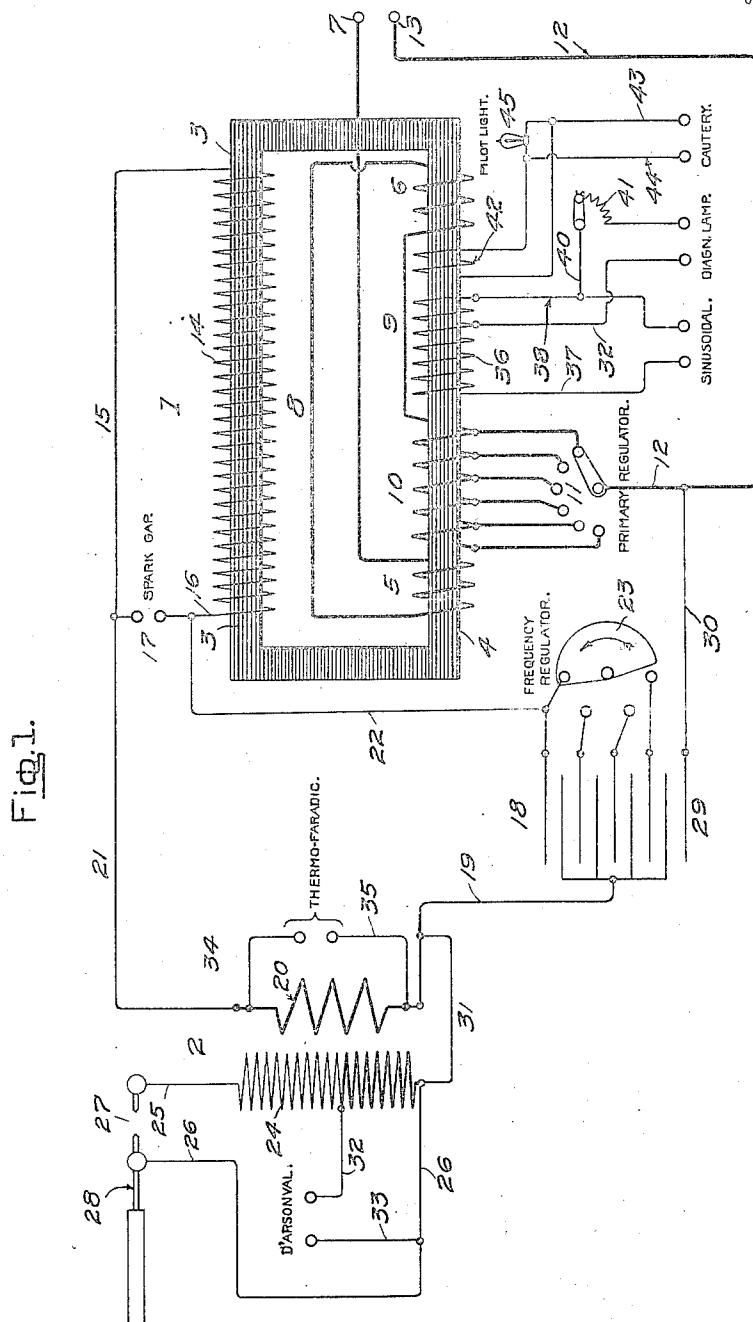


C. E. CAMPBELL.
ELECTROTHERAPEUTIC APPARATUS.
APPLICATION FILED NOV. 10, 1909.

1,012,326.

Patented Dec. 19, 1911.

6 SHEETS—SHEET 1.



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H. Drumme

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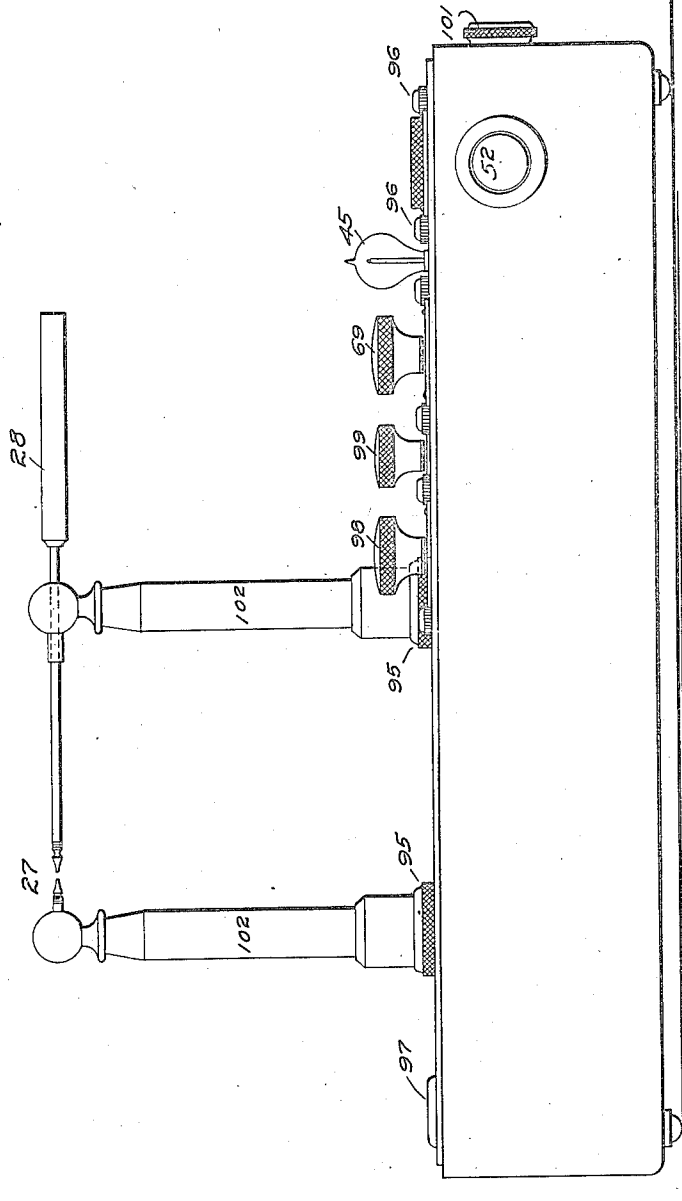
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6 SHEETS—SHEET 2.

1,012,326.

Fig. 2.



