

Jan. 19, 1932.

N. H. LOWRY

1,841,968

RADIO SURGICAL APPARATUS

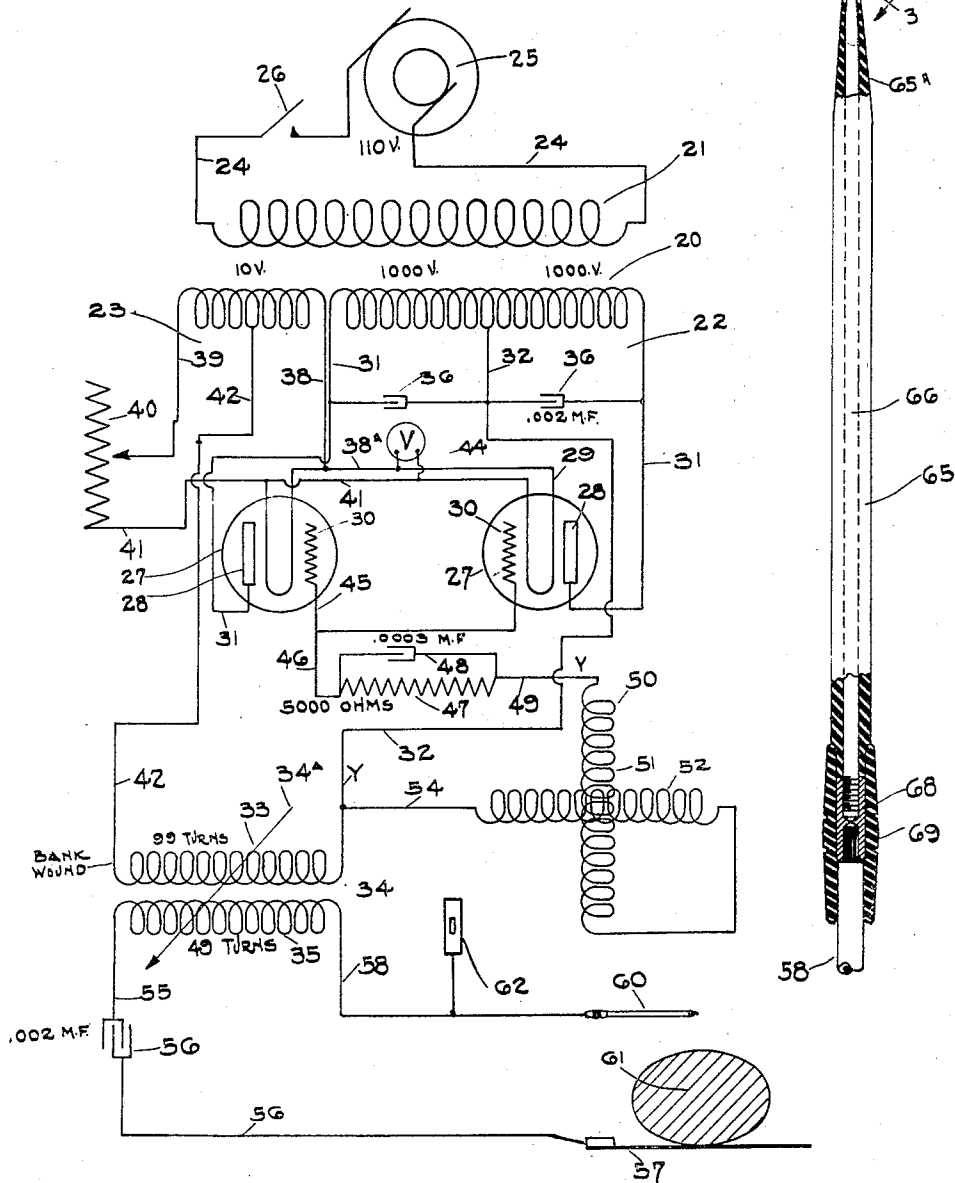
Filed Aug. 16, 1924

4 Sheets-Sheet 1

FIG 1

