July 14, 1931. W. T. BOVIE 1,813,902

ELECTROSURGICAL APPARATUS

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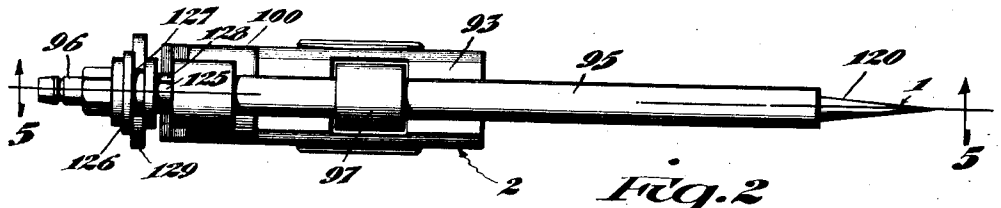

Fig. 2

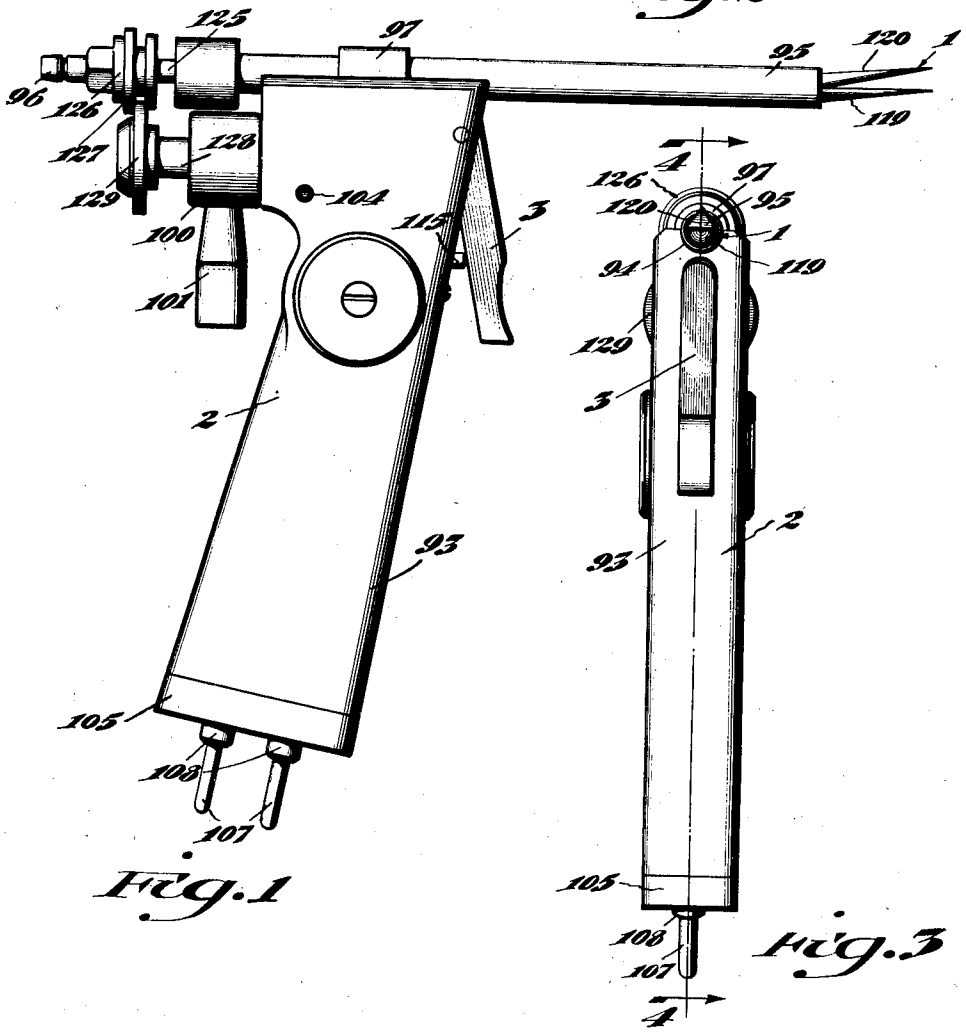

Fig. 1

Fig. 3

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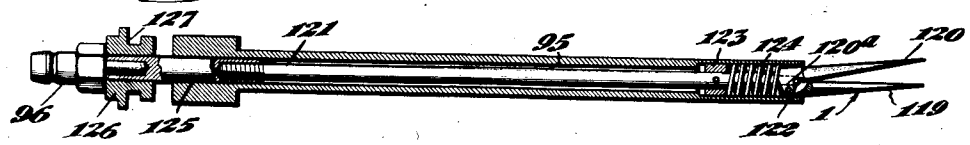
Fig. 5