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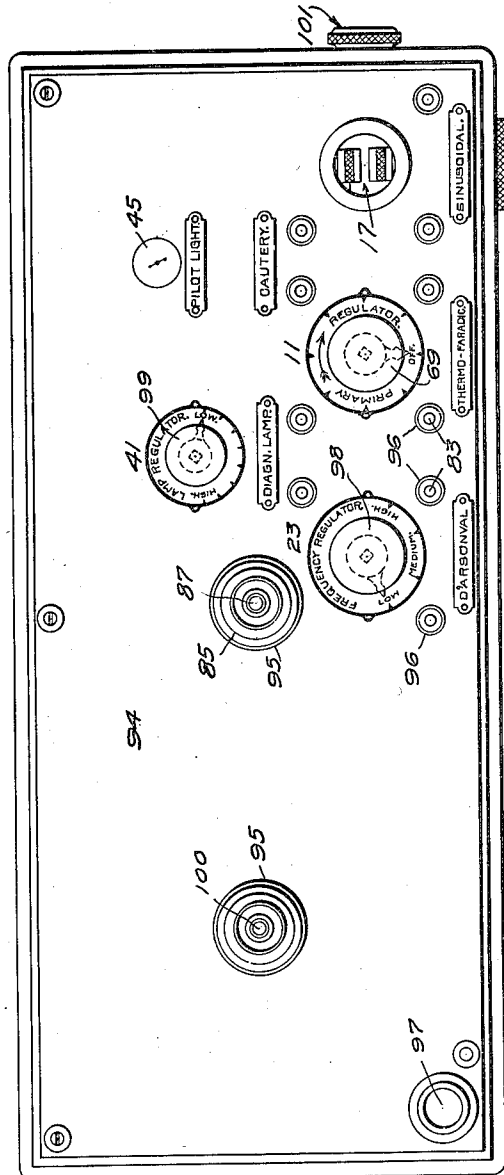
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6 SHEETS—SHEET 3

FIG. 3.



Witnesses:

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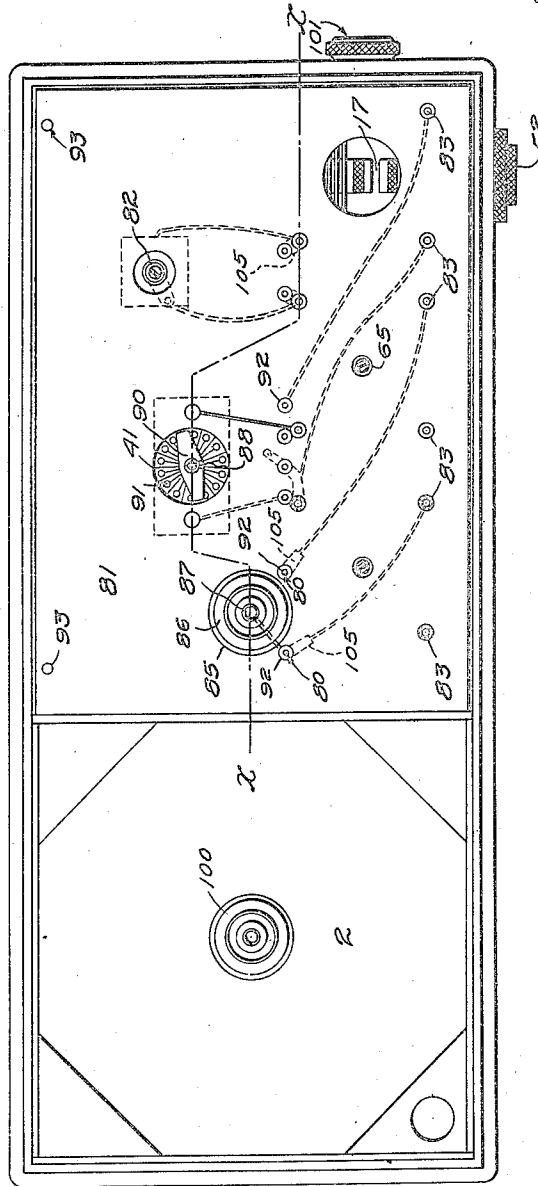
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6 SHEETS—SHEET 4.



4. 10. 17

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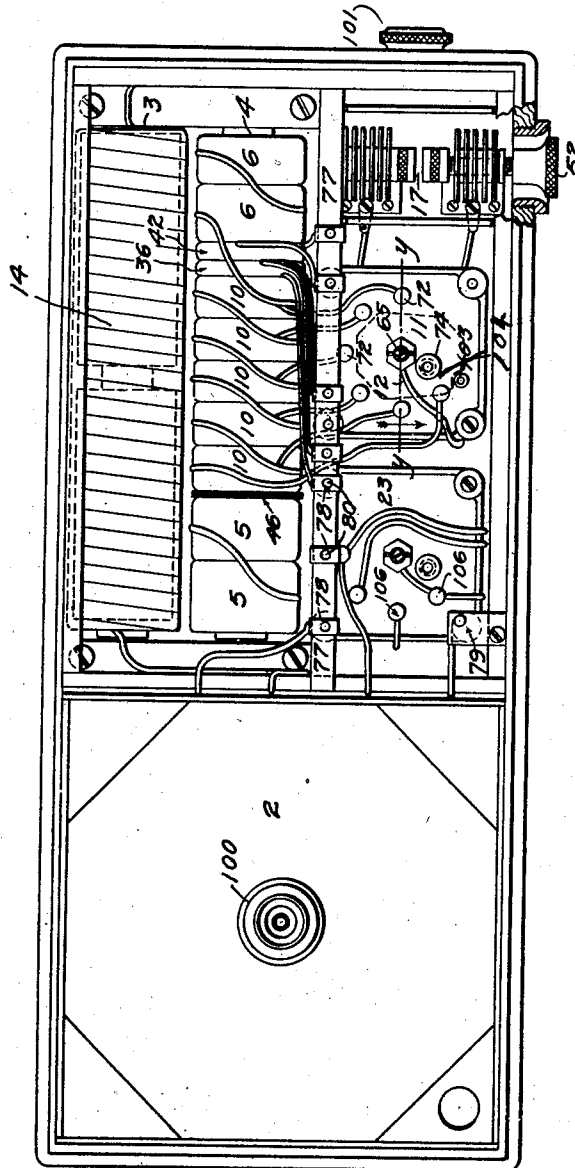
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6 SHEETS-SHEET 5.

Fig. 5.



