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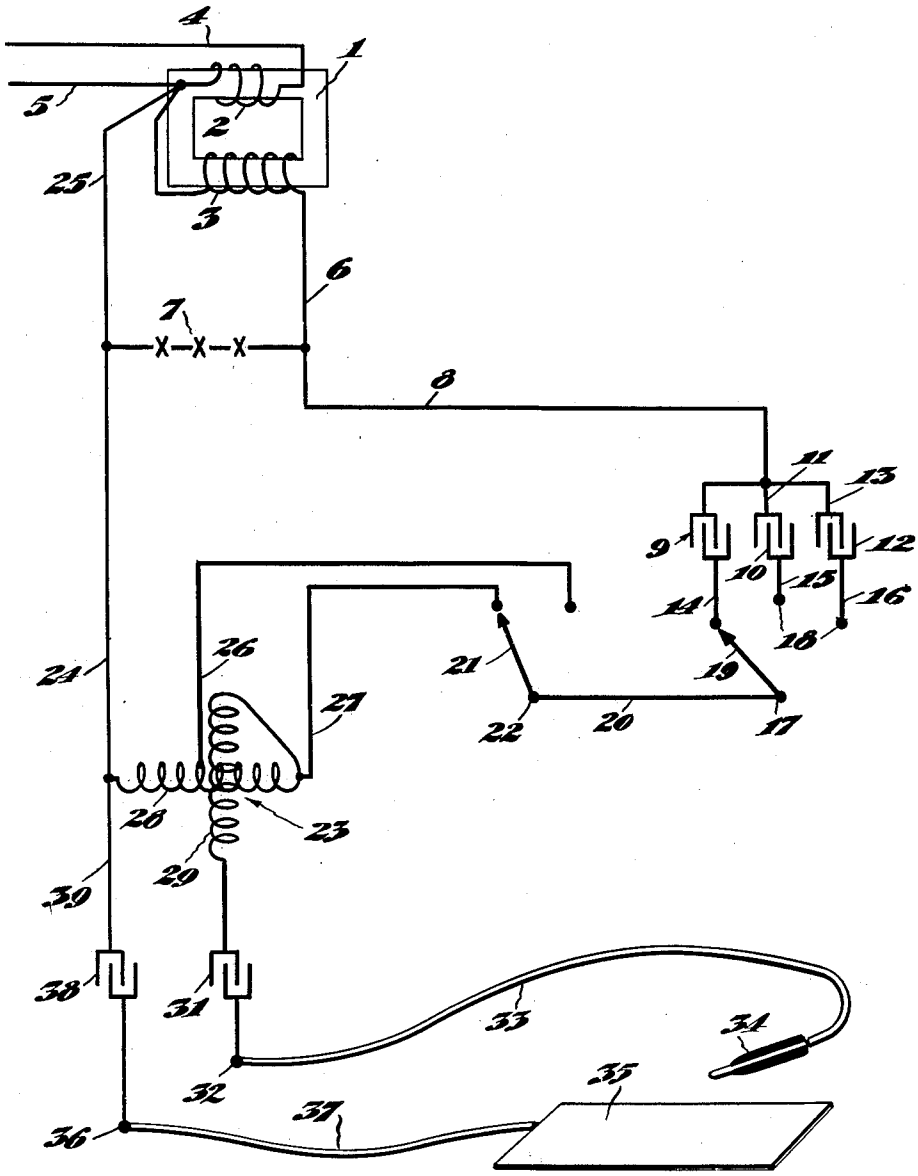

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SURGEON'S INSTRUMENT

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This invention relates to a surgical instrument to be used as a scalpel and also to a method of cutting tissue, fat, cartilage, etc. in surgical operations.

The mechanism and method of this invention are susceptible to many surgical uses but thus far have 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 present invention permits the rapid cutting of tissues and the sealing of the severed capillaries and lymphatics simultaneously, thus avoiding the spread of malignant cells, infection, the loss of blood, and the loss of time involved in checking hemorrhage and capillary seepage by conventional methods.

Moreover, the use of this invention enhances the patient's chances of recovery in that less time is consumed and there is less surgical shock than would be the case were the usual steel knife used.

It has long been known that electricity discharged into the human body with sufficient concentration has a disrupting effect upon tissue. A direct current at adequate potential would cut tissue but would at the same time produce a very unwholesome, if not fatal electrical shock to a living being as well as undesirable chemical action. Low frequency alternating current would administer a more severe electrical shock than direct current. In order to avoid these difficulties, high frequency currents have had the most common medical application for generating heat within the tissues. It has also been recognized that an undamped high frequency current is capable of disrupting tissue. This is due to the heat generated by the current as it is discharged from a needle or edge. A current of this nature, however, burns or carbonizes the tissue in its immediate path, thereby causing the generation of dangerous toxines. Moreover, a current of this nature does not prevent the bleeding of the patient unless the cutting is done so slowly that a considerable depth of flesh is charred.

One object of this invention is to provide a method of cutting living tissue with an electric current whereby a minimum of tissue is injured.

In performing a surgical operation, such as removing a brain tumor, it is desirable to work as rapidly as possible in order to minimize the shock. During such an operation it is necessary to dissect many varieties of tissue some of which bleed readily and profusely and some less so. It is therefore advisable that the cutting current be controllable so that its cutting characteristics as well as its power of stopping blood flow or dehydrating the tissue can be varied promptly at the will of the operating surgeon.