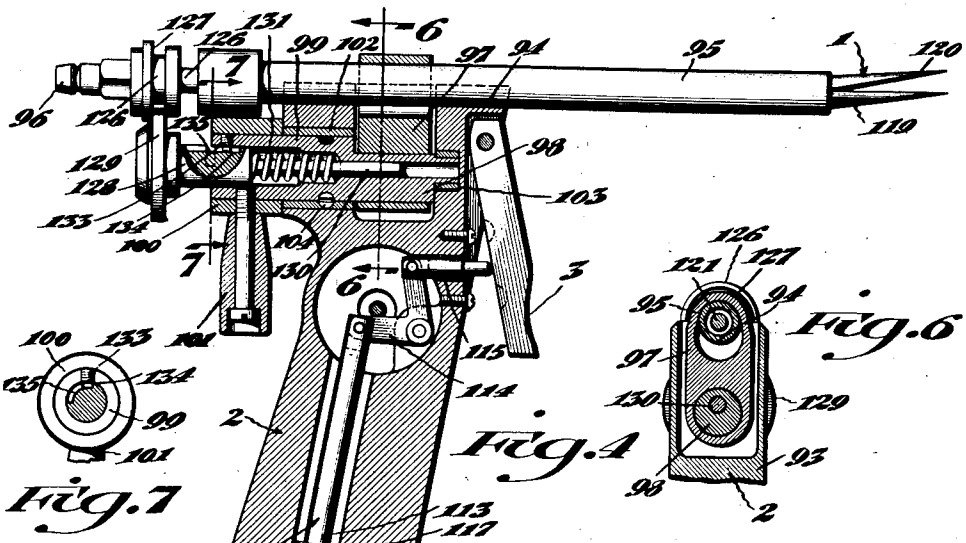


Fig. 4

Fig. 6

Fig. 7

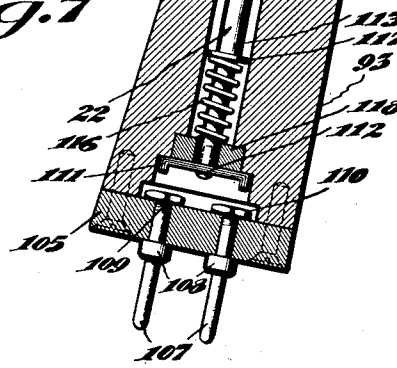


Fig. 9

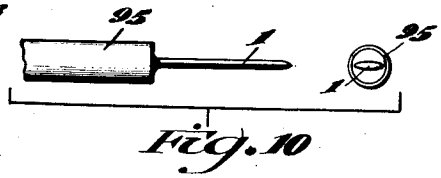


Fig. 10

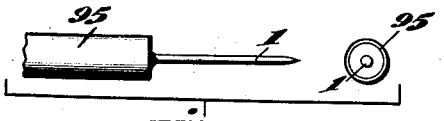
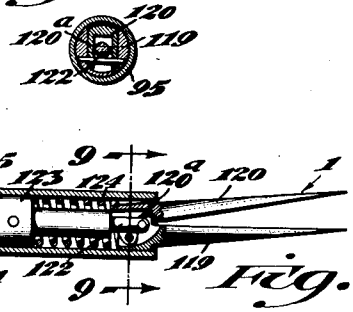


