Nov. 2, 1948. H. W. JOY 2,452,854

ELECTROTHERAPEUTICAL APPARATUS

Filed Nov. 18, 1944 2 Sheets-Sheet 1

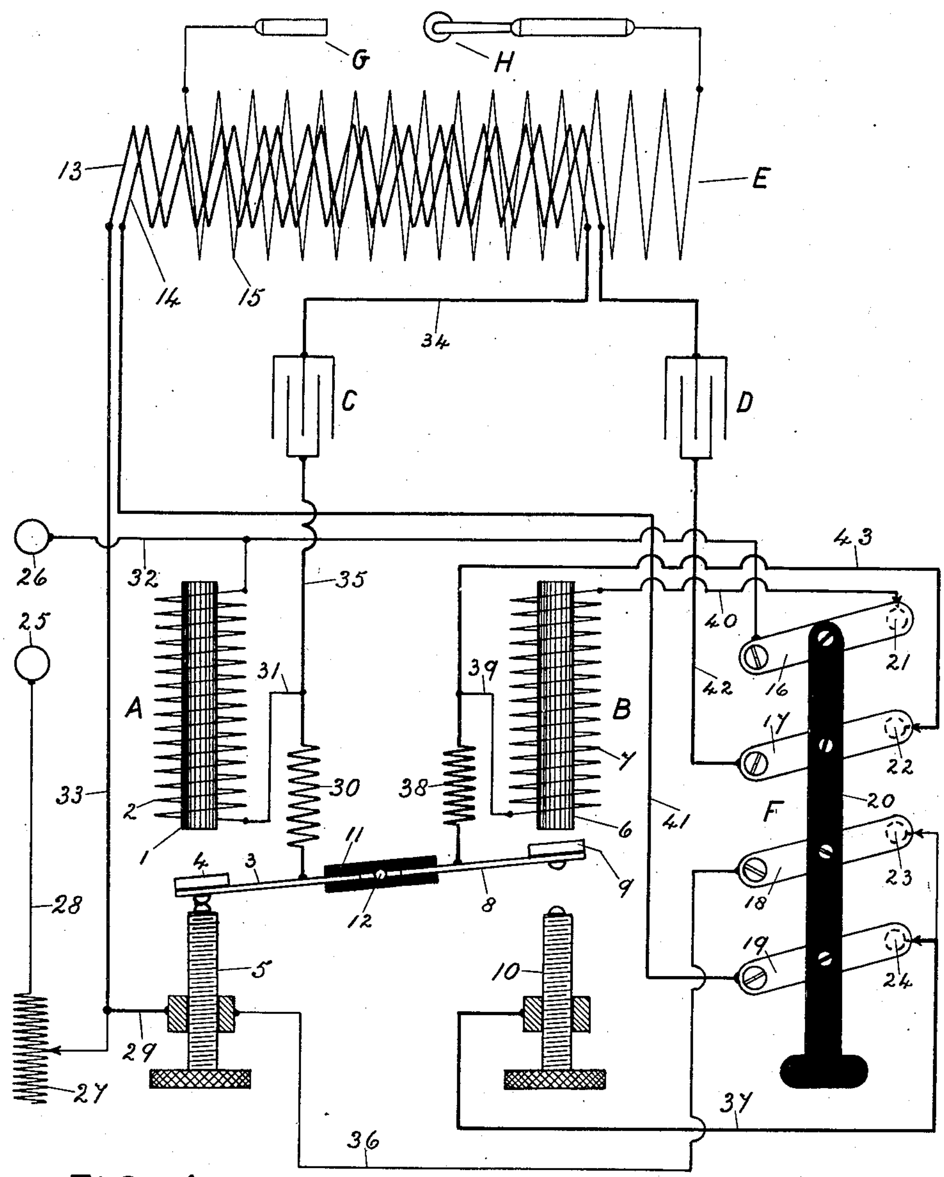

FIG. 1.

