points or contacts 35 and 36; the switch 25 includes switch points or contacts 37, 38, 39, and 41; the switch 26 has switch points or contacts 42, 43, 44, 45, and 46; the switch 27 comprises switch points or contacts 47, 48, and 49, and the switch 28 is an "off and on" switch with switch points or contacts 51 and 52.

The selector gang switch is adapted selectively to make and break electrical circuits which, as diagrammatically shown at 53 in Fig. 4, may have a common source of electrical energy of, for example, 60 cycle alternating current for energizing the primary winding of a suitable transformer T, and which are adapted to convert the supply energy from the source 53 into the desired types of currents at the proper voltages, or into the desired modalities. The transformer T is provided with a secondary winding 54. That secondary winding, a suitable rectifier R, an electrical filter F, and an oscillator O, are arranged electrically as sources of alternating current, rectified or pulsating current, galvanic or rectified and filtered current, and oscillating current, respectively. The rectifier R includes a thermionic tube V, the filament of which is heated or energized from a secondary winding 55 of the transformer T, and which is adapted to rectify the current from the secondary transformer winding 54. The filter F is electrically connected across the output of the rectifier R, for smoothing the pulsations out of the rectified current, and includes a "choke" or inductance coil 56 and a pair of condensers 57.

Connected across the output side of the filter F, are series connected resistors 58, 59, and 61, and the oscillator O, the resistor 58 having terminals 58' and 59', the resistor 59 having terminals 59' and 60, and the resistor 61 having terminals 60 and 61'. The oscillator O includes a thermionic tube V₁ with a coupling transformer 62 having its primary winding 63 connected between the plate electrode of the tube V₁ and the contact 38 of the switch 25, and its secondary winding 64 connected to the grid or control electrode of the tube V₁ and to the terminal 59'. The secondary winding 64 is shunted by a condenser 65 and the filament of the tube V₁ is heated or energized by a secondary winding 66 of the transformer T.

The transformer T may be provided with another secondary winding 67 for heating or energizing the filaments of thermionic tubes V₂ and V₃ which serve as thermionic resistors in the production of modalities having certain wavy characteristics. The tubes V₂ and V₃ are associated with a relay preferably of the polarized type shown in Figs. 3 and 4, and having coils 68 and 69, a pivoted armature 71, a contact operating member 72 operatively connected to the armature 71, and normally closed contacts 73 and 74 and normally open contacts 75 and 76. A coil 68 is connected in parallel with a variable resistance 77 and between the plate electrode of the tube V₂ and the contact 43 of the switch 26, the resistor 77 having a movable resistance varying member 78 connected to the contact 44 of that switch.

Like the coil 68, the coil 69 of the relay is connected in parallel with a variable resistance 79 having a movable resistance varying member 81. The parallel connected coil 69 and resistance 79 are connected between the plate electrode of the tube V₃ and the contact 47 of switch 27 and the resistance varying member 81 is connected to the contact 48 of that switch.

Between the movable contact members 32 of the switches 26 and 27 are connected resistors 82 and 83 having resistance varying members 84 and 85, respectively, operable by the voltage control means 15 and serving with the resistor varying members, as voltage dividers for varying the voltage applied across the patient's terminals 11

and 12. The resistance varying member 84 is electrically connected by a conductor 86 to the movable member of the multi-point switch 18. That switch 18, as shown in Fig. 4, is provided with a plurality of contacts that are electrically connected with the multi-scale current meter 17 which in turn is electrically connected by a conductor 87 to the patient's terminal 11. The contacts of the switch 18 are selectively engageable by the movable switch member for selecting the appropriate scale of the meter and connecting the meter in series with the resistance varying member 84 and the patient's terminal 11, or for short circuiting the meter as desired.

The resistance varying member 85 is electrically connected by a conductor 88 to the contact 35 of the switch 24, the movable contact member of which is connected by a conductor 89 to the patient's terminal 12. The contact 36 of the switch 24 is connected by a conductor 91 to a terminal 92 between, and connected to, each of the series resistors 82 and 83. That terminal 92 is connected by electrical conducting means 93 to the movable contact member of the switch 25.

The light 19 is connected to the movable contact member of the switch 26 and to a common terminal 94 which is connected through a resistor 95 to the conducting means 93, and which is connected to the light 21. The other terminal of the light 21 is connected by electrical conducting means 96 to the movable contact member of the switch 28. The contact 51 of the switch 28 is connected by a conductor 97 to the movable contact member of the switch 27. Thus, the resistors 82 and 83 and the lights 19 and 21 are electrically arranged in parallelism.