Fig. 11



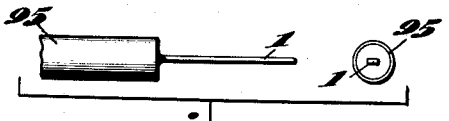


Fig. 12

Fig. 8

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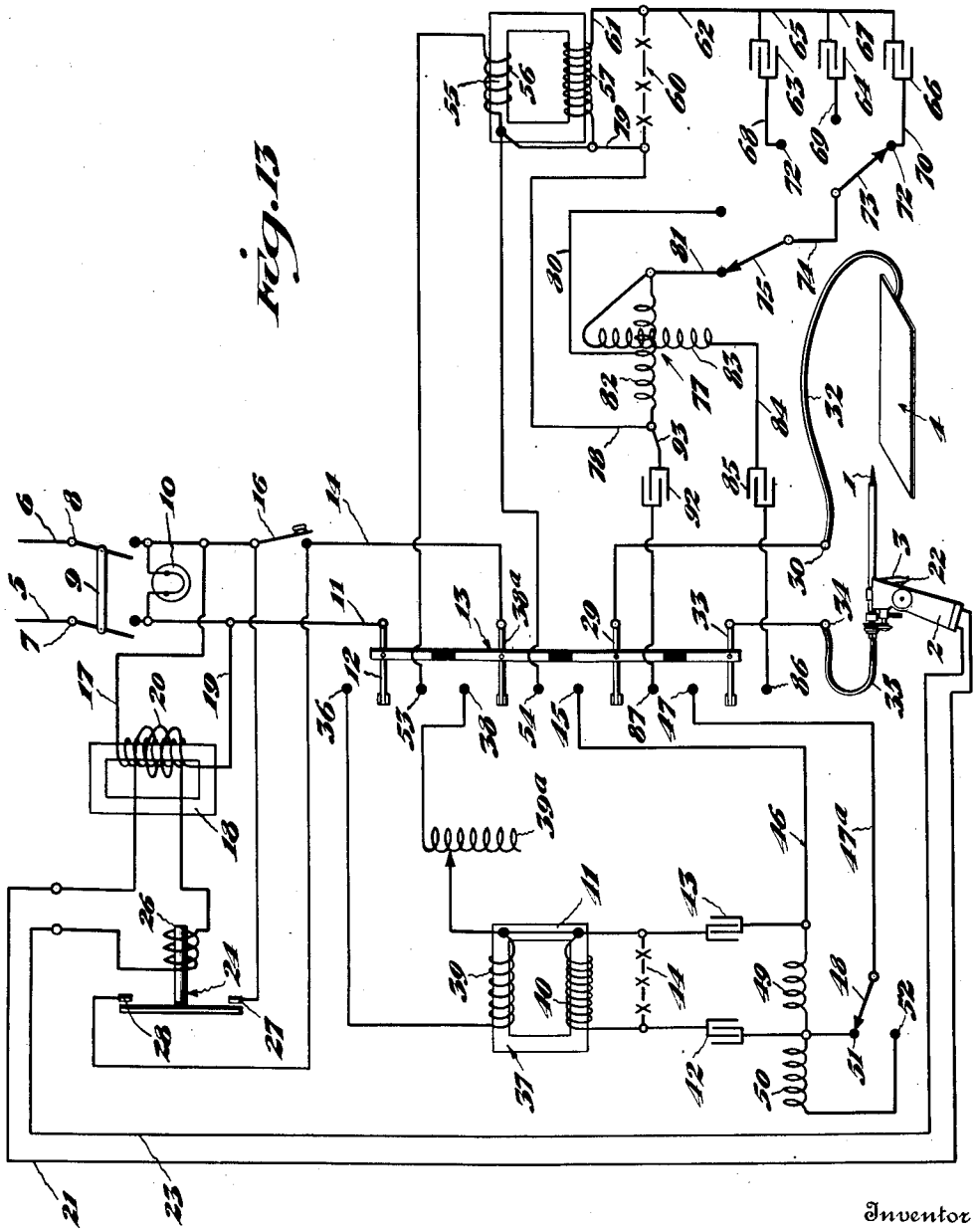
Fig. 13



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Patented July 14, 1931

1,813,902

UNITED STATES PATENT OFFICE

WILLIAM T. BOVIE, OF EVANSTON, ILLINOIS, ASSIGNOR TO THE LIEBEL-FLARSHEIM COMPANY, OF CINCINNATI, OHIO, A CORPORATION OF OHIO

ELECTROSURGICAL APPARATUS

Application filed January 18, 1928. Serial No. 247,719.

This invention relates to electro-surgical apparatus of the nature disclosed in the application to John G. H. Liebel, Serial No. 229,937, wherein the discharge of electric current from an electrode is used to dissect and/or dehydrate tissue, fat, cartilage, etc., in a surgical operation.

The mechanism of this invention is susceptible to many surgical uses but thus far has been employed most advantageously in eradicating cancerous growths and in operating on very vascular tissue both malignant and benign, such as brain tumors. Both of these specified operations are difficult to perform with the conventional knife due, in the case of cancer, to the likelihood of transplanting malignant cells into the blood stream, and in the case of brain tumor, to the loss of blood and surgical shock.

The electro-surgical apparatus of this invention comprises means for producing a variety of types of high frequency electric current over a requisite power range, means for holding different types of operating electrodes from which the current is discharged, and a remote control switch immediately associated with the electrode holder for turning on and off the primary operating current.

The means for producing the requisite currents is usually enclosed in a cabinet provided with a plug for connecting the power supplying wires, a plug for connecting the flexible wires leading to the electrodes, and a socket for connecting the wires leading to a remote control switch.