FIG 3

FIG 2



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FIG 4

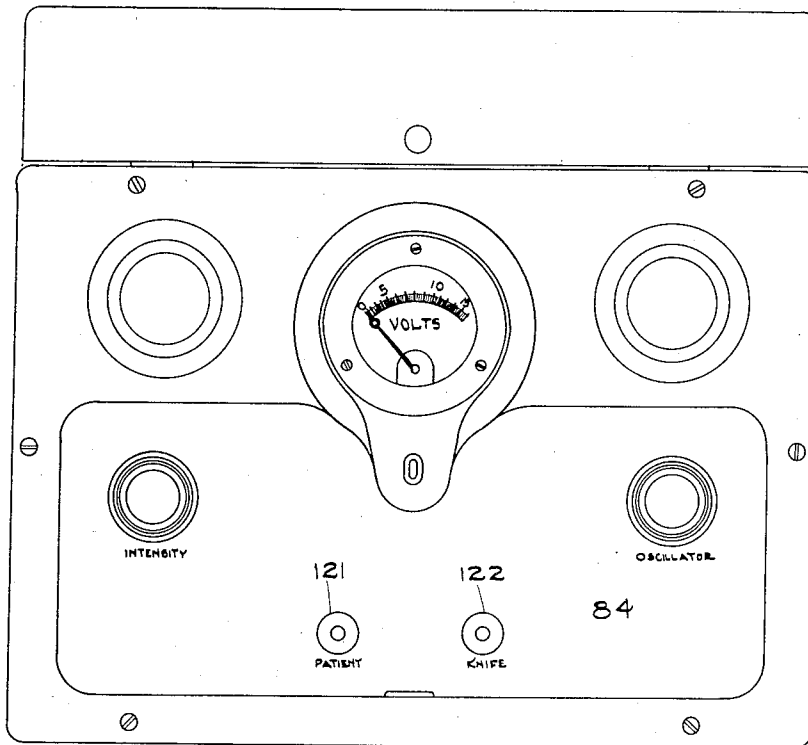
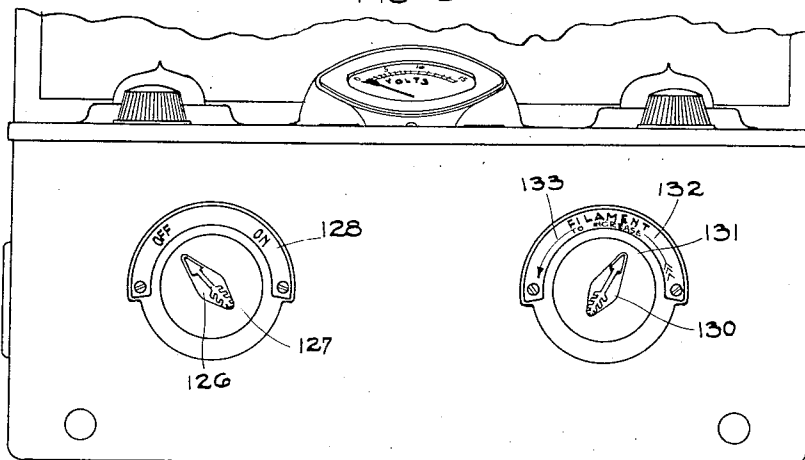