In order to complete the plate circuits of the tubes V₂ and V₃, the filament of each tube is connected by electrical conducting means 98 to the terminal 60 between the resistors 59 and 61. For controlling the current flow in those plate circuits, the grid or control electrode of the tube V₂ is connected by a conductor 99 to a common terminal 101 of a bank or plurality of resistors 102 having their other terminals respectively connected to a plurality of contacts 103 which are selectively engageable by a movable contact member 104 operable by the frequency control means 16. Likewise, the grid or control electrode of the tube V₃ is connected by a conductor 105 to a common terminal 106 of a bank or plurality of resistors 107 having their other terminals respectively connected to a plurality of contacts 108 which are selectively engageable by a movable contact member 109 operable by the frequency control means 16.

A condenser 111 is connected between the conducting means 98 and the conductor 99 by conductors 112 and 113, and a condenser 114 is connected by conductors 115 and 116 between the conducting means 98 and the conductor 105. The movable contact member 104 is connected by a conductor 117 to one of the normally closed relay contacts 73, the other contact of which is connected by a conductor 118 to a conductor 119 that in turn is connected to a line conductor 120 connecting the center of the secondary transformer winding 54 to the terminal 61'. The conductor 119 extends beyond its connection with the conductor 118 to connection with a resistor 121, the other terminal of which is connected to the contact 49 of the switch 27. The conductors 119 and 120 serve as a return or negative line conductor for either or both positive line conductors 122 and 123 extending respectively

from one end terminal of the transformer winding 54 to the contact 46 of the switch 26, and from the output of the rectifier R to the input side of the filter F. A conductor 123' connects the line conductor 123 with the contact 39 of the switch 25.

The conductor 117 is connected by a conductor 124 to one of the normally open relay contacts 75, the other contact of which is connected by a conductor 125 to the conducting means 98. The movable contact member 109 is connected by a conductor 126 to one of the normally open relay contacts 76, the other contact of which is connected by a conductor 127 to the conductor 119. The normally closed relay contacts 74 are connected by conductors 128 and 129 between the conducting means 98 and conductor 126.

A resistor 131 is connected by conductors 132 and 133 between the terminal 60 and the contact 42 of the switch 26. The conductor 134 connected at one end to the contact 45 of that switch, and at its other end to a point between the plate of the tube V₂ and the relay coil 68, may be employed to open circuit the parallel connected coil 68 and resistor 77 in the production of certain modalities.

As shown in the wiring diagram of Fig. 4, the selector comprising the switches 23 to 28, inclusive, is in the "off" position, in which, as will be seen by reference to the schedule constituting Fig. 5, the movable switch member of the switch 23 is in engagement with the contact 33 which is the "off" or open position for that switch. Hence, no energy is being supplied to the apparatus. The other contact positions of the various switches 23 to 28 in the selector, and the respective modalities resulting therefrom, are shown from (a) to (j), inclusive, in Fig. 5, and the circuits for producing such modalities will now be traced.

(a) Galvanic

By turning the selector operating means 14 through a predetermined distance, the switches 23 to 28 of the selector may be set in the positions indicated by a in Fig. 5. Such manipulation of the selector operating means completes a circuit which includes the secondary transformer winding 54, the rectifier R, and the filter F, thus impressing a rectified and filtered or substantially constant unidirectional voltage across the series resistors 58, 59, and 61 connected across the output side of the filter. A portion of that constant voltage is employed to energize a circuit extending from the terminal 58' through the contact 38 and movable member of the switch 25, the conductor 93, the terminal 92, the resistor 82, the light 19 and resistor 95 in parallel with the resistor 82, the contact 42 and movable member of the switch 26, the conductor 133, the resistor 131, and back by way of the conductor 132. Thus a substantially constant voltage is impressed across the parallel connected light 19 and resistor 82, causing the light to glow.

A variable portion of that constant voltage may be impressed on the terminals 11 and 12 whereby a patient connected thereto through usual connections will receive a substantially constant unidirectional or galvanic current. The applicator circuit thus includes the resistance varying member or voltage divider 54 operable by the voltage control means 15, the conductor 86, the switch 18 for selecting the appropriate terminal of the current meter 17, the meter 17 or its short circuiting terminal, and the con-

ductor 87 to the patient's terminal 11; and the terminal 92, the conductor 91, the contact 36 and movable member of the switch 24, and the conductor 89 to the patient's terminal 12.

(b) Galvanic wave

This modality is obtained from a pulsating unidirectional voltage of relatively low frequency. In order to obtain this modality the selector operating means 14 is manipulated to set the switches 23 to 28 in the positions indicated at b in Fig. 5. Thus a rectified and filtered or substantially constant voltage is impressed across the series resistors 58, 59, and 61 as described above in connection with the modality referred to as galvanic. A portion of that voltage is employed to charge the condensers 111 and 114 alternately, depending upon whether the relay contacts 73 or the relay contacts 76 are closed. The charging circuit for those condensers extends from the terminals 60 and 61' of the resistor 61 and includes the conductor 119 and either the conductor 118, the relay contacts 73, the conductor 117, the movable contact member 104, the selected contact 103 and resistor 102, the common terminal 101, the conductor 113, the condenser 111, the conductor 112 and the return conductor 98, or the conductor 127, the relay contacts 76, the conductor 126, the movable contact member 109, the selected contact 108 and resistor 107, the common terminal 106, the conductor 116, the condenser 114, the conductor 115, and the return conductor 98.