According to said invention of John G. H. Liebel, the high frequency electric discharge from a stylus or small electrode is used to sever tissue in a surgical operation and to seal the severed capillaries as the tissue is cut. The current is controllable as to its damping in relation to the tissue being cut in order that the tissue be dehydrated to prevent bleeding.

It is often desirable during an electro-surgical operation to use a very highly damped current which has little or no cutting power but which has great dehydrating, coagulating or desiccating effect on tissue. The use of this type current is desirable to stop the flow of blood from large capillaries or in some cases to destroy tissue altogether. The current having these desiccating or coagulating characteristics must usually be of different voltage and amperage than the current used for cutting tissue.

It is, therefore, one object of this invention to provide an electro-surgical machine adapted to deliver selectively to an operating electrode a plurality of types of high frequency electric currents of variable power.

It is often necessary for a surgeon to change operating electrodes in the course of an operation so it is also an object of this invention to provide an electrode holder readily susceptible to sterilization, the electrodes for which can be quickly and easily interchanged during the course of an operation.

Another object of the invention is to provide a means for turning off and on the operating current, said means associated with the electrode holder in order that the operating surgeon may turn the current on and off without releasing his attention from the steps of the operation immediately at hand.

It is another object of this invention to provide an electro-surgical apparatus having an electrode adapted to utilize both cutting current and coagulating current to best advantage in the severing of tissue and the sealing of capillaries during a surgical operation.

Another object of this invention is to provide an electro-surgical apparatus adapted to provide a plurality of types of current over a wide power range, said apparatus provided with adjustments and controls particularly suited to the convenience of the operating surgeon and his assistants, in order that the proper current may be applied to the patient at the proper time without fail and without danger of confusion which might result, if the switches and controls were improperly grouped or coordinated.

Further objects and advantages will be more fully set forth in the description of the accompanying drawings, forming a part of this specification, in which:

Figure 1 is a side elevation of the electrode holder.

Figure 2 is a top plan view of the electrode holder.

Figure 3 is a front view of the electrode holder.

Figure 4 is a sectional view taken on line 4—4, Figure 3, detailing the switch mounted within the holder for controlling the operating current and also showing the means for controlling the bird's beak type of operating electrode.

Figure 5 is a sectional view taken on line 5—5, Figure 2, further detailing the controlling means for the operating electrode.

Figure 6 is a sectional view taken on line 6—6, Figure 4, detailing the means for clamping the electrode in position on the holder.

Figure 7 is a detailed sectional view taken on line 7—7, Figure 4, detailing the means for securing the bird's beak electrode in closed position.

Figure 8 is a fragmentary sectional view of the outer end of the electrode, being enlarged out of Figure 5, for fully illustrating the construction of the bird's beak type of operating electrode.

Figure 9 is a sectional view taken on line 9—9, Figure 8, further detailing the mechanism shown in Figure 8.

Figure 10 indicates a fragmentary side view of the end of a modified type of electrode and end elevation thereof.

Figure 11 is a combination of views taken similar to Figure 10, showing another modified form of electrode.

Figure 12 is a combination of views taken similar to Figure 10, illustrating still another form of electrode.

Figure 13 is a wiring diagram illustrating the various circuits employed for providing the operating current which the electrode holder shown herein is used to apply.

This electro-surgical apparatus comprises a small or operating electrode 1, a holder 2 for said electrode, a switch in said holder operated by a trigger 3, said switch adapted to turn off and on the operating current, a large electrode 4, preferentially used to form a return path for the current, said large electrode being placed in contact with the patient, a unit adapted to provide cutting current, a unit adapted to provide desiccating or coagulating current, and a switch adapted to connect the power supplying wires and the wires to the electrodes to either the cutting or desiccating units alternatively.

The power supplying wires 5 and 6 are connected to the terminals 7 and 8 of the electro-surgical machine. A main switch 9 is provided for turning the current on and off. This supply current is usually 110 volts, 60 cycle, alternating current. Shunted across the power supplying wires is a bulb or glower 10, the function of which is to make a visible signal when the main switch 9 is closed. One of the power supplying wires 11 is connected directly to the first lever 12 of a four lever switch 13. The other power supplying wire 14 is connected to a second lever 15 of this switch, except that this connection 14 is interrupted by a switch 16 which is manually operable to make or break the circuit.