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6 SHEETS—SHEET 6.

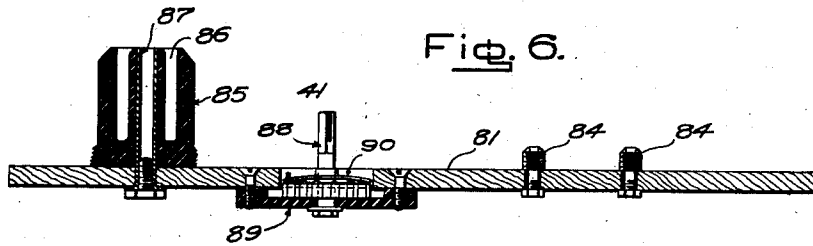


Fig. 6.

Fig. 7.

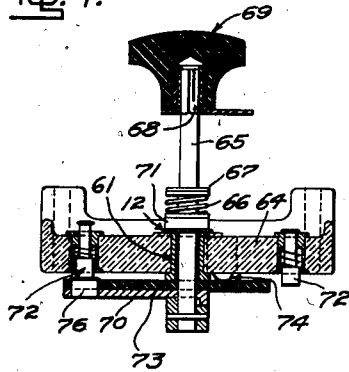


Fig. 8.

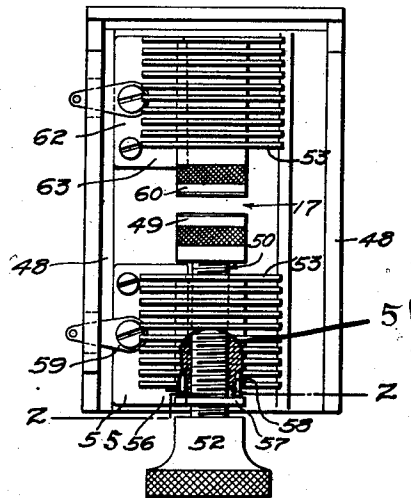
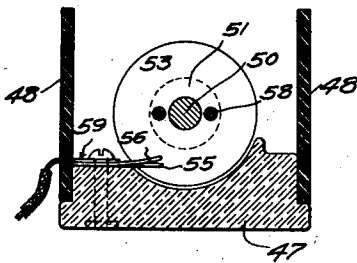


Fig. 9.



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UNITED STATES PATENT OFFICE.

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ELECTROTHERAPEUTIC APPARATUS.

1,012,326.

Specification of Letters Patent.

Patented Dec. 19, 1911.

Application filed November 10, 1909. Serial No. 527,153.

To all whom it may concern:

Be it known that I, CHARLES E. CAMPBELL, a citizen of the United States, residing at Lynn, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Electrotherapeutic Apparatus; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to electrotherapeutic apparatus adapted for use in connection with the various applications of electricity to medicine and surgery, such as radiography, cautery, diagnosis, and the application of electric currents to the body.

One object of the invention is to produce a simple and compact apparatus for the purposes above set forth, in which the several currents of the different characters and tensions required for the purposes referred to may be derived in a simple and safe manner from a single source of supply.

To this end my invention comprises a transformer adapted to produce currents of different tensions in a plurality of independent circuits either at the same time or separately.

Another object of the invention is to produce an apparatus of the kind referred to which shall be insured both against injury to itself arising from internal causes, and against injury to the operator arising either from careless operation or from accidental derangement in the apparatus.

To this end the invention comprises various novel arrangements and constructions which, together with novel and useful features of operation and construction not hereinbefore specifically referred to, will be set forth in connection with the following description of the illustrated embodiment of the invention.

In the accompanying drawings, Figure 1 is a diagram of the electric circuits in an apparatus constructed in accordance with the present invention; Fig. 2 is a front elevation of the apparatus diagrammatically illustrated in Fig. 1; Fig. 3 is a plan view of the apparatus; Fig. 4 is a plan view of the apparatus with the controlling handles, the cover-plate and other external parts removed; Fig. 5 is a plan view of the appa-

ratus with the connection-board as well as the external parts removed; Fig. 6 is a vertical section taken on line $x-x$ in Fig. 4, looking from front to rear, of the removable connection-board and parts carried thereby; Fig. 7 is a vertical section on line $y-y$ in Fig. 5, looking from the rear, of the primary regulator; Fig. 8 is a detailed plan view of the spark gap of the high-tension transformer; and Fig. 9 is a vertical section on line $z-z$ in Fig. 8, looking from front to rear.

The illustrated embodiment of my invention may be best understood by considering first the diagram of the electric circuits, Fig. 1 of the drawings. The apparatus comprises, as is common in apparatus of this type, a high-tension transformer adapted to be energized by alternating electric currents such as may be obtained from ordinary electric lighting systems. This transformer generates in its principal secondary winding an alternating current of high tension, which is converted into a succession of oscillatory discharges by means of a condenser and a spark gap. In combination with the high-tension transformer I use a high-frequency induction coil of the type known as the Tesla coil, this coil operating to generate alternating currents of high frequency and of such high tension as to evince many of the characteristics of static electricity.

In the diagram the high-tension transformer is designated generally by the reference number 1 and the Tesla coil by the reference number 2. The transformer 1, for reasons which will be stated hereinafter, is of what is commonly known as the "core type", having a core comprising two parallel legs 3 and 4 connected at their ends by end pieces so as to constitute a closed magnetic circuit. The primary windings of the transformer are placed upon the leg 4 and constitute a number of separately-wound coils. At the ends of the leg 4 are main primary coils 5 and 6 which are always operative when the transformer is in use. The coils 5 are connected with one of the terminals 7 through which the transformer is supplied with the alternating current by which it is energized. After traversing the coils 5 the current passes, through a wire 8, to the coils 6 which are wound in

the same sense as the coils 5. From the coils 6 the current passes through a wire 9 to a series of primary coils 10 arranged between the coils 5 and 6. Each of the coils 10 has an independent connection with one of the contact points of the primary regulator 11, and the movable contact member of the primary regulator is connected, by a wire 12, with the other supply terminal 13.