FIG 5



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FIG 6

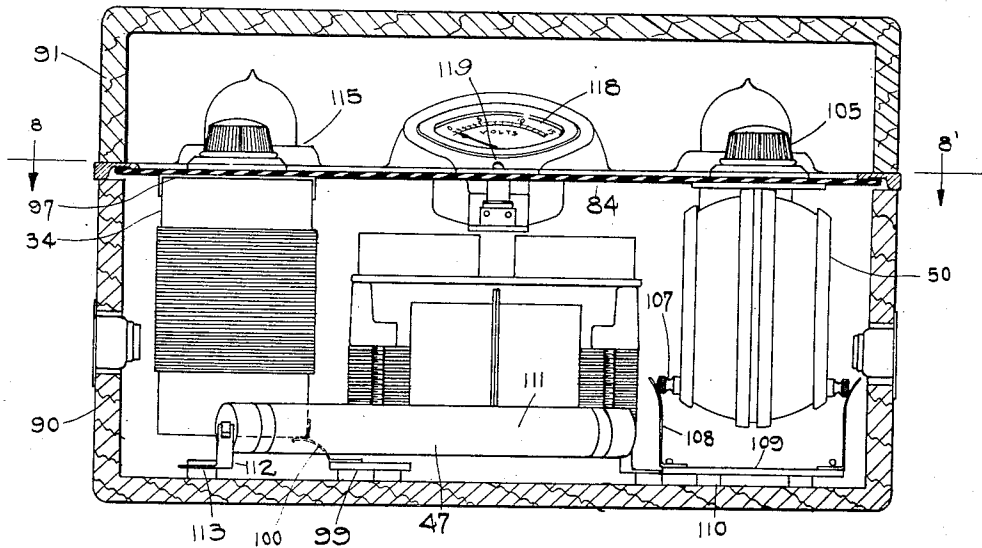
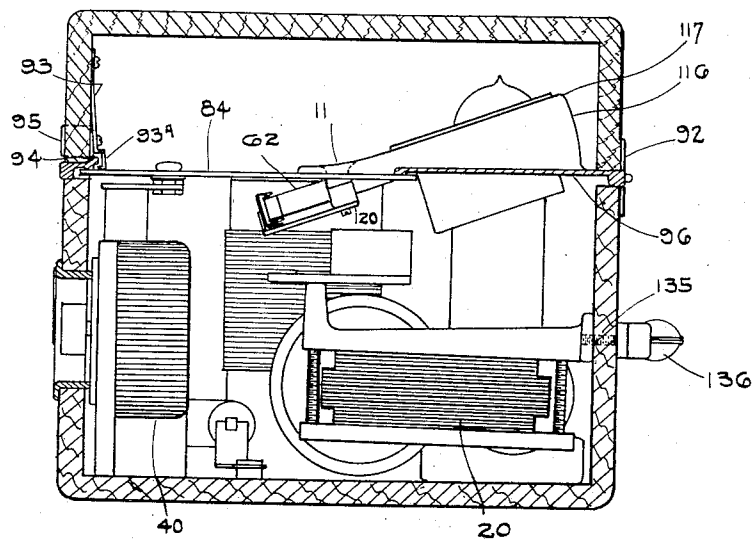


FIG 7



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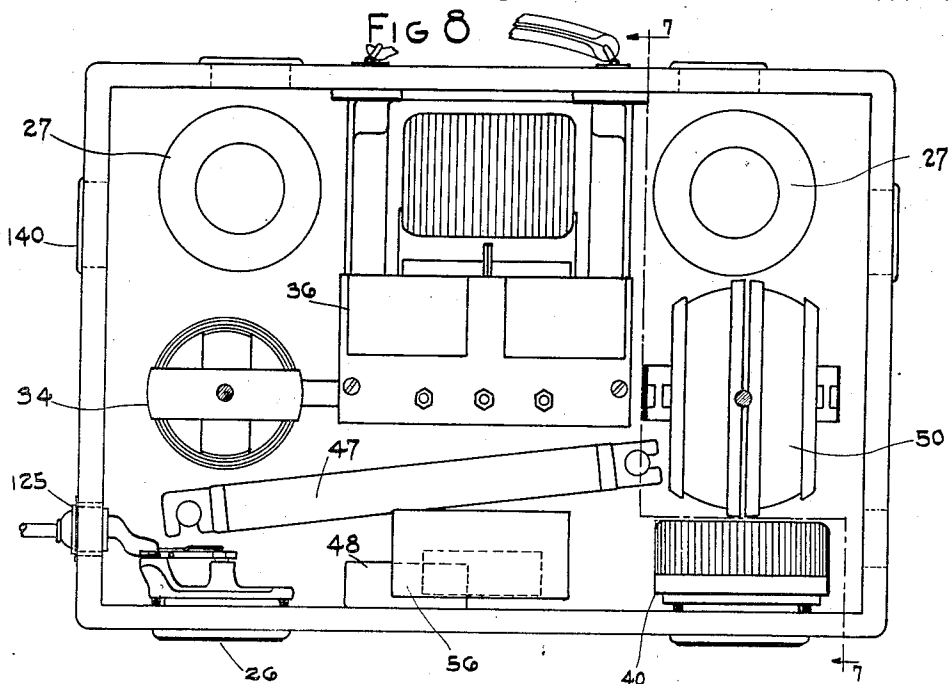