Thus, the condenser 111 may be charged when the relay contacts 73 are closed and the condenser 114 may be charged when the relay contacts 76 are closed. A discharge circuit is provided for each of the condensers 111 and 114. The discharge circuit for the former extends from one terminal of the condenser 111 to the common terminal 101 by way of the conductor 113, and therefrom through the selected resistor 102 and contact 103, the movable contact member 104, the conductor 117, the conductor 124, the relay contacts 75, and back to the other terminal of the condenser 111 by way of the conductors 125, 98, and 112. The discharge circuit for the condenser 114 includes the conductor 116 connected to one terminal of that condenser, the common terminal 106, the selected resistor 107 and contact 108, the movable contact 109, the conductor 126, the conductor 129, the relay contacts 74, and the conductors 128, 98, and 115.

It will be understood that when the relay coil 68 is energized the relay contacts 73 are closed (charging position for the condenser 111), and the relay contacts 75 are open. At that time the relay contacts 74 are closed (the discharging position for the condenser 114), and the relay contacts 76 are open. When the relay coil 69 is energized, the relay contacts 73 are open, the contacts 75 are closed (the discharging position for the condenser 111), the contacts 74 are open, and the contacts 76 are closed (the charging position for the condenser 114).

As will be presently described, the relay coils 68 and 69 are alternately energized and alternately deenergized, whereby the relay contacts 73 and 76 are operated for charging the condenser 111 while the condenser 114 is discharging, and for discharging the condenser 111 while the condenser 114 is charging. As will be seen by reference to Fig. 4, the grid or control electrode of the tube V₂ is connected to the charging

and discharging circuits of the condenser 111 at the common terminal 101 of the resistor 102 by the conductor 99. Likewise, the grid or control electrode of the tube V₃ is connected to the charging and discharging circuits of the condenser 114 at the common terminal 106 of the resistors 107 by the conductor 105. In that manner, a pulsating voltage may be impressed on the grids of the tubes V₂ and V₃ alternately, and the rate or frequency of those pulsations may be varied by varying the charging and discharging rates of the condensers 111 and 114. That is accomplished by the operation of the frequency control means 16 for adjusting the movable contact members 104 and 109 to select the resistors 102, 107, respectively, in each bank, which will provide the desired frequency.

The pulsating voltage on the grid or control electrode of the tube V₂ results in a pulsating current in the plate circuit of that tube which begins at the terminal 58' and includes the contact 38 and the movable switch member of the switch 25, the conductor 93, the resistor 95 and the light 19, the resistor 82 in parallel with the resistor 95 and the light 19, the movable member and the contact 44 of the switch 26, the resistance varying member 78, the parallel connected resistance 77 and relay coil 68, the plate and filament of the tube V₂, and return by way of the conductor 98 to the terminal 60 between the resistors 59 and 61.

In thus producing a pulsating current in the plate circuit of the tube V₂, the light 19 is caused to flicker at the frequency of the pulsations and the pulsating voltage across the resistor 82 is wholly or partially impressed on the patient's terminals 11 and 12 by the connections from the resistance varying member or voltage divider 84 to the conductor 86, the multi-point switch 18, and from that switch to the appropriate terminal of the current meter 17, the conductor 87 and the terminal 11; and by the connections from the terminal 92 to the conductor 91, the contact 36 and the movable switch member of the switch 24, the conductor 89 and the terminal 12.

While that pulsating current in the plate circuit of the tube V₂ during each cycle is increasing, it energizes the relay coil 68 which therefore tends to hold the relay contacts 73 and 74 closed for charging the condenser 111 and for discharging the condenser 114, respectively. As the charge of the condenser 111 increases during each cycle the plate-to-filament resistance of the tube V₂ increases, which causes the current in the plate circuit of that tube, and hence the current in the patient's circuit to decrease. Meanwhile, due to the increasing resistance of the plate circuit of the tube V₂, the current in the plate circuit of the tube V₃ will be increasing, since that latter circuit is in parallel with the former circuit. The plate circuit of the tube V₃ for the modality under discussion, extends from the terminal 58' to the contact 38 of the switch 25, the movable member of that switch, the conductor 93, the terminal 92, the resistor 83, the contact 48, and movable switch member of the switch 27, the resistance varying member 81, the parallel connected resistance 79 and relay coil 69, the plate and filament of the tube V₃ and the return conductor 98.