The above-described arrangement of primary coils constitutes means for varying the amount of current passing through the primary windings and energizing the transformer. When fewer turns are used in the primary winding the ratio of transformation between the secondary and primary voltages will be increased, the secondary winding being more strongly energized and forcing more current through the different external circuits connected thereto, and the primary will in consequence admit a greater primary current from the supply mains. When less energy is desired, more turns are used in the primary winding and the ratio between the secondary and the primary voltages is diminished, the result being that the secondary voltage is lessened, and less current forced through the various secondary circuits, with consequent diminution of the amount of current drawn by the primary from the supply mains. The impedance of any turn of the primary winding will be due to its own ohmic resistance and to the magnetic flux which links said turn. The magnetic lines which link both the primary and secondary and constitute the effective flux made up one component of the total flux linking said turn of the primary, and the impedance due to this component of the flux will vary with the impedance of the secondary circuit. Another component of the total flux is the leakage flux, or the magnetic lines linking said turn which do not cut the secondary windings, and the impedance due to the leakage flux is not dependent upon the impedance of the secondary circuit. The effective flux does useful work in exciting the secondary, while the leakage flux acts only to cut down the primary current. Any primary turn is of greater efficiency the larger the ratio is between the effective and the leakage flux linking the turn. This greater efficiency of some turns of the primary over others will depend upon their position upon the magnetic core with respect to the secondary coil. I have accordingly placed the coils 5 and 6, which are always in circuit, at the ends of the primary leg 4 of the core, and in a position upon the magnetic circuit closest to the high potential secondary 14, giving the coils 5 and 6 the position of highest efficiency. The regulating coils 10, which are not always in use, are placed on the magnetic circuit at a greater distance from the secondary windings than the windings

5 and 6, and consequently in a position of less efficiency. The effect of throwing the coils 10 into the circuit will not only lessen the ratio of voltage transformation between the secondary and the primary, but the greater leakage flux of the windings 10 will cause them to act in the nature of a choke coil in the primary circuit and very efficiently act to control the amount of energy drawn from the supply mains. By moving the primary regulator so as to include more or less of the primary coils 10 the turns of the primary winding, and thus its impedance, may be increased or diminished so as to vary the amount of current flowing through the primary winding.

The main secondary winding 14 of the transformer is mounted upon the leg 3 of the core and is connected, by wires 15 and 16, with the spark gap 17.

The primary winding consists of a comparatively few turns of wire, and the secondary winding of a greater number of turns, so that the transformer acts as a step-up transformer to step-up the primary voltage to a high tension secondary potential. By placing the primary and secondary windings upon different legs of the transformer core, they are more completely separated and better insulated from each other to guard against any possible break-down between the primary and secondary.

A condenser 18 is connected with the wire 16 by a wire 22, at one terminal, and the other terminal of the condenser is connected by a wire 19, with the primary winding 20 of the Tesla coil. The winding 20 is connected at its other terminal, by a wire 21, with the other side of the spark gap 17. By this arrangement the condenser is alternately charged and discharged through the winding 20 of the Tesla coil, and the discharges have the oscillatory character due to the use of the condenser and the spark gap.

In order to vary the frequency of the oscillatory discharges so as to modify the character of the currents produced by the Tesla coil, the condenser is arranged to have a variable capacity which is regulated by means of a frequency-regulator 23. This regulator comprises a conductive sector which may be rotated into position to connect together or disconnect a number of condenser plates of the same set as the uppermost plate, which plate is normally connected with the spark gap through the wire 22. In this way a greater or less number of plates is rendered operative and the capacity of the condenser and, consequently, its rate of charge and discharge is thus regulated.

The terminals of the secondary winding 24 of the Tesla coil are connected, by conductors 25 and 26, with the members of a

spark gap 27, which is adjustable, in the ordinary manner, by means of a sliding rod 28.

In place of connecting the primary and secondary windings of the Tesla coil with the earth in the usual manner, the lowermost plate 29 of the condenser 18 is connected, by a wire 30, with the wire 12 connected with the primary winding of the transformer and with the supply system by which the apparatus is energized. This arrangement constitutes in general the equivalent of a ground made in the ordinary manner, but it has advantages which will be hereinafter pointed out.

Currents of the characters usually employed in therapeutics and derived from a high-frequency coil are derived from the Tesla coil 2 in the present invention, either from the terminals of the spark gap 27 or by other connections illustrated in Fig. 1. A current of the character usually designated as a d'Arsonval current is obtained through terminals connected, by wires 32, 33 and 26, with a portion of the secondary winding 24. This portion is made of heavier wire than the rest of the secondary winding, and the arrangement is such that the d'Arsonval current supplied in this manner is of lower tension but greater volume than the current generated in the Tesla secondary as a whole. A current of high frequency but of lower tension than that produced in the secondary winding 24 is obtained through terminals connected by wires 34 and 35 with the terminals of the primary winding 20 of the Tesla coil. This current may be designated as a thermo-faradic current.

In addition to the high-tension and high-frequency currents above referred to, the apparatus is arranged to supply alternating currents of comparatively low tension and of the frequency of the alternating current by which the apparatus is energized. One of these currents, which may be designated as a sinusoidal current, and which is designed for direct personal application, is induced in an auxiliary secondary winding 36 in the transformer 1, and this secondary winding, for reasons which will be hereinafter pointed out, is located upon the same leg of the core as the primary winding of the transformer and is interposed between the coils of the primary winding. The sinusoidal current is obtained from terminals connected, by wires 37 and 38, with the terminals of the winding 36.

In addition to the currents above described for direct application, the apparatus is designed to furnish currents for indirect use, such currents being adapted for the operation of cauterizing apparatus and diagnostic lamps. The current for the diagnostic lamp is obtained from terminals which are connected, through wires 38, 39

and 40, and through a variable resistance device 41, with the secondary winding 36. The connections are arranged as shown in Fig. 1 so that in the production of this current only a portion of the winding 36 is employed, so that the lamp current is of lower tension than the sinusoidal current. The variable resistance device 41 constitutes a regulator for the diagnostic lamp.

The cautery current is obtained from another auxiliary secondary winding, 42, arranged adjacent to the winding 36. This winding 42 is so proportioned as to produce a current of very low tension, which may be safely used for the purpose designated. The cautery current is obtained from terminals connected with the winding 42 by means of wires 43 and 44.

To furnish at all times an indication when the transformer is in operation, a small electric lamp 45, designated as a pilot light, is connected across the wires 42 and 43 and this lamp glows whenever there is any flow of current in the primary winding of the transformer.