FIG 9

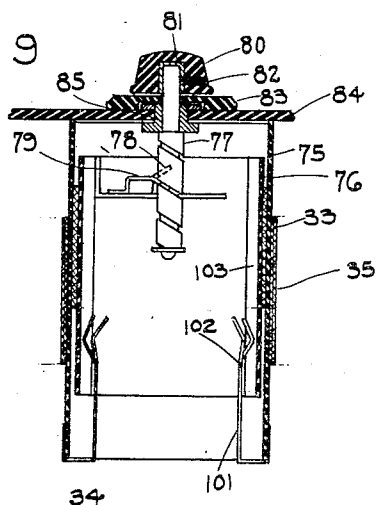
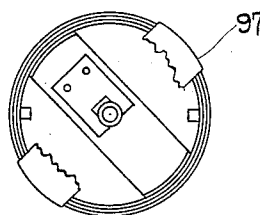


FIG 10



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RADIO-SURGICAL APPARATUS

Application filed August 16, 1924. Serial No. 732,532.

This invention relates to improvements in electro-surgical apparatus which operates by cutting the flesh or other tissue and which may be employed for removing abnormal tissues, for dissecting normal tissues, and for various other surgical purposes. The cutting of the flesh or tissue is effected without carbonization of the tissue by a high frequency electrical discharge such as that which is employed in radio sound transmission. The body of the patient forms one terminal or electrode of a secondary circuit and the other terminal or electrode of this circuit serves as the operating instrument which is manipulated by the surgeon during the process of performing the operation or dissection. This secondary circuit in which these terminals or electrodes are connected, is inductively related by an adjustable high-frequency oscillation transformer with the circuit in which the high frequency oscillations are produced and the frequency of the oscillations may be 3,000,000 per second, for example, or even higher, which is very much higher than any frequency which has heretofore been employed in any form of electro-surgical apparatus. Efforts have heretofore been made to use electrical current discharges for dessication surgery and the like but no satisfactory apparatus has heretofore been produced for surgical dissection and operations such, for example, as the removal of cancers, tumors, and other abnormal growths.

The apparatus of the present invention has numerous advantages and distinguishing features. The electrode itself is not sharp and does not itself sever the flesh, since the cutting is effected by an electric discharge of high frequency, but the electrode may be conveniently manipulated by the surgeon to move the path of the electric discharge and thereby effect a rapid separation of the tissue. Although the electrode is not hot, the electrical discharge operates to seal the tissue like a hot iron, thereby preventing the spread of malignant cells during operations for the removal of cancer growths, for example. The electrical effect also serves to kill cancer cells in the immediate vicinity

of the travel of the electrode. Operations performed by means of this apparatus are almost bloodless except where large blood vessels are severed, and the wounds heal quickly, even more quickly than wounds which are made by ordinary surgical instruments. The cut surface is not burned by the apparatus of this invention, but only slightly dehydrated and this brings about a more rapid healing of the tissues than would otherwise be possible. The apparatus makes possible a greater speed of operation with less fatigue to the patient and also with less fatigue to the surgeon because of the reduced time of the operation and the fact that no pressure is required on the operating instrument. Another important advantage of the invention is that the dehydration prevents bleeding except from large blood vessels which may readily be held by clamps, so that there is little blood loss and the strength of the patient is conserved, while at the same time the operating field is clear due to the fact that the tissues to be operated on are not saturated with blood. The absence of blood in the field of operation reduces the liability of infection and no infection is possible from the operating instrument itself because the wounds are automatically sterilized by the high frequency oscillations as they are being cut.

In addition to the use of the apparatus for the removal of cancerous growths, tumors, ulcers, and malignant lesions of all kinds, the apparatus of the present invention may be employed for all ordinary cautery and fulguration work and with improved results due to the fact that there is less scarring and no burning of the tissue.

Various other objects and advantages of the invention will appear more clearly from the following specification taken with the accompanying drawings in which one embodiment is illustrated. In the drawings Figure 1 is a diagrammatic view showing the circuit connections of the apparatus and the principal parts thereof; Fig. 2 shows an enlarged elevation of the operating handle and electrode with parts thereof broken away to illustrate the interior construction in section;

Fig. 3 is an enlarged section through the movable operating electrode, taken on the line 3—3 of Fig. 2; Fig. 4 shows a top plan view of the cabinet in which the apparatus is mounted with the cover thereof removed; Fig. 5 shows a partial front elevation of the cabinet and apparatus illustrated in Fig. 4; Fig. 6 shows a front elevation of the apparatus with the front of the cabinet and apparatus carried thereby removed; Fig. 7 shows a transverse section taken on the line 7—7 of Fig. 8; Fig. 8 shows a horizontal section taken on the line 8—8 of Fig. 6; Fig. 9 shows a vertical section through the high frequency oscillation transformer, and Fig. 10 shows a top plan view of the structure illustrated in Fig. 9 with parts thereof broken away.