Control unit

Between this switch 16 and the main switch 9 is connected a wire 17 which leads to a transformer 18 of the closed core type as disclosed. The other end of the primary winding of the transformer 18 is connected by means of a wire 19 to the power supplying wire 11. The secondary 20 of the transformer 18 is wound to deliver approximately 10 volts. A wire 21 leads directly from one end of the secondary of the transformer to one contact of switch 22 located in the handle of the operating electrode holder. A wire 23 leads back from the other contact of the switch 22 to the energizing coil of an electro-magnetic switch or relay 24 and thence back to the other end of the secondary of the transformer 18. The armature 26 of the magnetic switch 24 carries a contactor adapted to connect contacts 27, 28. These contacts 27, 28 are connected to the terminals of the switch 16. Therefore, when the trigger in the electrode holder is pressed, the switch 22 is closed and the ten volt current generated by the transformer 18 passes through the electro-magnet, draws the contactor across the contacts 27, 28, and completes the connection across the switch 16. Therefore, it will be observed that switches 16 and 22 are alternatively used to bring the current to the second lever of the four lever switch 13.

The third lever 29 of the four lever switch 13 is connected to a terminal 30 to which is connected the large or indifferent electrode 4 by means of a flexible connection 32. The fourth and last lever 33 of the four lever switch 13, is connected to a terminal 34 to which is attached the operating electrode by means of a flexible connection 35.

The levers of the four lever switch 13 are secured together to move as a unit, so that when they are moved in one direction the power supplying wires and electrode terminals are connected to the input and output terminals of the cutting unit and when moved the other way are connected to the input and output terminals of the desiccating unit.

Desiccating and coagulating unit

One input terminal 36 of the desiccating unit adapted to be contacted by the first lever of the four lever switch 13, leads to the primary 39 of a closed core transformer 37 of the leakage type. The other end of the primary 30 of the transformer 37 is connected to the other input terminal 38 of the desiccating unit, said terminal adapted to be con-

tacted by the second lever 38ª of the four lever contact switch 13. Interposed in the connection from the transformer primary to terminal 38 is a variable choke coil 39ª or another power regulating device. The secondary 40 of the transformer 37 is wound to provide 4000 volts. Both primary and secondary of this transformer are grounded upon the core 41 as disclosed.

One end of the secondary 40 of the transformer 37 is connected to one terminal of spark gap 44. The connection then runs to condenser 42. From condenser 42 connection is made to the middle terminal of the air core resonator 49, 50. From the other end of the resonator 49, 50 connection is made to the other terminal of spark gap 44 and thence to the other end of secondary 40 of the transformer 37, thus completing the primary oscillating circuit.

One end of the resonator 49, 50 is connected by means of wire 46 to the output terminal 45 which is adapted to be engaged by the third lever 29 of the four lever switch 13. From the other output terminal 47 of the desiccating unit (said terminal being adapted to be engaged by the fourth lever 33 of the four lever switch 13) connection is made by wire 47ª to the center of the two pole switch 48.

When the switch 48 is disposed so as to make contact with terminal 51 then the output of the desiccating machine is obtained from the primary portion 49 of the resonator 49, 50. When the switch 48 is disposed so as to make contact with terminal 52 then the output of the desiccating machine is obtained from the whole of the resonator 49, 50, that is, from the primary 49 plus the extended winding 50, thus supplying high voltage output.

The desiccating or coagulating unit, therefore, provides two power controls, first, the choke coil 39ª, the adjustment of which changes primary power, and second, the two pole switch 48, the throwing of which changes voltage output. The elements of this unit are proportioned and constructed as indicated to provide a highly damped high frequency current which readily dries up tissue.

Cutting unit

The input terminal 53 of the cutting unit is adapted to be contacted by the first lever of the four lever switch 13. The input terminal 54 of the cutting unit is adapted to be contacted by the second lever of the four lever contact switch 13. These terminals are connected to the primary winding of a transformer 55.

The primary winding is indicated by numeral 56 and the secondary by numeral 57. Both transformer windings are connected at one end to the transformer core for a purpose later described. Connected in circuit with the secondary of the transformer is a capacity, a spark gap 60, and a reactance or inductance.

More specifically, a wire 61 extends from the secondary terminal of the transformer not connected to the transformer core to one terminal of the spark gap 60. A wire 62 extends from this terminal of the spark gap to one terminal of a twelve plate condenser 63. To this same terminal of the twelve plate condenser is connected a six plate condenser 64, connection being made by a wire 65. A two plate condenser 66 is connected by a wire 67 to the same terminal of the six plate condenser to which is attached the wire from the twelve plate condenser. From the other terminals of these three condensers extend wires 68, 69, 70, respectively, to a multiple contact switch where they are connected to contacts 72 so that a pivoted switch arm 73 can be swung to connect any one of the condensers into the circuit selectively. It is also possible to accomplish the same result by adding capacities in parallel instead of switching in different condensers of different capacities.