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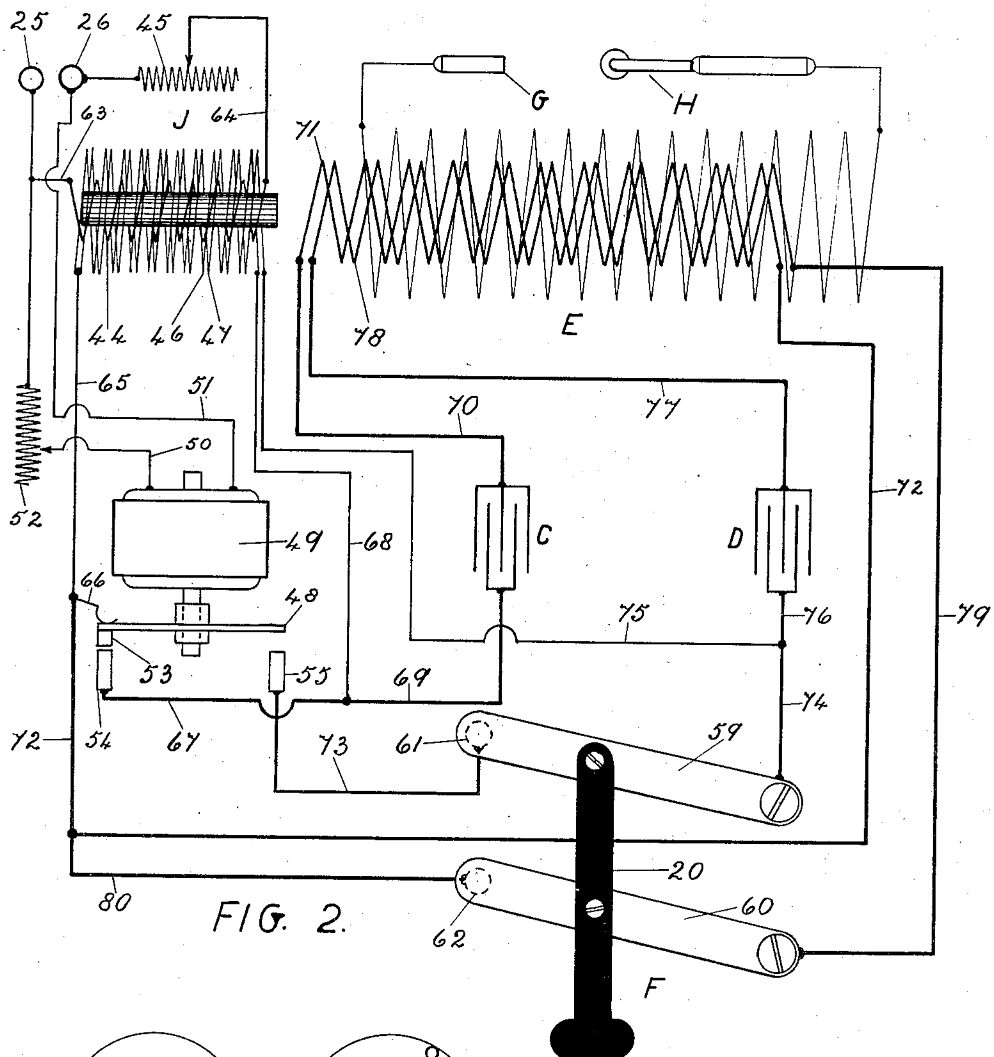

FIG. 2.

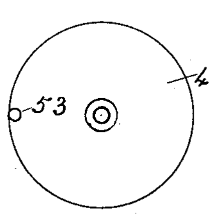

FIG. 3.

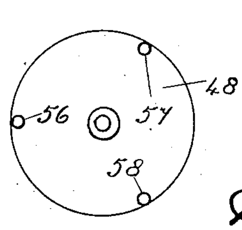

FIG. 4.

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2,452,854

ELECTROTHERAPEUTICAL APPARATUS

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9 Claims. (Cl. 128—422)

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This invention relates to electrical apparatus by means of which high frequency electrical currents are employed for the treatment of various ailments. In the practice of electro-therapy, it is desirable to provide an apparatus whereby a patient may be treated with a wide range of controllable high frequency electrical current wherein the voltage, periodicity, and power value of such high frequency current may be changed as desired with due regard to the respective periodic ratios as set up between such changing characteristics.

The object of this invention is to provide means whereby controllable high frequency electrical currents, having a wide range of frequency oscillations, may be produced at will primarily for use in electro-therapy, and wherein such currents are caused by consecutive separate cycles more or less overlapping each other, thereby eliminating time lag between cycles, and whereby a rapid succession of positive and negative currents are built up from such cycles resulting in practically a continuous current.

