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THERAPEUTIC APPARATUS

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Fig. 1.

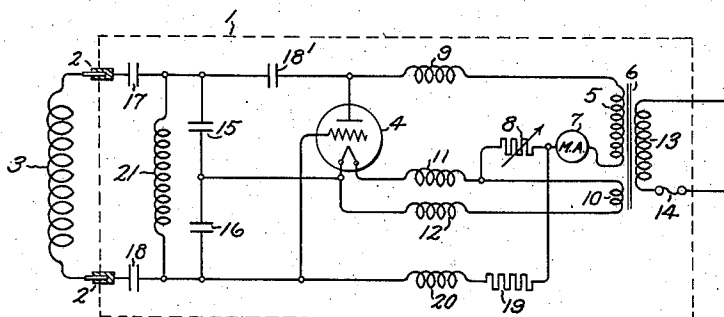
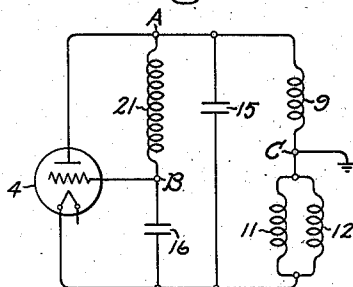


Fig. 2.



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THERAPEUTIC APPARATUS

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5 Claims. (Cl. 250—36)

My invention relates to therapeutic apparatus, and more particularly to that type of therapeutic apparatus adapted for treatment of the human body with high frequency magnetic fields, such as is produced, for example, by a high frequency coil. It relates more particularly to means for energizing the coils used in such equipment with high frequency oscillations.

The use of high frequency magnetic fields for the treatment of certain diseases is well known. In the construction of an oscillation generator for the above purpose it is desirable to obtain a self-contained unit of compact structure which is equipped with safety devices for protecting the patient against high voltages occasioned by a failure in the oscillator circuit. It is further desirable to provide a unit of the above type in which the high frequency field generating coil is disconnectable from the remaining elements of the oscillator circuit whereby it may be easily and quickly applied to the patient and following such application connected to the oscillator. In addition it is often advantageous to employ an oscillator wherein the field generating coil may be disconnected and reconnected to the oscillator without disturbing the operation of the oscillator, or causing injury to the electron discharge device connected in the circuit due to abnormal plate currents.

One form of electron discharge tube oscillator adapted for the above indicated use includes an input circuit, an oscillatory circuit and an anode circuit having a source of high voltage potential connected therein. Usually in this type of circuit a single voltage blocking condenser is connected between the anode circuit and the oscillatory circuit to prevent high voltage from being impressed on the latter circuit. It follows that in the event of a failure, or short-circuiting of the blocking condenser during operation of the oscillator, the high potential included in the anode circuit will be impressed directly upon the elements of the oscillatory circuit. Therefore, in the application specified in which one of the elements of the oscillatory circuit is in close proximity to the body of a patient undergoing treatment, it is desirable to provide a means for limiting the value and duration of the potential which may be applied to the elements of the oscillatory circuit in the event of a failure or short-circuiting of the blocking condenser.

It is therefore an object of my invention to provide in an oscillation generator of the above indicated type means for protecting the oscil-

latory circuit from high voltage occasioned by a short-circuiting of the plate voltage blocking condenser connected between the output and oscillatory circuits of the generator.

In the normal use of high frequency oscillators for the treatment of certain diseases and during the initial application of the high frequency field to the patient, the oscillator is adjusted to produce its maximum output corresponding to a high intensity of the generated field. After a predetermined time has elapsed in which the body of the patient undergoing treatment is heated to a predetermined temperature by the high frequency field, it is necessary gradually to reduce the strength of the applied field to prevent burning of the patient. It will thus be seen that it is desirable to provide a suitable control means whereby the intensity of the field generated by an element of the oscillatory circuit may be easily and smoothly controlled.

Accordingly, an additional object of my invention is to provide control means in the anode circuit of an electron discharge tube oscillator for simultaneously decreasing the potential applied to the anode of the tube and for increasing the grid bias applied to the tube, thereby to control the intensity of the high frequency field developed by the field generating inductance connected in the oscillatory circuit of the oscillator.