Connected to this multiple contact switch arm by a wire 74 is the pivoted arm 75 of a second multiple contact switch. Between this multiple contact switch and the terminal of the spark gap opposite to the one to which the condensers are connected is disposed the primary winding of a variometer 77. The variometer primary is connected to said gap terminal by a wire 78. This terminal of the spark gap is likewise connected with the secondary of the transformer by another wire 79. The connection between the variometer and the two contacts of the multiple contact switch 76 is made by means of two wires 80, 81, one of which disposes more turns of the variometer primary 82 in the circuit than does the other. The secondary variometer coil 83 is pivoted in relation to the primary and is connected to the terminal of the primary coil which disposes the full number of primary turns in the circuit. The other end of the secondary variometer coil is connected by means of a wire 84 to a filter condenser 85 of approximately eight plates, the other terminal of which is connected to the output terminal 86 adapted to be engaged by the fourth arm 33 of the switch 13 for connection to the terminal 34 from which extends the lead wire 35 on the end of which is the operating electrode, which is used in directing the cutting current into the patient. The plate 4 preferably of large area makes the other contact with the patient and is likewise connected to the terminal 30 of the machine by means of the lead wire 32. This terminal 30 is also connected with another output terminal 87 by means of the third arm 29 of the switch

13, the terminal 87 being connected to a filter condenser 92 of eight plates, the other terminal of which is connected by a wire 93 back to the primary of the variometer at the end connected to the spark gap and thence back to the core of the transformer via wires 78, 79.

It is to be noted that the large electrode 4 is connected save for the filter condenser directly to a power supply wire. The filter condenser 92 protects the patient contacting the plate from the 60 cycle current. The transformer which supplies this 60 cycle 110 volt current is always grounded and, therefore, the connection to a supply wire serves as a ground for the 1000 volt high frequency current.

The patient is, therefore, always at ground potential which means that the surgeon and attendants are free to handle the patient during an operation without sparks jumping from the patient to them.

In order to assist the skilled of the art in constructing machines of this type, the following disclosure is made as one example of correct proportioning of parts.

The transformer is preferably of the leakage type commonly used with a spark gap in generating high frequency currents, and delivers substantially 1000 volts from its secondary winding. The spark gap comprises three sets of gaps connected in series, each of which are spaced usually about three-fourths of a thousandth of an inch apart.

It is to be noted at this point that it is requisite to use a spark gap which will maintain relatively constant spacing between the sparking surfaces regardless of changes in thermal conditions. A spark gap of this type is the thermally compensating gap disclosed and claimed in the co-pending application of Edwin S. Flarsheim, Serial No. 161,931. Another type of spark gap which remains relatively constant despite thermal changes is described and claimed in the co-pending application of Edwin S. Flarsheim, Serial No. 228,964.

Were the gap to vary materially in spark electrode spacing during the course of an operation, the current would be altered in quality and quantity and might become intermittent or sputtery in character.

The condensers 63, 64 and 66, are of different capacities to provide different circuit conditions which produce different degrees of damping of the high frequency oscillations. The two plate condenser 66 has an effective area of approximately 2⅝ inches on one side of each plate with a dielectric consisting of approximately six one thousandths of an inch thick mica sheets between said condenser plates. The other two condensers 63, 64, have plates and dielectric of the same dimensions, the increased capacity being attained by increasing the number of plates.

Therefore, when the condenser of small capacity is switched into the circuit, the capacity being small, the discharge is relatively constant and the oscillations relatively undamped, though more damped than would be the oscillations produced by an electron tube. The six plate condenser provides more capacity, less constancy of discharge and greater damping of the high frequency wave trains. The twelve plate condenser 63 provides still more capacity, still less continuous discharge, and still greater damping.

The purpose of the second multiple contact switch 76 is to provide two voltage ranges. By throwing this switch from one contact to the other, the number of turns of wire on the stationary variometer coil is increased from six turns to eleven turns. The secondary variometer coil is provided with approximately twenty turns on an average diameter of about four inches and is pivotable over 180° so that it may be variably adjusted to back or boost the potential of the stationary winding and thereby give delicate control of the output current. Two voltage adjustments are therefore provided. First, the multiple contact switch 76 which provides two voltage ranges, and second, the variometer, the turning of the angular position of which increases or decreases the power in the surgical circuit.