In the generation of single phase alternating electric currents three zero points occur in each complete cycle at which instants of time practically no current flows. In the use of such current in electro-therapy an objectionable stinging effect is experienced by the user due to the time lag between successive cycles, and I have found that this objection is overcome by producing and applying a current of continuously and successively overlapping cycles in which the zero points are in effect eliminated.

In carrying my invention into effect I employ an apparatus comprising a plurality of spark coils or spark coil units arranged for connection in parallel relation and energized from an alternating current source of supply of relatively low frequency such as the commercial 110 volt 60 cycle circuit; a high frequency oscillatory member having a plurality of primary windings, equal in number to the spark units, and a single secondary winding; a condenser for each spark unit connected, respectively, in series relation with the primary windings of the high frequency oscillatory member and a spark coil interrupter or spark gap device. The applicators for applying to a user the current developed by such apparatus may be of any desired type.

In one form of my invention each spark coil unit comprises an iron core, a single coil winding, and a vibratory current interrupter. In another form the spark coil unit comprises an iron core, a single primary winding and a plurality of secondary

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windings, constituting a step-up transformer, and a vibratory current interrupter or rotary spark gap device, each secondary winding of the transformer being arranged to function alternately in effecting the charging and discharging of the condensers.

The current interrupters of the spark coil units may be arranged in various ways. In the preferred simplest form of my invention I employ a pair of spark coils, a pair of circuit interrupters, a pair of condensers, and a high frequency oscillatory member having a pair of like primary windings and a single secondary winding. One form of interrupter for such dual arrangement may comprise a pair of stationary contact points and a co-operating pair of vibrators, preferably in the form of flexible blades electrically insulated from each other and carrying armatures and contact points.

In the preferred arrangement of the flexible blade interrupters the blades are mounted in alignment upon a common pivot so as to oscillate in unison to alternately make and break the circuits of the two spark coils. An alternate form of spark device may comprise a pair of stationary spark points and a rotary disk carrying one or more spark points, constituting a rotary spark gap, the disk being rotated by a motor connected across the current supply circuit independently of the sparking units. This form of sparking device is preferably employed with the step-up transformer arrangement of dual spark unit having an iron core, a single primary winding, and a pair of secondary windings connected in series, respectively, with the pair of condensers, thus affording the same effect as the separate spark coil units. The high frequency oscillatory member for the dual sparking system in either arrangement comprises a pair of primary windings of heavy stranded conductors wound so as to have like characteristics, and a single secondary or high frequency winding to which the applicators are connected.

The invention is illustrated schematically in the accompanying drawings, in which,

Figure 1 is a diagram illustrating a pair of spark coil units having a dual vibrator, a pair of condensers, a high frequency oscillatory member having dual primary windings and a single secondary winding to which the applicators are connected, and a manually operated multiple contact switch for connecting and disconnecting one of the sparking units and its associated condenser and primary winding of the high frequency member into and out of circuit.

Figure 2 is a similar view illustrating the employment of a rotary sparking device and associated step-up transformer having an iron core, a single primary winding, and dual secondary windings.

Figures 3 and 4 are plan views illustrating rotary spark disks either of which may be employed with the arrangement of Figure 2.

Referring to the drawings and more particularly to Figure 1, A and B indicate the two spark units, C and D the condensers, E the high frequency oscillatory coil windings, F the multiple contact switch, and G and H the applicators which may be of any desired type. Spark unit A comprises soft iron core 1, a single coil winding 2, flexible vibrator blade 3 having soft iron armature disk 4, and stationary adjustable contact 5. Spark unit B comprises soft iron core 6, a single coil winding 7, flexible vibrator 8 having soft iron armature disk 9, and stationary adjustable contact 10. In order that vibrators 3 and 8 may oscillate oppositely in unison they are illustrated as mounted in alignment on a block 11 of insulating material, electrically insulating the blades from each other, and which block is centrally pivoted as indicated by a pin 12. I have found in practice that a dual vibrator for co-operation with a pair of spark coils will not function correctly if relatively non-flexible. In other words, for the purpose of my invention I have found it desirable to maintain a lingering contact at the spark points when employing a vibrating interrupter to compensate for the lag in demagnetization of the spark coil cores. Therefore it is necessary to provide a slight flexibility between the pair of vibrators or interrupters as the armature of one is attracted by its co-operating magnetized core and the spark point of the other vibrator is making contact with its co-operating stationary spark point. To meet this condition I preferably employ spring metal blades for the vibrators 3 and 8. In Figure 1, the vibrator 8 is illustrated as in the position when its armature is attracted by core 6, and vibrator 3 in the position of contact with its spark point 5. By this means I obtain not only a lingering contact but also by placing the contacting blade under tension a more certain and quicker rebound when the armatures are attracted by the respective spark coil cores.