From the standpoint of economy of construction it is desirable to construct an oscillator in which a single electron discharge tube is used as the control element. It is necessary to provide in such circuits some means for balancing the high frequency portions thereof with respect to ground. This is by reason of the fact that if the portions of the high frequency oscillatory system which oscillate at opposite potentials with respect to ground are not balanced with respect to ground unequal currents flow from these portions to ground and thence through the natural resistance between true ground and the power supply system of the oscillator back to the cathode of the oscillator. Such currents place a heavy load on the oscillator when it is in operation even though no other output is being drawn from it. On the other hand if opposite sides of the circuit be properly balanced with respect to ground such currents neutralize each other. In accordance with my invention a proper balancing is obtained by inserting inductances in the cathode and anode circuit leads having an inductance ratio such that the terminals of the oscillatory circuit included in the system are

maintained at the same high frequency potential with respect to ground.

Accordingly, a still further object of my invention is to provide an improved electron discharge tube oscillator circuit comprising a single electron discharge tube and having inductances connected respectively in the anode and cathode circuit leads so proportioned in magnitude that the terminals of the oscillatory circuit of the system are maintained at the same high frequency potential with respect to ground during operation of the apparatus.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and the method of operation will best be understood by reference to the following specification taken in connection with the accompanying drawing in which Fig. 1 shows one embodiment of my invention and Fig. 2 illustrates the circuit arrangement of Fig. 1 when high frequency currents are alone considered.

Referring to Fig. 1 of the drawing, I have diagrammatically illustrated the elements of my improved oscillation generator as being contained in a compartment 1 which is provided with suitable outlet connecting means 2 whereby the high frequency field generating coil 3, forming a part of the oscillatory circuit of the oscillator, may be readily disconnected and reconnected in the oscillator circuit.

The oscillator circuit illustrated is of a type well known in the art and includes an input circuit, an anode circuit and an oscillatory circuit, all of which circuits are connected to an electron discharge device 4. The discharge device 4 includes an anode, a cathode and a control grid and is shown as being of the directly heated cathode type although it will be understood that a discharge device of the indirectly heated cathode type may be used with only a slight modification of the circuit. The output, or anode circuit, of the oscillator is connected between the anode and cathode of the discharge device 4 and comprises a source of high voltage alternating potential derived from the secondary 5 of a power supply transformer 6, a milliammeter 7, an adjustable resistance 8 and an inductance coil 9. The cathode of the discharge device 4 is energized from a low voltage winding 10 forming a part of the transformer 6 through a pair of inductance coils 11 and 12 connected in the respective cathode leads. The primary winding 13 of the transformer 6 is arranged to be energized from a suitable source of alternating current (not shown) and one of the circuit leads of the primary winding has inserted therein an overload circuit interrupting device shown as a fuse 14 which is adapted to protect the oscillator against abnormal currents.

The oscillatory circuit of the oscillator includes, in addition to the high frequency field generating inductance 3, a pair of fixed tuning condensers 15 and 16 connected in series across the inductance 3 through a pair of condensers 17 and 18 which function to match the impedance of the oscillatory circuit with the characteristics of the discharge device 4. The oscillatory circuit is connected between the anode and cathode of the discharge device 4, the connection between one terminal of the circuit and the anode including a plate voltage blocking condenser 18' which functions to block the plate voltage from the oscillatory circuit.

The input circuit of the discharge device 4 includes the condenser 16 which forms a part of the oscillatory circuit and which is connected between the control grid and cathode of the discharge device 4. A suitable potential for biasing the control grid with respect to the cathode is derived from the voltage drop across the elements 8 and 11 which are connected in series in the anode circuit. This potential is impressed on the control grid through the circuit lead which includes the grid resistance 19 and the choke inductance 20.

The operation of the above-described circuit is as follows: With alternating current flowing in the primary 13 of the transformer 6 and during each positive half cycle of potential appearing across the secondary 5, the oscillatory circuit including the inductance 3 is energized to oscillate at its natural frequency. A portion of the potential developed across the oscillatory circuit is impressed on the control grid of the discharge device 4 by the condenser 16 and serves to maintain the oscillations in the oscillatory circuit at a stable value, determined by the constants of the oscillatory circuit, until the positive half cycle of potential in the secondary 5 of the transformer 6 is completed. The inductance 3 being connected in the oscillatory circuit and having the oscillatory currents of high frequency flowing therethrough generates a high frequency magnetic field. It will be seen that impulses of high frequency oscillations are generated in the oscillatory circuit and a high frequency field is developed by the inductance 3, the duration of each oscillatory impulse being determined by the frequency of the current flowing in the primary winding 13 of the transformer 6.