It will be observed for this modality that the switch 28 is open so that the light 21 is not energized, and that the movable switch member of the switch 24 is engaging the contact 36 so that the voltage across the resistor 83 is not impressed

on the patient's terminals. As the current in the plate circuit of the tube V₂ decreases, and as the current in the plate circuit of the tube V₃ increases, the relay coils 68 and 69 become deenergized and energized respectively so that the relay contacts 75 close, permitting the discharge of the condenser 111, and the relay contacts 76 close, permitting the charging of the condenser 114, the other relay contacts 73 and 74 being opened at this time.

As the condenser 111 discharges, the plate-to-filament resistance of the tube V₂ decreases, and as the charge of the condenser 114 increases, the plate-to-filament resistance of the tube V₃ increases. The plate current of the tube V₂ therefore will increase and the plate current of the tube V₃ will decrease again, causing the relay coil 68 to be energized, and causing the deenergization of the relay coil 69 whereby to return the relay contacts 73 to 76, inclusive, to the respective positions shown in Fig. 4. That cycle will be repeated so that the voltage across the resistance 82 will be of constant polarity and pulsating at a frequency which is variable in accordance with the particular resistance 102, 107 selected, and which will be visibly indicated by the flickering of the light 19.

(c) Slow sinusoidal

This modality is sometimes called reverse polarity galvanic wave, and results from an alternating voltage of relatively low frequency. In manipulating the selector means 14 to obtain this modality as indicated at c in Fig. 5, the switches 23, 25, 26, and 27 are set as in the preceding modality; the movable switch member of the switch 24 is moved into engagement with the contact 35; and the movable switch member of the switch 28 is moved to engagement with the contact 51. Thus the voltage impressed across the resistor 83, as well as that impressed across the resistor 82, is divided and impressed on the patient's terminals 11 and 12 when the voltage control means 15 is operated. The tubes V₂ and V₃, the relay coils 68 and 69, the relay contacts 73, 74, 75, and 76, the resistors 102 and 107, and the condensers 111 and 114 operate as described above in connection with galvanic wave, and since the voltage across the resistor 83 is of opposite polarity from that across the resistor 82, the resulting current wave will include successive waves alternating in polarity. The lights 19 and 21 will in this case flicker alternately at the frequencies of the current waves of the respective polarities, whereby to indicate the frequency of the positive waves, the frequency of the negative waves, and hence the polarity of the waves.

(d) Pulsating direct current

This modality is obtained by manipulating the selector operating means 14 to set the switches 23 to 28, inclusive, in the positions indicated at d in Fig. 5, and results from a voltage of constant polarity pulsating relatively rapidly as compared with the pulsations of galvanic wave.

For this modality, the pulsating or unfiltered output of the rectifier R is impressed on the line conductors 120 and 123'. The line conductor 120 is connected to the terminal 61' of the resistor 61. The terminal 60 of that resistor 61 is connected to the opposite side of the output of the filter F through the resistors 59 and 58 and to the conductor 98. The line conductor 123' is connected to the conductor 93 by way of the con-

tact 39 and the movable switch member of the switch 25.

The plate circuits of the tubes V₂ and V₃ are connected in parallel across the conductors 93 and 98 as in the modality described above as galvanic wave, but since the movable switch member of the switch 26 is in engagement with the contact 45 the conductor 134 open circuits the parallel connected resistance 77 and relay coil 68. During the operation of the apparatus for this modality, therefore, the relay coil 68 will be de-energized and the relay coil 69 will be energized, with the result that the relay contacts 75 and 76 will be continuously closed and the relay contacts 73 and 74 will be continuously open.

With the relay contacts 75 closed, the pulsating voltage of constant or unidirectional polarity on the conductor 98 is impressed on the grid or control electrode of the tube V₂ by way of the conductor 125, those contacts 75, the conductor 124, the conductor 117, the movable contact member 104, the selector contact 103 and resistor 102, the common terminal 101, and the conductor 99. Thus the pulsating potential difference between the conductors 93 and 98 will result in a pulsating current of constant polarity from the conductor 93 through the resistor 82, the resistor 95 and the light 19 in parallel with the resistor 82, the contact 45 and movable member of the switch 26, the conductor 134, the plate and filament of the tube V₂, and back by way of the conductor 98. The light 19 will therefore flicker at the frequency of the pulsations.

With the relay contacts 76 closed the condenser 114 is charged in the charging circuit already described. Thus the plate-to-filament resistance of the tube V₃ is relatively great so that a relatively small current will flow from the conductor 93 through the resistor 83, the contact 48 and the movable member of the switch 27, the resistance varying member 81, the parallel connected resistance 79 and relay coil 69, the plate and filament of the tube V₃, and back by way of the conductor 98. That current will, however, be sufficient to maintain the relay coil 69 energized to hold the relay contacts 75 and 76 closed and the relay contacts 73 and 74 open. The switch 28 being open, the light 21 will not be energized.