The mechanical construction of the apparatus may now be considered. This is most fully disclosed in Fig. 5 of the drawings, which shows a plan view of the interior arrangements of the apparatus. As shown in Fig. 5, the primary windings 5 and 6 each constitute two separately-wound coils. Owing to this arrangement and to the further division of the primary winding into the separately-wound coils 10, the entire primary winding of the transformer is divided into a large number of small sections. It has previously been common to arrange the secondary winding of an induction coil or high-tension transformer in separate sections in this manner, for the purpose of securing better insulation, but so far as I am aware the arrangement is novel in connection with the primary winding of a transformer or coil. The utility of this arrangement results from the production in high-frequency apparatus of static currents and waves of very high tension and of incidental character, which have a serious tendency to escape from the circuits of the apparatus and to leap considerable air spaces in preference to following conductors of high impedance. Such waves or currents occur in primary winding of the transformer and it has been found that in the absence of special precaution there is danger of the disruptive discharge of such currents through the primary and the consequent breaking down of the insulation therein, leading to the production of destructive arcs. I have found, however, that by winding the primary in separate coils or sections as above described, the insulation of the primary winding is so improved as to protect it against the effects which I have described.

The arrangement of the primary winding of the transformer is such that the intermediate coils 10, when they are not included in the primary circuit, tend to act as secondary coils with relation to the main coils 5 and 6, precisely after the manner of an auto-transformer, that is to say, a potential in the coils 10 is induced by the magnetic flux in the core due to the action of the coils 5 and 6. This potential is opposite to that of the alternating current by which the primary winding is energized, and when the coils 10 are not connected in series with the main coils the difference in potential between the left-hand coil 10 and the adjacent right-hand coil 5 is much higher than any difference in potential due to the energizing current alone. To guard against evil effects from this circumstance, a plate 46 of insulating material is interposed between the coils 5 and the coils 10.

The control of the transformer by varying the amount of primary winding in operation is an economical method, since the flow of current is controlled not by waste of current in external heat-producing resistance devices such as are commonly used, but by the impedance in the primary winding itself. The control of the transformer is thus accomplished in an economical and effective manner without the use of any additional parts except the controlling switch, and the bulk of the apparatus is thus minimized. The construction of the spark gap 17 is illustrated particularly in Fig. 8. This spark gap is provided with an adjustable member 49 which has a flat face covered by a thin plate of silver. The disruptive discharge between the spark-gap members heats them and causes their surfaces to oxidize. I have found that a metal of which the oxid so produced is electrically-conductive operates in a much more uniform and satisfactory manner than a metal of which the oxid acts as an insulating medium, and for this purpose I have found that silver is well adapted, since its oxid has the required conductivity. The member 49 is adjustable toward and from the other member of the spark gap, and to this end is mounted upon a screw 50 which is in threaded engagement with a metal sleeve 51. The outer end of the screw 50 is provided with a head 52 by means of which it may be turned to adjust the member 49 and vary the length of the spark.

To prevent over-heating of the spark-gap member, the sleeve 51 is provided with heat-radiating flanges 53. The sleeve 51 is mounted upon a plate 55 which engages a slot passing through the flanges 53, as shown particularly in Fig. 9. This plate 55 is fixed upon a porcelain block 47 which forms a base for the spark gap. The plate 55 has a resilient tongue 56 which normally springs upwardly above the plane of the body of the

plate so as to engage the foremost flange 53 and prevent this flange, and therefore the spark-gap member, from sliding outwardly upon the plate 55. When it is desired, however, to remove the parts from their normal position, the tongue 56 may be pressed downward into line with the slot in the radiating flanges and the parts may then be withdrawn through an opening provided for this purpose in the front of the casing of the apparatus.

To shield the other parts of the apparatus from the heat and the fumes produced by the discharge through the spark gap, vertical walls 48 of insulating material are fixed to the sides of the porcelain base 47, and as shown in Figs. 3 and 4, an opening is provided through the top of the casing both to allow inspection of the spark gap and to provide for the escape of heated fumes.

The fixed member 60 of the spark gap is similar in form to the adjustable member 49 and is also provided with heat-radiating flanges. This member is mounted in a similar manner upon a fixed plate 62 having a retaining tongue 63 similar to the retaining tongue 56 above described.

To maintain a good electrical connection between the adjusting screw 50 and the sleeve 51, a screw-threaded ring 57 is mounted upon the screw and is provided with two rearwardly-projecting pins 58 which loosely engage openings in the sleeve. The spring-pressed member or ring 57 is prevented from rotation with the adjusting screw 50 by means of the said pins 58. Spiral springs surround the pins and force the threaded ring 57 constantly against the threads of the screw 50 with sufficient pressure to maintain a close electrical contact and also to prevent accidental rotation of the adjusting screw 50 due to vibrations in the apparatus. The female screw threads of the spring-pressed ring 57 press forwardly against the male screw threads of the screw 50, while the female screw threads of the sleeve 51 resist this pressure by holding back against the male threads of the screw 50. Thus the screw 50 is engaged by two oppositely pressing screw-threaded members, viz., the ring 57 and the sleeve 51, which insures a constant longitudinal pressure between the threads of the screw 50 and the threads of the ring 57 and sleeve 51 whereby a close electrical contact is maintained and the screw 50 is prevented from turning too easily.

The plates 54 and 62 are provided with connection members 59 by which they are connected with the wires from the secondary winding of the transformer 1.

The construction of the primary regulator 11 is illustrated particularly in Fig. 7. This device is provided with a base 64 of insulating material, and for this purpose I have

found porcelain to be particularly adapted. Mounted at the center of the base is a vertical stem 65 having a squared upper end upon which is mounted an operating handle or knob 69. The end 68 of the stem is bifurcated so as to afford a resilient engagement with the square socket in the handle, operating to maintain the handle frictionally in place while permitting it to be readily disengaged when necessary.

The stem 68 is journaled in a sleeve 61 and the sleeve is secured in place and connected with the conductor 12 by means of a nut 71 threaded upon the sleeve. A spiral spring 66 engages at one end the nut 71 and at its other end the collar 67 fixed on the stem 68. This spring operates to maintain constantly a good electrical connection between the stem and the nut 71 and conductor 12. The stem 68 carries at its lower end a metal arm 70 bearing a contact button. The contact button may be moved, by rotating the stem 68, into engagement with either of a series of spring-pressed contact members 72 which are mounted in the base 64, and in this way the conductor 12 may be connected alternatively, as indicated in Fig. 1, with the wires connected with the primary coils 10. The connections between the coils 10 and the contact members 72 are illustrated in Fig. 5. To retain the primary controller in its several positions, a plate of insulating material 73 is mounted upon the stem 68 and is engaged by a spring-pressed ball 74 mounted on the base 64. By means of suitable recesses in the upper surface of the plate 73, the retainer may be caused to arrest the motion of the regulator at points where the contact members are squarely in engagement with each other. The spring 66 permits the stem to yield vertically and thereby facilitates the disengagement of the recesses from the retainer when the regulator is moved from contact to contact.