The high frequency oscillatory member E comprises a pair of primary windings 13 and 14 having like characteristics, and a secondary winding 15 to the terminals of which the applicators G and H are connected. The switch F may be of any suitable type having the necessary number of contacts, but for simplicity of illustration for the arrangement of Figure 1, it is shown as comprising four pivoted contact blades 16, 17, 18 and 19, each pivotally attached to an operating rod 20 of insulating material, which when operated by the knob, moves the four contact blades simultaneously into and out of contact with contacts 21, 22, 23 and 24. The alternating current supply circuit terminals are indicated at 25 and 26, and the supply current is controlled by any suitable type of rheostat indicated at 27.

The circuit connections in Figure 1 are as follows: For spark unit A, from supply circuit terminal 25 by wire 28 to rheostat 27, wire 29 to spark point 5, blade 3 and flexible connection 30 and wire 31 to spark coil winding 2, and wire 32 to supply terminal 26. From wire 29 a connection 33 leads to primary winding 13 of the high frequency member E and the other end of that winding is connected by wire 34 to condenser C and by wire 35 to the spark coil connection 31. For spark unit B, from rheostat 27 and connection 29 by wire 36 to switch blade 18, contact 23, wire 37 to spark point 10 (and when vibrator 8 is retracted) through flexible connection 38 and wire 39 to coil 7, wire 40 to switch contact 21 and switch blade 16 and wire 32 to supply terminal 26. From switch blade 19 a connection 41 leads to primary winding 14 of the high frequency generating member E and the other end of that winding is connected to condenser D and by wire 42 to switch blade 17 and contact 22 through wire 43 to spark coil connection 39. It will be noted that when switch rod 20 is pulled downward, disengaging the switch blades from contacts 21—24, the circuit 36 to switch blade 18 and contact 23 and circuit wire 37 to contact 24 and switch blade 19 and the circuit wire 41 to primary winding 14 of the high frequency member, condenser D, circuit wire 42 to switch blade 17 and contact 22 to circuit wire 43, wire 39 and spark coil winding 7, circuit wire 40, contact 21 and switch blade 16 to circuit wire 32 and terminal 26 is broken, and therefore spark unit B will be entirely cut out of circuit without affecting the operating connections of spark unit A.

Referring now to the arrangement illustrated in Figure 2 of the drawings, C and D indicate the condensers, E the high frequency generating member, and G—H the applicators, all as in Figure 1. J is a step-up transformer which in this arrangement is provided with a primary winding 44 controlled by variable rheostat 45, and a pair of identical secondary windings 46 and 47 which correspond to and function in a manner similar to the single winding spark coils 2 and 7 of Figure 1. The rotary spark disk 48 is mounted on the shaft of a motor 49, the terminals of which are connected across the supply circuit terminals 25 and 26 by wires 50 and 51, the speed of the motor being controlled by variable rheostat 52. The spark disk 48 as shown in Figures 2 and 3 is provided with a single spark point 53 which successively passes in close proximity over the stationary spark points 54 and 55. Thus in Figure 2 the rotation of disk 48 causes a spark twice for each revolution of the disk. By employing a spark disk 48 having three spark points 56, 57 and 58, Figure 4, each revolution of the disk as these points successively pass over the stationary spark points 54 and 55 will cause six sparks for each revolution of the disk. The multiple blade switch F in the arrangement of Figure 2 requires only two blades 59 and 60 operated by the rod 20 and two circuit contacts 61 and 62 for neutralizing one set of high frequency producing elements.