The electrode holder

The electrode holder 2 comprises a handle 93 at the top of which is a concave or V-shaped groove 94, in which is clamped the rod 95 on the end of which is the active electrode 1. The rod is preferably of insulating material such as hard rubber and is provided at the end opposite to the end at which the active electrode is disposed with a stud 96 on which is secured the lead wire from the high frequency machine. Connection is made between this stud and the active electrode through the interior of the rod. This rod is secured at the top of the electrode holder by a block 97, disposed in the top of the electrode holder, said block provided with an elongated aperture, the long axis of which is aligned generally with the longitudinal extent of the electrode holder. The rod 95 extends through this elongated aperture in the block so that the lowering of the block in the electrode holder secures the rod to the seat at the top of the electrode holder. A second aperture is provided in this block within the electrode holder and through this aperture extends the eccentric 98 on a cylindrical member 99.

Therefore, the rotation of this cylindrical member cams the block up and down so that the rod can be removed from the electrode holder or can be clamped thereto. This cylindrical member 99 extends to the outside of the electrode holder where it is provided

with a knob 100 and a handle 101 extending radially from the knob.

Bearings 102 and 103 are provided within the electrode holder for this cylindrical member 99. The cylindrical member is keyed against longitudinal movement in the outer bearing 102 by means of a screw 104 which passes through this bearing and through an annular groove in the cylindrical member 99.

In the end of the electrode holder opposite to the end of which is mounted the active electrode is disposed the switch mechanism 22 which controls the circuit which turns the primary current on and off. This end of the electrode holder is recessed to accommodate the mechanism. Over the recessed end of the electrode holder fits a plate 105 secured to the end by means of screws. In this plate are mounted two members, each of which comprises a prong 107 extending outwardly from the plate, a shoulder 108 disposed against the outside of the plate, and a threaded portion 109 extending through the plate to the other side on which threaded portion is a nut 110.

Reciprocable over these nuts is a contactor 111 adapted to engage and form a pathway for current between them. This contactor is secured by a screw 112 to a plunger rod 113 which extends upwardly through the handle to an annular recess a short distance below the top of the handle. At this point the rod is connected to a bell crank lever 114 which is mounted in the electrode handle. The other end of this bell crank lever is pivoted to a member 115 of insulating material which extends to the outside of the electrode handle, so that the end of it is adapted to be engaged by the trigger 3 which is pivoted to the outside of the electrode handle. The depression of the trigger therefore presses this rod inwardly, swings the bell crank lever, lowers the plunger and closes the switch 22 which is adapted to turn on and off the primary current.

A coiled spring 116 is provided about the plunger and is under compression between an abutment 117 on the plunger and a block 118 secured within the electrode handle. This block 118 also serves as a guide for the plunger.

Electrodes

Various types of electrodes are adapted to be used with this electro-surgical apparatus. For instance, the electrode may be shaped like a small knife as disclosed in Figure 10 with either sharp or dull edges, or the electrode may be shaped like a needle as disclosed in Figure 11 or the electrode may be shaped like a square tipped knife as disclosed in Figure 12.

One type of electrode which has particular utility in relation to a machine of the type disclosed in this application is known as a bird's beak electrode. In the bird's beak electrode the rod 95 is hollow and has mounted at its forward end an active electrode comprising two members, a stationary member 119 secured to the inside of the hollow rod 95 and a member 120 pivoted in relation thereto.

These members form a pair of pinchers or more preferably a delicate pair of tweezers.

The member 120 is provided with arms 120^a formed integrally therewith and it is these arms which are pivoted at their ends to the stationary member 119.

These members 119 and 120 are opened and closed by means of a rod 121 upon the inside of the hollow rod 95. This rod abuts the movable member 120 tangentially in relation to its pivot to close the bird's beak. A pin 122 extends forwardly from the end of this rod and is provided at its end with a cross pin which contacts the arms 120^a so that retracting the rod opens the bird's beak. This rod 121 is provided with a collar 123 pinned thereto. Confined between this collar and the stationary member 119 is a coiled spring 124 under compression. This coil spring therefore holds the bird's beak normally open. Screwed onto the other end of the rod 121 and within the hollow rod 95 is a threaded stud 125 upon which is screwed a collar 126. This collar is provided with an outwardly disposed annular groove 127. A plunger 128 is mounted to reciprocate within the cylindrical member 99. This plunger is provided with an annular flange 129 which is disposed within the annular groove 127 so that reciprocating this plunger in and out closes and opens the bird's beak electrode.