Since the movable member of the switch 24 is for this modality in engagement with the contact 36 the potential drop across the resistor 83 will not be applied to the terminals 11 and 12. All, or a portion of the potential drop across the resistor 82, depending upon the position of the variable member 84, will, however, be impressed on those terminals through the connections already described. Thus a voltage of constant polarity, pulsating relatively rapidly, is impressed on the patient's terminals 11 and 12 for producing the modality under discussion.

(e) Pulsating direct current wave

For the positions of the switches 23 to 28, inclusive, reference is made to e in Fig. 5. This modality results from a relatively rapidly pulsating voltage of constant polarity, which gradually increases to a maximum, and gradually decreases to a minimum at a frequency or periodicity less than that of the pulsations. In other words, this modality may be considered as a combination of galvanic wave and pulsating direct current. The circuit differs from that just described under pulsating direct current, only in that the movable member of the switch 26 en-

gages the contact 44 whereby to include the parallel connected variable resistance 77 and the relay coil 68 in the plate circuit of the tube V₂.

As thus connected, the relay coils 68 and 69 will alternately open and close the relay contacts 73 and 74, and the relay contacts 75 and 76 respectively. As described above in connection with the galvanic wave, such operations of the relay contacts 73 to 76, inclusive, result in a relatively low frequency pulsating voltage being applied to the resistor 82. Since, however, the voltage applied to the grid or control electrode of the tube V₂ is derived from the same source as that described under pulsating direct current, the voltage applied to the resistor 82 in the plate circuit of that tube is also pulsating relatively rapidly. The resultant voltage effect is then a series of relatively rapid pulsations which gradually increase in amplitude to a maximum, and then gradually decrease in amplitude to a minimum, the rate of increase and decrease in amplitude being controlled by the frequency control means 16 as described above.

All, or a portion of that resultant voltage across the resistor 82, is impressed on the patient's terminals 11 and 12 in the manner described under pulsating direct current for producing the modality known as pulsating direct current wave.

(f) Pulsating sinusoidal wave

For the positions of the switches 23 to 28, inclusive, to produce this modality, see f in Fig. 5. This modality is the result of a relatively rapidly pulsating voltage which, at a frequency less than that of the pulsations, gradually increases in amplitude to a maximum and gradually decreases to a minimum, reverses polarity, and gradually increases to a maximum and gradually decreases to a minimum at the reverse polarity. In other words, this modality may be considered as a combination of slow sinusoidal and pulsating direct current. The circuit differs from that just described under pulsating direct current wave, in that the movable member of the switch 24 is in engagement with the contact 35 and the movable member of the switch 28 is in engagement with the contact 51.

Thus, as in slow sinusoidal, the voltage across the resistor 82 will cooperate with the voltage of opposite polarity across the resistor 83 to produce an alternating voltage of relatively low frequency. Since, however, the voltage applied to the grids or control electrodes of the tubes V₂ and V₃ is derived from the same source as that described under pulsating direct current, the voltages applied to the resistors 82 and 83 in the plate circuits of the tubes V₂ and V₃ are also pulsating relatively rapidly. The resultant voltage effect is therefore a plurality of series of relatively rapid pulsations of one polarity, which gradually increase in amplitude to a maximum and then decrease in amplitude to a minimum, and which alternate with a plurality of series of such pulsations at the opposite polarity, that gradually increase in amplitude to a maximum, and then gradually decrease in amplitude to a minimum. The rate of increase and decrease in amplitude of the resultant voltage effect across the resistors 82 and 83 is controlled by the frequency control means 16 as already described.

In this modality the lights 19 and 21 being respectively in parallel with the resistors 82 and 83, will flicker alternately to indicate the frequency and polarity of the pulsations. All or a portion of the resultant voltage across the resistors 82 and 83

33 is impressed on the patient's terminals 11 and 12 in the manner described under slow sinusoidal.