In Figure 1 of the drawings there is shown a diagrammatic representation of the electrical circuit connections which are preferably employed in the radio-surgical apparatus of the present invention. These circuit connections are in some respects similar to the connections which are employed in one form of apparatus for radio sound transmission of the continuous wave type but differ therefrom in certain important features. As shown in the drawings, the apparatus comprises a low frequency transformer 20 having a primary winding 21, a high voltage secondary winding 22 and a low voltage secondary winding 23. The terminals of the primary winding 21 are connected by conductors 24 to a suitable source of supply 25, which may preferably be a 110 volt, 60 cycle, alternating current system. A switch 26 is connected in the primary circuit for controlling the operation of the apparatus. The apparatus comprises two vacuum tubes 27, each comprising a plate 28, a filament 29, and a grid 30, these parts being similar in construction to those commonly employed in radio sound transmission. The high voltage transformer winding 22 has its terminals connected by conductors 31 to the plates 28 of the vacuum tubes, and the middle point of the secondary winding 22 is connected by a conductor 32 to one terminal of the primary winding 33 of a high frequency transformer 34, of the variable type as indicated by the inclined arrow 34^a, which has a secondary winding 35. In order to maintain an exact electrical balance between the divisions of the secondary winding 22 of the transformer 20, condensers 36 are connected between the conductors 31 and the conductor 32 which leads from the middle point of the winding 22, thereby effecting the impression of equal voltages upon the two plates 28 of the vacuum tubes. The low voltage winding 23 of the transformer 20 is connected to the filaments 29 of the vacuum tubes which are arranged in parallel electric circuits. A conductor 38 leads from one terminal of the winding 23 and is connected to branch conductors 38^a which lead to one terminal of

each of the filaments 29. A conductor 39 leads from the other terminal of the winding 23 to a rheostat 40 and a conductor 41 leads from the other terminal of the rheostat to the other terminals of each of the filaments 29 so that by varying the adjustment of the rheostat 40 the voltage which is impressed on each of the filaments may be regulated as desired. This voltage is indicated by a voltmeter 44. The middle point of the secondary winding 23 of the transformer 20 has a conductor 42 leading therefrom to the terminal of the primary winding 33 of the high frequency transformer 34 opposite that to which the conductor 32 is connected, it being apparent therefore that the terminals of the primary winding 33 are connected to the middle points of each of the secondary windings of the transformer 20.

The grids 30 of the vacuum tubes 27 are connected by conductors 45 to a common conductor 46 which leads through a non-inductive resistance 47, having a condenser 48 connected in parallel therewith, to another conductor 49 which is connected to one terminal of a variometer 50 comprising two inductive windings 51 and 52 which are connected in series and which are capable of relative angular movement in order to vary their inductive effect. The other terminal of the variometer is connected by a conductor 54 to the conductor 32, previously referred to, which leads to one terminal of the transformer winding 33. The variable transformer 34 may be located in inductive relation to the variometer 50 or oscillations may be set up in the transformer due to the usual "feed-back" relation commonly existing in radio circuits.

The switch 26 in the supply circuit of the transformer 20 controls the operation of the apparatus, and having closed this switch and impressed a suitable voltage on the primary winding 21 of the transformer 20, secondary voltages are induced in the windings 22 and 23 and are impressed thereby on the plates 28 and filaments 29 of the vacuum tubes. The voltage on the filaments is indicated by the voltmeter 44, and is regulated by the rheostat 40 until it reaches the value for which the apparatus is designed, preferably about 10 volts. The voltage which is impressed upon the grids 30 of the vacuum tubes and the inductance of the grid circuit are varied by the regulation of the variometer 50 until the whole circuit is brought into oscillation by reason of the oscillatory discharges which take place between the plates 28 and the filaments 29 through the grids 30 which, in the actual construction of the apparatus, are located between them. These undamped high frequency oscillations, are transmitted through the variometer to the primary winding 33 of the oscillation or high frequency transformer 34 with the result that high frequency oscillations are induced in the second-