This plunger is provided with a stem 130 about which is a coil spring 131 under compression between the outer portion of the plunger member and a shoulder within the cylindrical member 99. The plunger is keyed to the cylindrical member by means of a screw 133 which extends through the bearing 102 and into the key-way 134 in the cylidrical member. This key-way is provided near its outer end with the annular groove 135. When the plunger is pressed inwardly and then rotated the bird's beak is locked in a closed position by this screw 133, in the annular groove 135 in the plunger (see Figure 7).

In use, the tweezers are closed and cutting done with them as if they were an ordinary electrode. After a large capillary is severed the tweezers are opened and the end of the capillary seized with them. Then the coagulating current is turned on and the capillary dried up. The cutting current is then shifted back and the cutting continued.

This electro-surgical apparatus, therefore, comprises a mechanism which is capable of producing operating current which will cut

the tissue more rapidly than a sharp knife, which will seal the sides of the incision simultaneously, whether the tissue be full of blood or otherwise, which will coagulate the blood and which will dehydrate the tissue, even to the point of its absolute destruction. The operating surgeon has therefore at his command operating currents possessed of many different and desirable physiological effects upon the patient. The controls are conveniently grouped and coordinated so that one switch throws the input and output from the cutting unit to the desiccating unit automatically. The electrode holder or pistol grip, as it is often called, is convenient for the surgeon, is susceptible to sterilization, enables the surgeon to change electrodes rapidly and provides a control of the primary current through the trigger which distracts the surgeon from the operation less than would any other control. The electrodes illustrated meet a variety of surgical requirements. Therefore, the apparatus disclosed provides complete operating equipment for the surgeon.

Having described my invention, I desire to be limited only by the ensuing claims:

1. An electro-surgical apparatus, comprising, an operating electrode, means for supplying said electrode with high frequency operating current, a holder for said electrode, a switch associated with said holder, and a circuit insulated from the power supply circuit, said circuit including said switch and an electro-magnetic switch adapted to turn the operating current on and off by its motion.

2. An electro-surgical apparatus, comprising, an operating electrode, means for supplying said electrode with operating current, a handle one end of which is detachably secured to said electrode, a switch associated with said handle, said switch adapted to turn the operating current on and off, and a trigger mounted in said handle, said trigger connected to the switch in the handle.

3. An electro-surgical apparatus, comprising, an operating electrode, means for supplying said electrode with operating current, a holder detachably secured to said electrode, a control circuit insulated from the circuits supplying the operating current, a switch operated by the control circuit for turning the operating current on and off, and a switch associated with said electrode holder for opening and closing the control circuit.

4. An electro-surgical apparatus, comprising, an operating electrode having the form of a small pair of tweezers shaped when closed to provide an electrode adapted to discharge a cutting current, means for supplying said electrode with tissue cutting current, and means for supplying said electrode with tissue desiccating current.

5. An electro-surgical apparatus, comprising, an operating electrode having the construction of delicate tweezers shaped when closed to provide an electrode adapted to discharge a cutting current, means for supplying said electrode with tissue cutting current, means for supplying said electrode with tissue desiccating current, means for shifting from one type current to the other, and means for holding said tweezers open or closed.

6. An electro-surgical apparatus, comprising, an operating electrode having the construction of a delicate pair of tweezers shaped when closed to provide an electrode adapted to discharge a cutting current, means for generating tissue cutting current, means for generating tissue desiccating and coagulating current, means for supplying power to said apparatus, and a switch for connecting said electrode and said current supply to the means for generating the tissue cutting current and the means for generating the tissue desiccating and coagulating current selectively.

7. An electro-surgical apparatus, comprising, an operating electrode, means for supplying said electrode with different degrees of damped operating current, a holder detachably secured to said electrode, a control circuit induced by but insulated from the circuit supplying the operating current, a switch operated by the control circuit for turning the operating current on and off, and a switch associated with said electrode holder for opening and closing the control circuit.

8. An electro-surgical apparatus, comprising, an operating electrode, means for supplying said electrode with different degrees of damped operating current, a control circuit induced by but insulated from the circuit supplying the operating current, a switch operated by the control circuit for turning the operating current on and off, and a switch accessible to the operator for opening and closing the control circuit.

9. An electro-surgical apparatus, comprising, means for generating currents suitable for surgical operations, and an active electrode connected therewith, said electrode constructed in the form of a delicate pair of tweezers and shaped externally to constitute when closed an electrode suitable for discharging the operating current.

In witness whereof, I hereunto subscribe my name.

WILLIAM T. BOVIE.