In the use of the above described apparatus for electro-therapeutic purposes the inductance 3 is wrapped around or otherwise applied to the body of a human being to be treated. In order that the inductance 3 may be properly placed on and shifted to various portions of the patient's body it is obviously advantageous to be able to disconnect the element 3 from the remaining portions of the circuit without interrupting or otherwise disturbing the operation of the circuit.

In accordance with my invention the above noted operation may be readily performed since a means is provided for stabilizing the operation of the oscillator when the inductance element 3 is removed from the circuit. This means comprises an impedance element shown as an inductance 21 connected in parallel with the oscillatory circuit across the frequency determining condensers 15 and 16.

With the above arrangement and with the oscillator in operation the inductance 3 may be disconnected from the circuit without interrupting or otherwise disturbing the operation thereof. This disconnection of the inductance 3, causes the frequency output of the oscillator to change to a value determined by the single inductance element 21 and the condensers 15 and 16. Otherwise the operation of the oscillator is unchanged and remains the same as is described above. When the inductance element 3 is reinserted in the circuit the frequency of the generated oscillations again returns to the normal operating value.

The inductance element 21 performs an added function in that it protects the discharge device 4 against damage due to abnormal plate current which would otherwise occur if the inductance 3 were inadvertently removed from the circuit

during operation of the oscillator, or if the oscillator were inadvertently connected to the current supply source with the inductance 3 disconnected from the circuit. Thus, during operation of the oscillator and assuming the inductance 21 to be absent from the circuit, if the element 3 were disconnected from the circuit a large portion of the control potential would be removed from the grid of the device 4 and the impedance thereof would accordingly be reduced sufficiently to permit an abnormal current to flow through the tube. However, with the impedance element 21 connected in parallel with the oscillatory circuit the control potential impressed on the grid of the device 4 is substantially unchanged in magnitude by a removal of the element 3 from the circuit. This, of course, means that the current flowing in the anode circuit of the oscillator and through the device 4 is limited in magnitude by the inductance 21 during the intervals when the element 3 is disconnected from the circuit.

A further advantage of connecting the element 21 in parallel with the oscillatory circuit will be observed from an inspection of the circuit arrangement wherein it will be seen that the blocking condenser is the only means insulating the elements of the oscillatory circuit from the high voltage source, included in the anode circuit. In the event of a failure or short-circuiting of this condenser, the high voltage of winding 5 would be impressed directly on the elements of the oscillatory circuit. The magnitude of this voltage might be sufficient to cause a breakdown of the condensers 17 and 18 and a breakdown of the insulation on the inductance 3. It follows that the voltage would be impressed on the body of the patient undergoing treatment, thereby resulting in a severe shock and possible injury to the patient. However, with the element 21 connected in the oscillatory circuit, the grid and anode of discharge device 4 are effectively short-circuited to currents of the power frequency following a failure of the condenser 18'. Such short-circuiting impresses a positive potential on the control grid and thereby permits an abnormal current to flow in the discharge device 4 which causes the overload circuit interrupting device 14 to open and isolate the transformer 6 from its current supply source. In this manner the inductance 3 is protected from the high voltage included in the anode circuit of the device 4.

The provision of the adjustable resistance 8 in the anode circuit of the discharge device 4 for controlling the intensity of the field developed by element 3 forms an important feature of my invention. It will be understood that the intensity of the high frequency field developed is dependent upon the potential difference between the anode and cathode, and further upon the magnitude of the biasing potential supplied to the control grid of the discharge device 4. By connecting the adjustable resistance 8 in the anode circuit in the manner illustrated it serves simultaneously to control the grid bias potential and the anode-cathode potential. Thus, as the value of the resistance 8 is increased to decrease the anode-cathode potential, a simultaneous increase in the grid biasing potential across elements 8 and 11 occurs. The combined effect of simultaneously increasing the grid potential and decreasing the anode-cathode potential is to decrease the intensity of the field developed by the inductance 3. The converse procedure of decreasing the value of resistance 8 included in the

anode circuit thereby to increase the anode-cathode potential and decrease the grid biasing potential of course results in an increase in the strength of the high frequency field developed by the inductance 3. By employing a manually operable rheostat as the adjustable resistance 8 the field developed may be smoothly and easily adjusted to the desired strength.