It is desirable to prevent retrograde movement of the primary regulator by which it might be turned so as to throw the transformer into full operation at once, and for this purpose a spring-pressed member 103, similar in construction to the contact members 72, is mounted in such position that it will engage a shoulder 104, shown in dotted lines in Fig. 5, upon the plate 73. The position of the parts is such as to arrest the contact arm 70 if it be attempted to turn it backward into engagement with the last of the series of contact members 72 by which the direct connection is made between the conductor 12 and the wire 9.

Owing to the large number of circuits and connections necessary in an apparatus of the present character, it is difficult and inconvenient to make the necessary connections through or upon the base-board or

the casing of the apparatus in the ordinary manner and I have, therefore, devised an arrangement by which the connections of the various portions of the apparatus are simplified, this arrangement being such also as to permit the removal of the cover of the apparatus without the manipulation of any of the connections so that access may be readily and conveniently had to the interior parts of the apparatus for purposes of examination and repair.

To the above ends I provide the casing of the apparatus with a member upon which the various exterior terminals of the apparatus are mounted and, provide this member with conductors arranged to normally engage corresponding fixed conductors mounted in the casing. When this connection member is removed the conductors are separated, while when the said member is replaced in position, the conductors are thereby engaged, and in this manner the terminals are connected with the interior parts of the apparatus without attention on the part of the operator.

The connection member is embodied, in the illustrated apparatus, in a plate or board 81 of wood or other non-conducting material which normally covers the apparatus, with the exception of the Tesla coil 2, and this board is normally secured in place by means of screws 93. The board 81, which I shall hereinafter designate as the "connection-member," carries, with one exception, the exterior terminals 83 through which the d'Arsonval, thermo-faradic and sinusoidal currents are derived and also the terminals for the diagnostic lamp and the cautery current. These various terminals are connected, by means of wires and other conductors shown principally by dotted lines in Fig. 4, with a number of contact devices 105 fixed to the bottom of the board. The contact devices 105 are arranged in a line in such position as to be directly above a cross bar 77 fixed in the casing of the apparatus directly beneath the connection-member. This cross bar 77 is made of wood or other non-conducting material and it carries contact devices 78 in the form of flat metal plates arranged in position to engage the contact devices 105 when the connection-member is in position. To insure a good contact between the contact devices 78 and 105, the former are provided with threaded stems 80 which project upwardly through the connection-member and are provided with nuts 92 by which the board is drawn firmly down into position.

When the nuts 92 and the screws 93 are removed the connection-member may be freely removed from the casing thereby automatically disconnecting all of the external terminals from the apparatus, and when the connection-member is replaced the cir-

cuits are automatically restored again by the operation of the contact devices 78 and 105.

In addition to the external terminals and their connections, the connection-member carries a socket 85 for the reception of one of the pillars 102 of the spark gap of the Tesla coil. This socket 85 is provided with an annular recess 86 for the reception of the tubular pillar and with a central metal conductor 87 constituting a portion of the conductor 26 illustrated diagrammatically in Fig. 1. The regulator 41 for the diagnostic lamp is also carried by the connection-member 81. This regulator comprises a stem 88 provided with a handle 99 of the same form as the handle 69 of the primary regulator. The stem 88 is journaled in a plate 89 of insulating material and carries a conductive cross-arm 90 which engages the several contacts 91 of the resistance coil by which the strength of current in the lamp is regulated. The socket 82 for the pilot lamp 45 is also carried upon the connection-member.

The construction of the frequency-regulator 23 is similar in general to that of the primary controller 11 except that the frequency-regulator is provided with a sector of conducting material adapted to engage simultaneously any number of the spring-pressed contacts 106, as indicated diagrammatically in Fig. 1. The frequency-controller is provided with a knob or handle 98 similar to the knob 69 of the primary regulator.

The conductor 25, connecting the secondary winding of the Tesla coil with the spark gap 27, passes through a pillar 102 mounted in a socket 100 similar to the socket 85 already described.

The entire apparatus is covered by a plate 94 of rubber or other insulating material, and collars 95, threaded to the sockets 85 and 100 are screwed down upon the upper surface of this plate. The sockets are arranged to project well above the apparatus to prevent discharges from the pillars to the parts below the sockets. The terminals 83, etc., are covered by caps 96 of insulating material so that there are no exposed conductors from which accidental shocks may be obtained. The terminals 7 and 13 of the primary winding of the transformer are located in a socket 101, through which connection may be made with a screw plug, in the ordinary manner, to introduce the alternating current by which the apparatus is energized.

The arrangement of the apparatus throughout is such as to prevent, so far as possible, accident either to the operator or to the apparatus itself due either to internal derangements in the apparatus or to careless handling on the part of the operator.

One means has already been described by which disruptive discharges in the primary winding of the transformer are prevented. In this connection, however, the supplemental plate 29 of the condenser, hereinbefore described, serves as an additional safeguard, since, without constituting an actual metallic connection between the transformer and the high-tension portions of the apparatus, it operates in the manner of a ground to afford an outlet for the static waves or impulses which might otherwise find a way through the primary winding. It also prevents severe shocks to the operator which might occur in the absence of such precaution in case his body should accidentally come in contact both with a terminal of the Tesla coil and with a ground connection of any kind.

The general form of the transformer is in itself a protection against the action of the high-tension oscillatory currents generated, since it permits a sufficient separation of the primary and secondary windings to prevent occurrence of disruptive discharges from the secondary winding through the primary winding. This form of transformer has thus peculiar advantages when used in connection with a condenser and a spark gap to produce oscillatory currents of high tension, and such an arrangement is novel so far as I am informed.

A further advantage resulting from the arrangement of the main primary coils 5 and 6 at the extremities of the leg 4 of the transformer core resides in the fact that the principal portions of the primary winding are thus brought as close as possible to the secondary winding, so that the magnetic paths connecting the primary and secondary windings are thus of the shortest possible length and thus efficiency and economy in the operation of the transformer are secured. This arrangement also permits the location of the primary-regulating coils 10 at a point where their inductive effect is slight, so that the impedance of these coils may act more effectively to regulate the production of current in the secondary winding.