dary winding 35 of this transformer. The wave length of the oscillations generated by the apparatus may preferably be approximately eighty meters or less with a corresponding frequency of about three thousand seven hundred and fifty kilocycles per second. One terminal of the secondary winding 35 of the oscillation transformer is connected by a conductor 55, leading through a series condenser 56, to a plate 57 constituting an indifferent electrode adapted to contact with the body of the patient constituting the subject to be operated on. A conductor 58 leads from the other terminal of the secondary winding 35 to the movable operating electrode 60 which, upon being brought in proximity to the body of the patient, represented at 61, completes the secondary circuit of the transformer 34, the high frequency discharge between the terminal of the operating electrode 60 and the body of the patient operating to sever the flesh or tissue so that a cut is produced substantially like that made by a sharp knife. A neon tube 62 is connected to the conductor 58, as shown in Fig. 1, to act as an indicator, the character of the discharge within the tube indicating the existence of a sufficiently active high frequency discharge to permit the use of the apparatus for operating purposes. The operating electrode 60, embodied in the apparatus described above, is constructed as shown more particularly in Figs. 2 and 3. It comprises a tubular handle 65 of insulating material having mounted therein a metallic member 66 which terminates in a more or less sharp metallic terminal or electrode proper 67 which is only slightly exposed at the end of the insulating handle so that a point discharge is insured. The metallic member 66 is curved longitudinally and somewhat elliptical in cross-section, to facilitate its use in small openings. The end of the insulating handle 65 adjacent the terminal 67 is tapered as shown at 65^a in order to permit the more ready insertion of the instrument into relatively inaccessible places and at the other end of this operating instrument the metallic conductor 66 is connected by a sleeve 68 with the extremity of the conductor 58 leading from the oscillation transformer 34. An insulating sleeve or ferrule 69 surrounds the conducting sleeve 68 so that the hand of the surgeon is fully protected by insulating material. In using the operating electrode 60 on the body of the patient, the point or extremity of the terminal 67 is directed toward the surface to be cut so that the electrical discharge takes place from the point, as distinguished from the surface or curved side of the terminal. When the extremity of the terminal 67 is brought into proximity with the surface of the flesh or tissue of the patient, a cutting of the flesh or tissue begins immediately due to the high frequency electrical discharge which takes place

and this cutting is effected without actual contact of the terminal 67 with the patient.

The voltage between the body of the patient or subject and the movable operating electrode 60 is regulated by the adjustment of the variable transformer 34, the proper conditions for operating purposes being indicated by the character of the discharge in the neon tube. The variable transformer may preferably be constructed as shown in Fig. 9, where it is shown as comprising an outer stationary sleeve 75 having wound thereon the primary winding 33, and a relatively movable sleeve 76 having wound thereon the secondary winding 35. The windings are arranged on the two sleeves so that they are of the same length longitudinally of the sleeves and the inductive effect is varied by regulating the position of the secondary winding within the primary winding. This is accomplished by means of an adjustable threaded member 77, the threads of which are engaged by prongs 78 formed on a bracket 79 which is secured to the movable sleeve 76. When the adjusting member 77 is rotated, the engagement of the prongs 78 with the threads will effect a corresponding movement of the secondary winding in one direction or the other. The rotation of the adjusting member 77 is effected by means of an insulating cap or handle 80 which is secured to the reduced stem 81 of the adjusting member by means of a set screw 82. The cap 80 is mounted on the end of the part 81 above a collar 83 which seats on an insulating supporting member 84 having mounted therein a bushing 85 in which the part 81 rotates. The proper adjustment of the transformer may be determined by trial of the operating electrode or by observing the neon tube which preferably shows a substantially white light when the proper adjustment of the apparatus is attained.

The various parts of the apparatus which are shown connected in the circuit of Fig. 1 are housed within a box or cabinet 90 having the form illustrated particularly in Figs. 6 and 7. This cabinet is provided with a cover 91 which is hinged at 92 so that it swings upwardly and toward the right as viewed in Fig. 7 in order to reveal certain parts of the apparatus which must be inspected by the surgeon during the operation of the apparatus. The cover is normally held in closed position by means of a spring latch member 93 which is secured on the inside of the cover and which has a hooked extremity 93^a adapted to engage a lug 94 secured to the box or cabinet. The latch member 93 is released from the lug 94 by means of a push-button 95. The top of the box or cabinet is closed beneath the cover by means of the insulating supporting plate 84, previously referred to, and by means of a metallic plate or casting 96 which is secured to

the edges of the box and which supports the insulating plate.