(g) *Oscillating current*

5 This modality results from a voltage of constant polarity which oscillates at a frequency that is relatively rapid as compared with the frequency of pulsating direct current. By reference to g in Fig. 5, it will be observed that the circuit made
10 by the switches 23 to 28 for this modality is practically the same as that for pulsating direct current, except that the oscillator O provides the source of energy, since the movable member of the switch 25 is in engagement with the contact
15 37, and except that the parallel connected resistor 79 and relay coil 69 are directly connected in series in the plate circuit of the tube V₃ by virtue of the engagement between the movable switch member and the contact 47 of the switch 27.
20 With the movable member of the switch 25 contacting the switch contact 27, the oscillator O energizes the conductors 93, 98, and 119. As in pulsating direct current, the plate circuits of the tubes V₂ and V₃ are connected in parallel across
25 the conductors 93 and 98; and the movable member of the switch 26 engages the contact 45, thus causing the conductor 134 to short circuit the parallel connected resistance 77 and relay coil 68. During the operation of the apparatus for this
30 modality, therefore, the relay coil 68 will be de-energized and the relay coil 69 will be energized with the result that the relay contacts 75 and 76 will be continuously closed, and the relay contacts 73 and 74 will be continuously open.
35 The grids or control electrodes of the tubes V₂ and V₃ are energized from the conductors 93 and 119 as already described, and therefore the oscillating voltage between the conductors 93 and 98 will cause an oscillating current to flow in the
40 plate circuits of the tubes V₂ and V₃ including the resistors 82 and 83. Due to the fact that the movable member of the switch 24 is in engagement with the contact 36, only the potential drop across the resistor 82 is utilized for energizing the
45 patient's terminals 11 and 12 as explained under pulsating direct current. The voltage across the patient's terminals being derived from that across the resistor 82 caused by the oscillating current therein, will be oscillating. Since the switch 28 is
50 open, the light 21 will not be energized, but the light 19 in parallel with the resistor 82 will flicker at the frequency of oscillations of the current.

(h) *Oscillating wave*

55 The positions of the switches 23 to 28 for this modality are shown at h in Fig. 5. This modality results from a voltage oscillating as in oscillating current described above, and the oscillations are of constant polarity which gradually increase in
60 amplitude to a maximum and then gradually decrease in amplitude to a minimum at a frequency less than the frequency of oscillation. In other words, this modality may be considered as a combination of galvanic wave and oscillating current. The circuit differs from that just described under
65 oscillating current, only in that the movable member of the switch 26 has been moved to engagement with the contact 44 for connecting the parallel connected resistance 77 and relay coil 68 in the plate circuit of the tube V₂.
70 Except for the source of energy, the circuit for this modality is substantially identical with that described under pulsating direct current wave. The current oscillations in the plate circuit of
75 the tube V₂ will therefore gradually increase in

amplitude to a maximum, and thereafter decrease in amplitude to a minimum at a frequency which is variable by the frequency control means 16. The oscillating wave current will produce an oscillating wave voltage drop across the resistor 82
5 and, as in pulsating direct current wave, all or a part of that oscillating wave voltage drop across the resistor 82 is impressed on the patient's terminals for producing oscillating wave. The light 19 is in parallel with the resistor 82 and will
10 therefore flicker at the frequency of oscillations.

(i) *Oscillating sinusoidal wave*

See i in Fig. 5 for the positions of the switches 23 to 28 to produce this modality. This modality
15 results from a voltage oscillating as in oscillating current, and the oscillations gradually increase in amplitude to a maximum and gradually decrease in amplitude to a minimum, reverse polarity, and gradually increase to a maximum and decrease to
20 a minimum amplitude at the reversed polarity. In other words, this modality may be considered as a combination of slow sinusoidal and oscillating current. The circuit differs from that just described for oscillating wave, in the same re-
25 spects that the circuit for pulsating sinusoidal wave differs from that for pulsating direct current wave.

Thus the oscillating voltage impressed on the patient's terminals will have, in addition to the
30 relatively rapid oscillating effects, the sinusoidal characteristics with a periodic reversal of polarity as described above under pulsating sinusoidal wave. The lights 19 and 21 will flicker alternately at the frequencies of the respective polarities to
35 indicate polarity and frequency.

(j) *Alternating current*

The positions of the switches 23 to 28, inclusive, for this modality are shown at j in Fig. 5. To
40 produce this modality, the movable members of the switches 26 and 27, respectively, engage the contacts 46 and 49, whereby to close a circuit from one terminal of the secondary transformer wind-
45 ing 54 to the line conductor 122, the contact 46 and the movable member of the switch 26, the resistor 82, the common terminal 92, the resistor 83, the movable member and the contact 49 of the switch 27, the resistor 121, the conductor 119, and
50 back to the center tap of the secondary transformer winding 54 by way of the conductor 120. Thus the alternating voltage induced in the secondary winding 54 of the transformer T will pro-
55 duce an alternating current in the circuit just traced.

As a result of that alternating current, the volt-
age drop across the resistors 82 and 83 will be alternating. All, or a portion of that alternating
60 voltage drop, may be impressed on the patient's terminals 11 and 12 by operating the voltage control means 15 to adjust the resistance varying
65 members 84 and 85 which are electrically connected to the patient's terminals 11 and 12 respectively in the manner described under slow sinusoidal above. Since the switch 28 is closed, the
70 lights 19 and 21 are in parallel with the resistors 82 and 83 and will therefore flicker alternately at the frequency of the alternating current.

Thus the energy from a conventional source may be electronically, as distinguished from me-
75chanically or electro-mechanically, converted into various modalities for use in physiotherapy, whereby to permit of accurate and reliable control and to secure uniform results at the respective selector positions, and whereby to simplify the

construction, maintenance, and control of electrophysiotherapeutic apparatus for accomplishing such results.