The circuit connections in Figure 2 are as follows: The primary winding 44 of the step-up transformer J is connected through rheostat 45 across the supply circuit terminals 25 and 26 by wires 63 and 64. The secondary winding 46 of unit J is connected by wire 65 to contact brush 66, disk 48, spark points 53 and 54 and wire 67 to wire 68 back to winding 46. From the junction of wires 67 and 68, wire 69 connects to condenser C and wire 70 to primary winding 71 of the high frequency unit E and wire 72 to brush 66. The secondary winding 47 of unit J is connected by wire 65 to contact brush 66, disk 48, spark points 53 and 55 to wire 73, switch contact 61 and switch blade 59 and wires 74 and 75 back to winding 47. From the junction of wires 74 and 75, wire 76 connects to condenser D and wire 77 to primary winding 78 of the high frequency unit E and wire 79 to switch blade 60 and contact 62 and wires 80 and 72 to brush 66. It will be noted that when switch rod 20 is pulled downward disengaging the switch blades from contacts 61 and 62 the circuit 73, 61, 59, 74 and 75 to secondary winding 47 of unit J is opened, and simultaneously circuit 76 to condenser D and wire 77 to primary winding 78 of the high frequency unit E and wire 79 to switch 60, contact 62 and wires 80 and 72 to brush 66 is broken, and hence spark point 55, condenser D and winding 78 will be cut out of circuit and cease to function without, however, affecting the connections or functioning of spark point 54, condenser C and winding 71 of the high frequency unit E.

The operation of the apparatus is as follows: In Figure 1, when the circuit is established at rheostat 27, current will flow through contact screw 5, interrupter 3, connection 30—31 to spark coil 2, thus energizing the coil and magnetizing core 1, causing the attraction of armature 4 to open the circuit at 5—3 and sparking between the spark points. Simultaneously with the interruption of the circuit, the condenser C is charged through the circuit 33, primary coil 13, and circuit 34—35—30. This causes a current surge through primary coil 13 which is amplified by the discharge of the condenser and inductively creates a current of higher frequency in the secondary winding 15 of the high frequency unit E. Before the core 1 is fully demagnetized and while secondary coil 15 is still inductively energized by primary coil 13 due to the residual magnetism of core 1, the circuit will have been established at contact screw 10 by vibrator 8, thus energizing spark coil 7 and producing a similar effect upon primary coil 14 and condenser D to impart additional inductive effect upon secondary coil 15 before the preceding cycle is completed, or before coming to the zero point, thereby greatly increasing the periodicity of the current developed in that coil and eliminating time lag between successive cycles. By adjusting the rheostat 27, the range of periodicity and voltage may be varied. By the operation of switch F to control the functioning of spark unit B together with the adjustment of rheostat 27, the range of periodicity and voltage may be varied from the minimum obtainable by the operation of spark unit A individually to the maximum obtainable by the operation of spark units A and B in alternating sequence as above described.

In the arrangement of Figure 2 the functioning and result is similar to that of Figure 1 but the result is further amplified by virtue of the larger area of the spark points of Figure 2 and also by the controlled higher excitation voltages delivered by the secondary coils 46—47 of the step-up transformer J, whereby when desired, additional energy may be applied in the treatment of more deep seated diseases.

To vary the functioning of the arrangement of Figure 2, the speed of the spark gap motor is varied by rheostat 52, and the value of the incoming energy impressed upon primary coil 44 of the step-up transformer is varied by rheostat 45. While such adjustments determine the voltage and the current energy values generated by the oscillating unit E, any required range of periodicity within the limitations of the unit E may be obtained by varying the number of spark gaps per revolution of the disk 48. By reason of the effects following each discharge or spark, the condensers C and D are alternately charged in such rapid succession that before a current cycle reaches the zero point it is overlapped by the next succeeding cycle to a more or less extent depending upon the rapidity of sparking, and therefore, lapse of time between such alternate successive charges and discharges is eliminated due to the overlapping effects occurring in the step-up transformer. Thus the effect of the step-up transformer controlled by the rotary spark gap device is to inductively develop a higher frequency alternately and successively in the secondary windings 46—47, causing a current of relatively higher periodicity to be impressed alternately and successively on the primary windings 71—78 of the high frequency unit E, and consequently a current of still higher frequency to be delivered by the secondary winding of that unit to the applicators G and H.

It is to be noted that in the operation of my apparatus the dual primary coils of the high frequency unit are not at the same instants of time fully and equally active. For example and assuming that in Figure 1 the primary coil 13 is fully active, then it must re-act inductively upon both the then apparently dormant primary coil 14 and also upon the secondary coil 15, but at such instant the respective potentials of the two primary coils are not equal. Therefore an intervening train of cycles having differential values is set up in the secondary coil 15 before the respective polarities of the two primary coils are reversed or amplified as the case might be by the next incoming train of cyclic impulses as are then being generated by the spark unit B and condenser D. This results in a drop in voltage while maintaining the desired high frequencies and causes damped waves of like periodicity to be produced.