The transformer 34 is mounted in the cabinet 90 as shown in Fig. 6 with the outer cylinder 75 thereof secured to the insulating plate 84 by means of screws or the like connected to the cross arms 97 which are attached to the upper end of the cylinder as shown in Figs. 8 and 10. The lower end of the transformer 34 is spaced somewhat above the bottom of the cabinet and the bottom wall has mounted thereon insulating lugs 99 carrying spring contact clips 100 which are connected in the electrical circuit and which are adapted to establish electrical connection with the secondary winding 35 of the transformer through spring vanes 101 which are attached to the cylinder 75 and which have upwardly directed arms within the cylinder terminating in bifurcated parts 102 which are adapted to slide on contact plates 103 which are suitably insulated and connected to the secondary winding so that an electrical connection is made with the secondary winding in all positions of the sleeve 76.

The variometer 50 is located in the cabinet in a position opposite that of the transformer 34 and is similarly suspended from the insulating plate 84. The variometer is provided with an operating handle 105 which is located above the plate 84 so that it is exposed for operation when the cover is lifted upwardly. The casing of the variometer is provided adjacent the lower part thereof with contact terminals 107 which are adapted to be engaged by flexible springs 108 extending upwardly from an insulating plate 109 located on the insulating lugs 110 secured to the bottom wall of the box or cabinet. In this way an electrical connection is readily made with the terminals of the variometer, it being understood that the springs 108 are connected in the circuit by the conductors heretofore described which are located within the cabinet but are not shown in the drawings, for the sake of clearness.

The grid resistance 47 which is connected in the grid circuit, is located in an insulating tube 111 mounted on the bottom wall of the casing by means of contact springs 112 which are connected to insulating blocks 113 carried by the bottom wall.

The two vacuum tubes 27 are located in the rear corners of the box and their upper ends project through openings 115 in the plate 96 so that they are exposed when the cover 91 is elevated. These vacuum tubes are suitably supported on the bottom wall of the casing as shown particularly in Fig. 7.

Between the openings for the vacuum tubes 27, the plate 96 is provided with an upward projection 116 having a flat face 117 which carries the dial 118 of the voltmeter heretofore referred to. In front of the voltmeter,

the plate 117 is provided with an opening 119 through which the neon tube 62 may be observed by the operator, this tube being mounted on a bracket 120 immediately beneath the plate 84, as shown in Fig. 7. The plate 84 also has mounted therein terminal sockets 121 and 122, as shown in Fig. 4, these sockets being located adjacent the front edge of the insulating plate 84 and being adapted to receive the terminals of the conductors which lead to the electrode 57 and the movable operating electrode 60, respectively.

Other parts which need to be manipulated by the operator of the apparatus are located conveniently in the front wall of the cabinet, as shown in Fig. 5, these being the devices for regulating the resistance in the filament circuit and the switch for controlling the primary circuit of the transformer 20. As shown in Fig. 8, the end wall of the cabinet is provided with a socket 125 through which a connection can be made with the ordinary 110 volt, 60 cycle, alternating current lighting circuit by which the primary of the transformer 20 is supplied. The connections from the socket 125 are controlled by means of the switch 26 which is operated by a shaft extending through the front wall of the cabinet and controlled by an operating handle 126. This handle has an arrow 127 thereon which points toward the various positions of the switch which are indicated by the words "On" and "Off" mounted on a dial plate 128 located around the handle 126. At the other side of the front wall, there is provided a handle 130 for operating the rheostat 40 by which the voltage on the filaments of the vacuum tubes is regulated. The handle 130 is similarly provided with an arrow 131 pointing toward a dial plate 132 which is mounted around the handle and which marked thereon an arrow 133 to indicate the direction in which the handle should be turned to increase the voltage, this voltage being determined by observation of the voltmeter, as heretofore indicated. The rheostat 40 is mounted immediately behind the front wall of the cabinet, as shown in Fig. 7, so that the operating handle 130 can be directly connected thereto.