While I have described a preferred embodiment of my invention, many modifications may be made without departing from the spirit of the invention, and I do not wish to be limited to the precise details of construction set forth, but desire to avail myself of all changes within the scope of the appended claims.

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

1. An electrotherapeutic apparatus, comprising a single pair of patient's terminals, a source of alternating current, thermionic means for converting the energy from said source into various wavy modalities of electrophysiotherapy, and selector means for selectively modifying the operation of the thermionic means and thereby selectively applying any of said modalities to said patient's terminals, said means including a condenser for controlling the action of said thermionic means, a relay for effecting the charging and discharging of the condenser, and a variable resistance for controlling the periodic time of the operation of said relay.

2. An electrotherapeutic apparatus, comprising a single pair of patient's terminals, a source of alternating current, thermionic means for converting the energy from said source into various wavy modalities of electrophysiotherapy, selector means for selectively modifying the operation of the thermionic means and thereby selectively applying any of said modalities to said patient's terminals, said means including a condenser for controlling the potential of a control electrode and thereby the output of said thermionic means, a variable resistance for varying the time required to charge said condenser, and a relay for effecting the charging and discharging of said condenser, and means for indicating the frequency and polarity of the current in the selected modality.

3. An electrotherapeutic apparatus, comprising a source of alternating current, a source of pulsating current, a source of oscillating current, a source of galvanic current, means for converting the currents from said sources into electrophysiotherapeutical modalities known respectively as alternating current, pulsating direct current, oscillating current, and galvanic current, thermionic means for periodically varying the current amplitudes of the last three mentioned modalities to convert them into electrophysiotherapeutical modalities known respectively as pulsating direct current wave and pulsating sinusoidal wave; oscillating wave and oscillating sinusoidal wave; and galvanic wave and slow sinusoidal, and selector means controlling the current sources, the converting means, and said thermionic means for selectively producing the desired modality, said means including a condenser for controlling the potential of a control electrode and thereby the output of said thermionic means, and means for selectively varying the time required to charge and discharge said condenser.

4. An electrotherapeutic apparatus having a single pair of output terminals, comprising a source of alternating current, means for converting energy from said source into the electrophysiotherapeutical modality known as alternating current, thermionic means for converting the energy from said source into the electrophysiotherapeutical modalities known as galvanic; pulsating direct current; and oscillating current,

thermionic means for converting the last mentioned modalities into the modalities respectively known as galvanic wave and slow sinusoidal; pulsating direct current wave and pulsating sinusoidal wave; and oscillating wave and oscillating sinusoidal wave, and means for selectively causing the production of said modalities and applying them to said output terminals, said means including a condenser for controlling the potential applied to a control electrode and thereby the output of said thermionic means, and a relay for controlling the charging and discharging of said condenser.

5. An electrotherapeutic apparatus having a single pair of output terminals, comprising a source of alternating current, means for converting energy from said source into the electrophysiotherapeutical modality known as alternating current, a pair of thermionic means for converting energy from said source into the electrophysiotherapeutical modalities known as galvanic, galvanic wave, slow sinusoidal, pulsating direct current, pulsating direct current wave, pulsating sinusoidal wave, oscillating current, oscillating wave, and oscillating sinusoidal wave, and means for selectively causing the production of said modalities and applying them to said output terminals, said means including a pair of condensers for controlling the potentials applied to control electrodes and thereby the outputs of said thermionic means, and a relay for controlling the charging and discharging of said condensers in alternation.

6. In an electrotherapeutic apparatus having a source of electrical energy and output terminals, an electrical circuit electrically interposed between said source and said terminals for converting the energy from said source into a desired modality, said circuit including a thermionic tube having plate, filament, and control electrodes, a relay coil in series with said plate electrode, a condenser having charging and discharging branch circuits electrically connected with the control electrode of said tube, and contact means in each of said branch circuits and operable by said relay coil for alternately charging and discharging said condenser thereby cyclically varying the amplitude of the voltage applied to said control electrode whereby cyclically to vary the amplitude of the current in said electrical circuit.

7. In an electrotherapeutic apparatus having a source of electrical energy and output terminals, an electrical circuit electrically interposed between said source and said terminals for converting the energy from said source into a desired modality, said circuit including a thermionic tube having plate, filament, and control electrodes, a relay coil in series with said plate electrode, a condenser having charging and discharging branch circuits electrically connected with the control electrode of said tube, and contact means in each of said branch circuits and operable by said relay coil for alternately charging and discharging said condenser thereby cyclically varying the amplitude of the voltage applied to said control electrode whereby cyclically to vary the amplitude of the current in said electrical circuit, and means electrically connected with said condenser for controlling the rate of charging and discharging whereby to control the frequency of the amplitude variations of current in said electrical circuit.