The arrangement of the transformer with a plurality of independent secondary windings adapted to generate currents of different volumes and tensions permits the use of a single transformer for a variety of purposes and thus greatly increases the usefulness of the apparatus without correspondingly increasing its bulk or expense. In this connection it will be noted that by suitably proportioning the several secondary windings, currents of any volumes and tensions within the extreme limitations of the apparatus may be secured. In the preferred embodiment of the invention I have found that for the production of the cau-

tery current a winding of very few turns of heavy wire adapted to give a heavy current under an E. M. F. of about three volts gives satisfactory results while restricting the voltage to such low tension as to render it perfectly safe and convenient for use in cauterizing apparatus. In the diagnostic lamp, I find an E. M. F. of ten volts to be sufficient, while in the sinusoidal circuit I employ an E. M. F. of twenty-four volts and the winding 36 is, therefore, suitably proportioned to produce such voltages.

The position of the secondary windings 36 and 42 upon the same leg of the transformer as the primary windings is a novel feature of importance, since it secures economy in space by placing these secondary windings at a point where primary windings would have a comparatively low efficiency in exciting the secondary winding 14. Moreover, by placing the secondary windings 36 and 42 upon the same leg and between the two primary coils, a good magnetic linkage is obtained between these windings and the primary, with a correspondingly good efficiency of current transformation. The arrangement has a further advantage in that it removes the comparatively low-tension secondary windings from the neighborhood of the high-tension secondary winding 14 and thereby reduces the liability of disruptive discharges in the transformer.

A detail of construction by which the reception of dangerous shocks by a patient or operator is avoided consists in the use of entirely independent conductors, such as the wires 21 and 34, for connecting the thermo-faradic terminals and the spark gap 17 with the terminals of the Tesla coil primary 20, as shown diagrammatically in Fig. 1. With the connection so arranged, if either of the connections should become accidentally broken the result would be merely to disconnect the thermo-faradic terminals entirely from the apparatus. If, on the other hand, the wire 34 were united to the wire 21, or vice-versa, in place of the independent connections with the primary winding 20, a dangerous shock might result from accidental breakage of the common connection with the winding 20. In such an event the thermo-faradic terminals would constitute the only path for the discharge of the condenser, which discharge would pass through the person connected with these terminals, whereas in the normal operation of the apparatus the primary winding 20, which consists of very few turns of a heavy conductor, and therefore has comparatively low impedance, is connected in shunt with the thermo-faradic terminals so as to conduct the greater part of the discharge from the condenser.

Another danger to be guarded against in the operation of the apparatus resides in the

possibility of connecting applicators to one of the d'Arsonval terminals and one of the thermo-faradic terminals, so as to put the patient or the operator into circuit with the secondary windings of both the transformer and the Tesla coil. Such a result may occur, for example, by using the right-hand d'Arsonval terminal and the upper thermo-faradic terminal in Fig. 1. To prevent danger from such a cause, the windings of the Tesla coil are so arranged and connected that in a circuit formed as above described they oppose each other, so that the resulting flow of current is equal to the difference and not to the sum of the currents which may be derived from either pair of terminals when properly connected. This arrangement also avoids a high difference in potential between the adjacent terminals of the primary and secondary windings of the Tesla coil.

As a further protection to the apparatus, the parts are so proportioned and arranged that a short-circuit, either in the spark gap 17 or in the sinusoidal diagnostic lamp or cautery terminals, cannot result in burning out the transformer. This is due partly to the form of the transformer in which the magnetic flux through the core is limited by suitably proportioning the end-pieces of the core, and also to the use of sufficient resistance in the secondary coils 36 and 42 and of a sufficiently small number of turns in these coils to prevent the overloading of the primary coils of the transformer.

While the various features of my invention are particularly susceptible to conjoint use in an apparatus of the kind hereinbefore referred to, since they all contribute to the production of a safe and reliable apparatus, it will be obvious that the invention in some of its aspects may be embodied in an apparatus from which some of the noted features are omitted.

The invention hereinbefore described is not limited to the embodiment specifically illustrated and described, but may be embodied in various other forms within the spirit of the invention and the scope of the following claims.

I claim—

1. An electro-therapeutic apparatus having, in combination, a transformer comprising a core having two substantially parallel legs connected by end-yokes, a secondary winding on one of said legs and a primary winding having main sections located near the ends of said leg and normally in operation, and a plurality of auxiliary sections located between the main sections, and a regulating device for controlling the operation of the transformer, the regulating device being arranged to throw more or less of the auxiliary primary sections into series with the main primary sections.

2. An electro-therapeutic apparatus hav-

ing, in combination, a transformer provided with a secondary winding and with a primary winding divided into two main sections connected in series and normally operative, and a plurality of auxiliary sections, a regulating device for controlling the operating of the transformer arranged to throw more or less of the auxiliary sections into series with the main sections of the primary winding, and a body of insulating material located between one of the said main sections and the adjacent auxiliary section, to prevent disruptive discharge between said sections.

3. An electro-therapeutic apparatus having, in combination, a high-tension transformer, a high-frequency coil energized thereby, a safety connection between the high frequency coil and the primary circuit of the high-tension transformer, and a condenser interposed in said connection.

4. An electro-therapeutic apparatus having, in combination, a high-tension transformer provided with a primary winding and a secondary winding, a high-frequency coil, a condenser, the high-frequency coil and the condenser being connected in series with the secondary winding of the high-tension transformer, and an independent auxiliary plate in said condenser connected with the primary circuit of the high-tension transformer and operating as a safety connection for the high-frequency coil.

5. An electro-therapeutic apparatus having, in combination, a high-tension transformer provided with a primary winding and a secondary winding, a high-frequency coil connected with and energized by the secondary winding of the transformer, and connections between the high-frequency coil and the primary circuit of the transformer constructed and operating as a safety connection between the high-frequency coil and said primary winding.

6. An electro-therapeutic apparatus having, in combination, a high-tension transformer provided with a primary winding and a secondary winding, and a condenser and a spark gap connected with said secondary winding, the spark gap having an adjustable member mounted upon an adjusting screw, and a spring-pressed member threaded upon the screw but prevented from rotating therewith, the spring-pressed member operating to preserve electrical contact between the screw and the fixed portion of the spark gap circuit.