The transformer 20, which is relatively heavy as compared with the other parts of the apparatus, is mounted between the vacuum tubes 27 and between the positions occupied by the transformer 34 and the variometer 50, as shown in Fig. 7. The frame of the transformer 20 is secured to the rear wall of the casing by means of screws or other fastening devices 135 which also serve as fastening means for securing in place a handle 136 by which the entire apparatus can be carried from one place to another. In this way the heavy part of the apparatus has a direct connection with the supporting handle. The condensers 36 are mounted above the casing of the transformer and the other condensers 48

and 56 are located in proximity to the front wall of the casing, as shown in Fig. 8, so that all of the principal parts of the apparatus are contained within the cabinet. All of the wiring connections, except those leading from the source of supply and the insulated conductors which lead to the electrodes 57 and 60, are also contained within the cabinet, but for the sake of clearness these conductors have not been shown in the drawings of Figs. 4 to 10 inclusive. In order that the heat generated by the apparatus may be dissipated and the apparatus maintained in a sufficiently cool condition during its operation, the cabinet 90 is provided with a plurality of ventilating openings which are covered by perforated caps 140 having openings therethrough of sufficient size to permit a thorough ventilation of the interior of the cabinet. The parts of the apparatus of the present invention may be constructed according to various designs and the resistances, inductances, and capacities may have various values and relative values. In one form of apparatus which has heretofore been successfully operated for surgical purposes of the type hereinbefore referred to, a 110 volt, 60 cycle alternating current was impressed on the primary of the transformer 20 and the secondary windings of the transformer were designed to give 2000 volts across the secondary winding 22, this voltage being equally divided between the two halves of the winding on opposite sides of the conductor 32, while the secondary winding 23 was designed to give a pressure of 10 volts, subject to regulation by the rheostat 40. The condensers 36 had a capacity of .002 microfarads each and the condensers 48 had a capacity of .0003 microfarads, while the resistance 47 in the grid circuit had a resistance of 5000 ohms. In the apparatus referred to, the high frequency oscillation transformer 34 was designed so that the primary winding 33 bore the relation to the secondary winding 35 of 99 to 49 and the condenser 56 employed in the work circuit had a capacity of .002 microfarad. With these proportions, the apparatus operates to cut the flesh or tissue readily without burning.

It will be apparent that the apparatus not only has the advantages hereinbefore referred to, as well as many others, but that it is compact and may be used and moved about conveniently. In assembling the apparatus in the cabinet the various devices carried by the plates 84 and 96 are first assembled thereon and then upon applying the plates to the cabinet, the transformer 34 and the variometer 50 automatically become electrically connected to the spring contact vanes carried by the casing. In the use of the device, it may be moved from place to place and, in general, it may be operated from the usual lighting circuit.

Although one form of apparatus has been shown and described by way of illustration, it will be understood that it may be embodied in various other forms without departing from the scope of the appended claims.

I claim:

1. In electro-surgical cutting apparatus, an electrical circuit, a vacuum tube device connected in said circuit, said device comprising a plate and a filament and a grid, a source of electric current, means connected to said source for impressing voltages on said plate, said filament, and said grid, said means comprising a plurality of branch circuits, means for varying the voltage impressed on said filament, a variable inductance in the circuit of said grid, a transformer in which high frequency oscillations are produced by the operation of said vacuum tube device, means for connecting one terminal of said transformer to a surgical patient, means for connecting another terminal of said transformer to a movable operating electrode, and means for regulating the inductive effect of said transformer.

2. In electro-surgical apparatus, a source of oscillating current, means for connecting one terminal of said source to the surgical subject, a movable electrode connected to the other terminal of said source and having a sharp point, and an insulating member surrounding said electrode and leaving only the extreme tip portion thereof exposed.

3. In electro-surgical apparatus, a source of oscillating current, means for connecting one terminal of said source to the surgical subject, a movable electrode connected to the other terminal of said source, and an insulating member surrounding said electrode and leaving the extreme end portion thereof exposed, said insulating member and said electrode adjacent said exposed portion of said electrode being curved longitudinally, said exposed portion terminating in a point.

4. In electro-surgical apparatus, the source of oscillating current, means for connecting one terminal of said source to the surgical subject, a movable electrode connected to the other terminal of said source, and an insulating member surrounding said electrode and leaving the end portion thereof exposed, said exposed extremity of said electrode being elliptical in cross section.

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