When the spark coil unit A of Figure 1 and its co-operating units are caused to function without the functioning of spark coil unit B and its co-operating units by the opening of switch F, the resultant voltage as developed by the secondary coil of the high frequency unit E is higher than when both units A and B are in operation in alternating sequence. It will be noted that when both units are in operation with the switch F closed as shown in Figure 1, the periodicities as generated are considerably increased and caused to overlap more or less and thereby greatly reducing and practically eliminating the stinging effect which occurs when time lag is present between successive cycles. I have found in practice that the use of high voltage currents in electro-therapy for the treatment of diseases is highly objectionable and is generally ineffective. To obtain beneficial results in electro-therapeutic treatment I have found it necessary to employ apparatus by means of which a wide range of variable high frequency currents are developed at relatively low voltages and selected power values.

What I claim is:

1. In apparatus of the class described, the combination of a pair of spark producing windings energized from a suitable source of electrical current, a rotary sparking device having a plurality of spark points co-operating with said windings, a condenser coupled to each of said windings and said sparking device, a high frequency oscillatory member having a pair of separate primary windings and a single secondary winding, said primary windings being separately coupled to said condensers, a pair of applicators connected to the terminals of said secondary winding, and circuit connections whereby the primary windings of said high frequency oscillatory member are alternately energized in rapid

succession to neutralize time losses between cycles as generated.

2. In apparatus of the class described, the combination of a step-up transformer comprising a single primary coil wound on an iron core and two identical secondary coils wound as a double coil upon said primary coil, a rotary sparking device having a spark point connected in series with each of said secondary coils, a high frequency oscillatory member having a plurality of separate primary windings and a single secondary winding, and a plurality of condensers, each spark point being connected in series with a condenser and one of the primary windings of said oscillatory member, whereby the condensers will be alternately charged and discharged through the primary windings of said oscillatory member, and whereby in the secondary winding of said oscillatory member is developed a high frequency current of overlapping cycles without the effect of time lag between successive cycles of the current delivered by the oscillatory member.

3. In an apparatus as defined in claim 2, a multiple contact switch for neutralizing one of the high frequency producing elements.

4. An apparatus of the class described, the combination of a high frequency oscillatory member having a plurality of separate primary windings and a single secondary winding, said primary windings being adapted to inductively affect each other and successively produce damped waves, of a plurality of exciter circuits, an exciter winding in each of said circuits energized from a low frequency supply circuit, a condenser and a primary winding of said high frequency member in series with each exciter winding, a spark device connected across each exciter circuit, and means for controlling the energy supplied to said exciter windings, whereby the low frequency current is converted into a high frequency current of successive chains of damped waves of like periodicity in alternating sequence without time lag between resulting cycles.

5. In an apparatus as defined in claim 4, a circuit controller for neutralizing one of the exciter circuits to vary the functioning of the oscillatory member.

6. In an apparatus of the class described, the combination of a plurality of exciter windings adapted to be energized from a low frequency supply circuit, a high frequency oscillatory member having a plurality of separate primary windings and a single secondary winding, said primary windings being adapted to inductively affect each other to successively produce damped waves, and each exciter winding being continuously connected in series with a condenser and one of said primary windings, a spark device connected across each exciter circuit in series with the condenser and one of said primary windings, and means for controlling the energy supplied to each exciter circuit, whereby the low frequency current is converted by the oscillatory member into a high frequency current of successive chains of damped waves of like periodicity in alternating sequence without time lag between resulting cycles.

7. In an apparatus as defined in claim 6, a circuit controller for neutralizing one of the primary windings of the high frequency oscillatory member to vary the functioning of said member.

8. In apparatus of the class described, the combination of a step-up transformer comprising a single primary coil and two identical secondary coils, said primary coil being adapted to be energized from a low frequency supply circuit, a high frequency oscillatory member having two primary windings and a single secondary winding, said primary windings being adapted to inductively affect each other to successively produce damped waves, each of said secondary coils of the step-up transformer being connected in series with one of the primary windings of the oscillatory member in separate exciter circuits, a condenser in each exciter circuit, a spark device connected across each exciter circuit, and means for controlling the energy supply to the exciter circuits, whereby the low frequency current is converted into a high frequency current of successive chains of damped waves of like periodicity in alternating sequence without time lag between resulting cycles.

9. In an apparatus as defined in claim 8, a circuit controller for neutralizing one of the exciter circuits to vary the functioning of the oscillatory member.

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