Another important feature of my invention is the inclusion of the inductances 11 and 12 and the inductance 9 in the anode circuit of the oscillator. These inductances balance the high frequency oscillatory circuit with respect to ground in a manner which will be readily understood by reference to Fig. 2 wherein I have shown the inductances 11 and 12 connected in parallel between the cathode of the device 4 and ground. In like manner the inductance 9 is shown connected to ground. This is an accurate representation of the circuit when high frequency currents are alone considered since the windings of the transformer 6 may be considered as being at ground potential in so far as the high frequency portions of the circuit are concerned. The points A and B represent the terminals of the oscillatory circuit and the high frequency potentials existing between each of these two points and the ground point C must be maintained equal in magnitude if a proper balance of the oscillatory circuit is to be secured. By connecting the inductances 9, 11 and 12 in the circuit in the manner shown and properly proportioning the value of the inductance 9 to the value of the parallel connected inductances 11 and 12 the desired condition of equal voltages between points A, C and points B, C may be readily obtained. The values of the inductances 9, 11, and 12 may be quite small so long as the correct ratio between the values, corresponding to a condition of equal high frequency potentials at the points A and B, is preserved. It will of course be understood that if it is desired to use a discharge device 4 of the indirectly heated cathode type, a single inductance may be substituted for the two inductances 11 and 12 of the circuit illustrated.

By balancing the circuit in the manner described a flow of high frequency energy back into the low frequency current supply source is prevented, thereby minimizing radio interference occasioned by operation of the apparatus and insuring a maximum field intensity output from the inductance 3 for a given power input to the apparatus. Proper balancing of the oscillatory circuit also prevents high frequency potential differences from existing between the element 3 thereof and ground thereby eliminating the possibility of shocks or burns to the operator handling the apparatus, or to the patient undergoing treatment.

While I have shown a particular embodiment of my invention, it will of course be understood that I do not wish to be limited thereto since many modifications in the structure may be made, and I contemplate by the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In combination, an electron discharge device having an anode, a cathode and a control grid, an anode circuit connected between said anode and said cathode, an input circuit connected between said control grid and said cathode, an oscillatory circuit connected between said an-

ode and said cathode, said oscillatory circuit including a high frequency magnetic field generating inductance, and means including a pair of inductances connected respectively to said anode and said cathode and included in said anode circuit for balancing said oscillatory circuit with respect to ground, said inductances having an inductance value ratio such that the terminals of said field generating inductance are maintained at the same high frequency potential with respect to ground potential.

2. In combination, an electron discharge device having an anode, a cathode and a control grid, an anode circuit connected between said anode and said cathode, an input circuit connected between said control grid and said cathode, an oscillatory circuit connected between said anode and said cathode, said oscillatory circuit including a high frequency magnetic field generating inductance, and means including a pair of inductances connected respectively to said anode and said cathode and included in said anode circuit for balancing said oscillatory circuit with respect to ground for high frequency potentials, said inductances having an inductance value ratio such that the potential differences between each of the terminals of said oscillatory circuit and ground are equal.

3. The combination, in an oscillation generator, of an electron discharge device having an anode, a cathode, and a grid, an oscillatory circuit connected between said anode and grid, and means to cause said anode and grid to oscillate at substantially equal potentials with respect to ground, said means comprising an inductance connected between said anode and cathode, and having two portions, and means to maintain a point of said inductance intermediate said portions at ground potential, said portions having an inductance value ratio such that the potential differences

between each of the terminals of said oscillatory circuit and ground are equal.

4. The combination, in an oscillation generator of an electron discharge device having an anode, a cathode, and a grid, an oscillatory circuit connected between said anode and grid, and means to cause said anode and grid to oscillate at substantially equal potentials with respect to ground, said means comprising a pair of inductances connected in circuit between said anode and cathode, a source of anode operating potential connected between said inductances in said circuit between said anode and cathode, said source being maintained at substantially ground potential at the frequency at which said oscillation generator operates, said inductances having an inductance ratio such that the potential differences between each of the terminals of said oscillatory circuit and ground are equal.

5. In combination, an oscillation generator comprising an electron discharge device having an anode, a cathode, and a grid, an oscillatory circuit connected between said anode and grid, a source of energizing potential comprising a commercial power distribution system connected between said anode and cathode, and means to maintain said anode and grid at equal potentials with respect to ground at the frequency of oscillations generated by said oscillation generator, said means comprising a pair of inductances connected in circuit between said anode and cathode and having an inductance ratio such that the potential differences between each of the terminals of said oscillatory circuit and ground are equal, whereby oscillatory currents flowing from opposite sides of said oscillatory circuit to ground and through said power distribution system tend to neutralize each other.

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