7. An electro-therapeutic apparatus having, in combination, a high-tension transformer provided with a primary winding and a secondary winding, and a condenser and a spark gap connected with said secondary winding, the spark gap comprising a member provided with a plurality of heat-

radiating flanges longitudinally slotted from their periphery inward, and a fixed plate engaging the flanges at their slotted portion and acting as a support for said member.

8. An electro-therapeutic apparatus having, in combination, a high-tension transformer provided with a primary winding and a secondary winding, and a condenser and a spark gap connected with said secondary winding, the spark gap comprising a member provided with a plurality of heat-radiating flanges longitudinally slotted from their periphery inward, and a fixed plate engaging the flanges at their slotted portion and acting as a support for said member, said plate having a resilient tongue engaging the face of one of the flanges to prevent longitudinal movement of the spark gap member upon the plate.

9. An electro-therapeutic apparatus, having, in combination, a Tesla coil provided with a secondary winding having a portion of greater conductivity than the remainder, and applicator terminals connected across said portion for the derivation of currents of greater volume and lower tension than the currents produced in the secondary winding as a whole.

10. An electro-therapeutic apparatus, having, in combination, a high-tension transformer, and a Tesla coil connected with and energized by the transformer and having an electrical connection between its primary and secondary windings, a pair of terminals adapted to receive applicator conductors connected across the primary winding, and a second pair of terminals adapted to receive applicator conductors connected across the secondary winding, the primary and secondary windings being wound in such direction that in a circuit formed between one of the primary applicator conductors and one of the secondary applicator conductors and passing through both primary and secondary windings and their connection, the primary and secondary windings will act in opposition to each other.

11. An electro-therapeutic apparatus, having, in combination, a Tesla coil having a primary and a secondary winding, terminals adapted to receive applicator conductors connected across the secondary winding, and a second set of terminals adapted to receive applicator conductors connected across a portion only of the secondary winding for the derivation of currents of greater volume and lower tension than the currents produced by the secondary winding as a whole.

12. An electro-therapeutic apparatus having, in combination, a high-tension transformer having a primary winding and a secondary winding, a high-frequency coil having a primary winding and a secondary winding, a condenser connected in series

with the secondary winding of the transformer and the primary winding of the coil, a spark gap connected in shunt with said primary winding condenser, and terminals adapted to receive applicator conductors connected with the terminals of the primary winding of the coil, the connections of the terminals which receive the applicator conductors being entirely independent of the other connections with said primary winding so as to prevent the conduction of excessive discharges through the applicator conductors in case of the breakage of any of such connections.

13. An electro-therapeutic apparatus having, in combination, a casing, means located in the casing for producing a high-frequency current of high tension, means located in the casing for producing a low-tension current adapted for energizing a cautery, connections for energizing said means from a common source external to the casing, and external terminals mounted on the casing for said high-tension and low-tension currents.

14. An electro-therapeutic apparatus having, in combination, transforming devices for producing a high-tension current and a low-tension current adapted for energizing a translating device, and a common regulator for regulating both of said currents simultaneously.

15. An electro-therapeutic apparatus having, in combination, a high-tension transformer provided with a primary winding, and a plurality of secondary windings, one of said secondary windings being constructed and arranged to produce a high-tension current, a condenser and spark gap connected with said winding to produce an oscillatory discharge, a Tesla coil comprising a primary and secondary, and having its primary connected in and energized by the high tension secondary winding of the transformer, a set of terminals connected with and energized by another of the transformer secondary windings, this winding being constructed and arranged to produce a current of comparatively low tension and of same frequency as the primary current, a second set of terminals connected across the primary of the Tesla coil for the derivation of an oscillatory current of low tension and large volume, a third set of terminals connected across a portion only of the secondary winding of the Tesla coil for the derivation of an oscillatory current of higher tension and smaller volume than that derived from the second set of terminals, and a fourth set of terminals connected across the entire secondary winding of the Tesla coil for the derivation of an oscillatory current of still higher tension and smaller volume.

16. An electro-therapeutic apparatus having, in combination, a high tension trans-

former provided with a primary winding, and a plurality of secondary windings, one of said secondary windings being constructed and arranged to produce a high tension current, a condenser and spark gap connected with said winding to produce an oscillatory discharge, a Tesla coil comprising primary and secondary windings, and having its primary connected to and energized by the high-tension secondary of the transformer, a set of terminals connected with and energized by another of the transformer secondary windings, this winding being constructed and arranged to produce a current of comparatively low tension, a second set of terminals connected across the primary winding of the Tesla coil for the derivation of an oscillatory current of comparatively large volume and low tension, and a third set of terminals connected across the secondary winding of the Tesla coil for the derivation of an oscillatory current of higher tension and smaller volume.

17. An electro-therapeutic apparatus having, in combination, a Tesla coil comprising primary and secondary windings, a set of applicator terminals connected across the primary for the derivation of an oscillatory current of comparatively large volume and low tension, and a second set of applicator terminals connected across the secondary Tesla coil for the derivation of an oscillatory current of comparatively small volume and high tension.

18. An electro-therapeutic apparatus having, in combination, a high-tension transformer provided with a primary winding and a plurality of secondary windings, one of said secondary windings being constructed and arranged to produce a high-tension current, a condenser and spark gap connected with said winding to produce an oscillatory discharge, a Tesla coil connected to and energized by this high-tension secondary winding of the transformer, a set of applicator terminals connected to the Tesla coil, and a second set of terminals connected with and energized by another of the transformer secondary windings, said windings being constructed and arranged to produce a current of comparatively low tension, a common means for regulating simultaneously the currents derived from both sets of terminals, and a second regulating means for regulating the current derived from the first set of terminals independently of the current derived from the second set.

19. An electro-therapeutic apparatus having, in combination, a transformer provided with a primary winding, and a plurality of secondary windings, one of said secondary windings having a ratio of turns to the primary windings to produce a current of comparatively low tension, and another of

said windings having a ratio of turns to the primary winding to produce a high tension current, a condenser and spark gap, together with a Tesla coil, connected with said high-tension winding to produce an oscillatory discharge, this high-tension winding of the secondary being wound separately from and

highly insulated from the first-mentioned secondary winding.

CHARLES E. CAMPBELL.

Witnesses:

HORACE VAN EVEREN,
A. ACKROYD.