8. In an electrotherapeutic apparatus, the combination with input and output terminals, a plurality of branch circuits interposed between

the input and output terminals for converting electrical energy into a desired modality, a said branch circuit including a thermionic tube having plate, filament, and control electrodes and a relay coil in series with said plate electrode, another said branch circuit being in parallel with the first said branch circuit and including a thermionic tube having plate, filament, and control electrodes and a relay coil in series with the last said plate electrode, a condenser having charging and discharging branch circuits electrically connected with the first said control electrode, another condenser having charging and discharging branch circuits electrically connected with the second said control electrode, and contact means in each of said last mentioned branch circuits and operable by said relay coils for alternately charging and discharging said condensers, thereby cyclically varying the amplitude of the voltages applied to said control electrodes whereby cyclically to vary the amplitude of the current in the parallel branch circuits.

9. In an electrotherapeutic apparatus, the combination with input and output terminals of a plurality of branch circuits interposed between the input and output terminals for converting electrical energy into a desired modality, a said branch circuit including a thermionic tube having plate, filament, and control electrodes and a relay coil in series with said plate electrode, another said branch circuit being in parallel with the first said branch circuit and including a thermionic tube having plate, filament, and control electrodes and a relay coil in series with the last said plate electrode, a condenser having charging and discharging branch circuits electrically connected with the first said control electrode, another condenser having charging and discharging branch circuits electrically connected with the second said control electrode, and contact means in each of said last mentioned branch circuits and operable by said relay coils for alternately charging and discharging said condensers, thereby cyclically varying the amplitude of the voltages applied to said control electrodes whereby cyclically to vary the amplitude of the current in the parallel branch circuits, and means electrically connected with each of said condensers for controlling the rate of charging and discharging whereby to control the frequency of the amplitude variations of current in said parallel branch circuits.

10. An electrotherapeutic apparatus for operation from an alternating current source and comprising a transformer for connection to the source, a current rectifier connected to the transformer, a filter connected to the rectifier, an oscillator connected to the filter, a pair of thermionically controlled current modifiers, a pair of patient's terminals, and a gang selector switch for varying the connections between the transformer, rectifier, filter, oscillator, current modifiers and patient's terminals selectively to deliver to the patient's terminals a steady unidirectional current, a pulsating unidirectional current, a reverse polarity current having a frequency less than the frequency of the source, a pulsating current having a frequency greater than the frequency of the source and an alternating current of the same frequency as the source.

11. An electrotherapeutic apparatus for operation from an alternating current source and comprising a transformer, a rectifier, an oscil-

lator, a pair of patient's terminals, and means for periodically modifying the current delivered from the oscillator to the patient's terminals, said means including a thermionic tube having a grid for controlling the output thereof, a condenser connected to the grid, a relay for periodically charging and discharging the condenser, and a variable resistance for varying the rate at which the condenser is charged.

12. An electrotherapeutic apparatus for operation from an alternating current source and comprising a transformer for connection to the source, a current rectifier, a current filter, an oscillator, a pair of patient's terminals, thermionically controlled means for modifying the current delivered to the patient's terminals from the rectifier, from the filter and from the oscillator, a polarized relay for periodically varying the action of the thermionically controlled means, and a series of simultaneously operable manual switches for selectively controlling the action of the thermionically controlled means and the action of the relay.

13. An electrotherapeutic apparatus for operation from an alternating current source and comprising a transformer for connection to the source, a current rectifier, a filter, an oscillator, a pair of patient's terminals, a plurality of simultaneously actuated switches under manual control for selectively associating the transformer, rectifier, filter and oscillator to produce unidirectional constant and unidirectional pulsating and oscillating current as desired, a pair of thermionic tubes for modifying any current so produced, and means acting periodically to vary cyclically and alternately the modifications produced by the tubes to impress upon the patient's terminals a recurring series of modified current waves.

14. An electrotherapeutic 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 electrophysiotherapy, said means including a circuit interconnecting said source and terminals, thermionic means in said circuit having a control electrode, the potential of which is adapted to be varied to control the conductivity thereof, and automatically and periodically operating means including a relay for varying the potential applied to said electrode, thereby to vary the conductivity of said thermionic means.

15. An electrotherapeutic 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 electrophysiotherapy, said means including a circuit interconnecting said source and terminals, thermionic means in said circuit having a control electrode, the potential of which is adapted to be varied to control the conductivity thereof, a condenser connected to said control electrode, resistors adapted selectively to be placed in circuit with said condenser and control electrode, and periodically operating relay means for alternately charging and discharging said condenser through a selected resistor, thereby cyclically to vary the amplitude of the potential applied to said control electrode and cyclically to vary the amplitude of the current supplied to said output terminals.

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