Therefore, a second object of this invention is to provide a mechanism for cutting living tissue with an electric current, the characteristics of which current are controllable by the surgeon in relation to the tissue being dissected.

Some tissue is more easily cut than other tissue and it is therefore another object of the invention to provide a mechanism of the class described wherein the power of the cutting current is controllable, as well as the characteristics of the current wave.

In order to cut the tissue it is requisite to have available approximately 1000 volts. If the patient were charged with this voltage sparks would jump from the patient to the hands of the surgeon and attendants as they handled the patient during the operation.

Therefore, another object of the invention is to provide an electrical cutting instrument wherein the patient is maintained at a potential such that the surgeon and the attendants can handle the patient freely without receiving electrical discharge from the patient.

Another object of the invention is to provide a mechanism of the class disclosed which insures the patient against harmful results

arising from low frequency oscillation or surges and from electrical shock from the commercial current supply due to grounding of the patient.

This method of cutting living tissue, comprises, the application of the electric current discharged from the edge of an instrument to the tissue to be severed, said current characterized by a high frequency and the partial damping of the oscillations.

The characteristic of a direct current, an alternating current or of an endamped or continuous wave high frequency current is that it flows through a definite and limited path in the living tissue thereby disrupting or charring the cells in that path. The characteristic of a highly damped high frequency current is that it flows through a multitude of paths in the tissue thereby heating a large area but destroying fewer cells having a desiccating rather than a charring or burning action. The characteristic of the partially damped high frequency current of this invention is that it follows a sufficiently direct path immediately ahead of the instrument from which it is discharged to part the tissue ahead of said instrument but also makes contact with the tissue at a multitude of loci thereby drying or dehydrating the sides of the incision with a very limited amount of burning, charring, or cell destruction.

The mechanism best adapted to produce this surgical wave includes an instrument, stylus, needle, knife or electrode adapted to discharge the high frequency current into the patient at the locus of the desired dissection, and a plate or large electrode adapted to make a second contact with the patient to make a return path for the current, although in some instances the return path is not essential. The stylus may be of any desired shape or bluntness. Smallness is usually desirable in order to concentrate the current. The blunter the stylus, the greater is the dehydration of the tissue. The stylus and plate are constituted the terminals of a circuit designated the surgical circuit.

A high frequency circuit is so associated with this surgical circuit as to control the wave characteristics of the surgical circuit. This high frequency circuit or control circuit includes a condenser or condensers, a spark gap and an inductance. These three members are proportioned to provide high frequency current of sufficiently constant amplitude to dissect the tisuse, yet of sufficiently inconstant amplitude to dehydrate the sides of the incision. Otherwise expressed, a single alternation of 60 cycle current in the condenser charging circuit produces in the oscillating circuit a series of wave trains, the individual waves of which have differential amplitude, the major amplitude being intermittent, but a certain minimum amplitude being greater than zero throughout the period of the alternation. Obviously, the foregoing description disregards the infinitely brief zero points inherent in the high frequency oscillations at the instant of reversal of polarity of any given oscillation.

Since different tissues have different tendencies to bleed it is desirable that the dehydrating power of the applied current be variable in order to provide for efficient operation on these different tissues. Therefore, the control circuit is provided with means for damping the oscillations to different degrees, such as a plurality of condensers of different capacities selectively incorporable in said control circuit.

The power is supplied to this control circuit by a step-up transformer which is in turn supplied with the conventional 110 volt 60 cycle alternating current. The control and surgical circuits can be variously associated one method being the associating via a variometer whereby the control circuit generates current in the surgical circuit, the power in the surgical circuit being a function of the variometer setting. It is likewise feasible to connect the control circuit with the grid circuit of a three element vacuum tube, and the surgical circuit with the plate circuit so that the control circuit determines the characteristics of the current in the surgical circuit.

Another feature of this mechanism for producing a proper current for tissue dissecting purposes is the presence of filter condensers in the surgical circuit. These filter condensers filter out and protect the patient from low frequency currents which might result from heterodyming or other causes or from a 60 cycle in case of accidental grounding of the patient or operator.

Other objects and further advantages of the invention will appear in the description of the accompanying drawing, in which:

Figure 1 is a schematic diagram of a surgeon's electric scalpel, showing the preferred wiring of the circuits.

A transformer 1 is provided with a primary 2 and a secondary 3. Both transformer windings are connected at one end to the transformer core for a purpose later described. The primary is connected with the source of current supply by means of wires 4, 5. Connected in circuit with the secondary of the transformer is a capacity, a spark gap 7, and a reactance or inductance. More specifically, a wire 6 extends from the secondary terminal of the transformer not connected to the transformer core to one terminal of the spark gap 7. A wire 8 extends from this terminal of the spark gap to one terminal of a twelve plate condenser 9. To this same terminal of the twelve plate condenser is connected a six plate condenser 10, connection being made by a wire 11. A two plate condenser 12 is connected by a wire 13 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 14, 15, 16, respectively, to a multiple contact switch 17 where they are connected to contacts 18 so that a pivoted switch arm 19 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 20 is the pivoted arm 21 of a second multiple contact switch 22. Between this multiple contact switch 22 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 23. The variometer primary is connected to said gap terminal by a wire 24. This terminal of the spark gap is likewise connected with the secondary of the transformer by another wire 25. The connection between the variometer and the two contacts of the multiple contact switch 22 is made by means of two wires 26, 27, one of which disposes more turns of the variometer primary 28 in the circuit than does the other. The secondary variometer coil 29 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 30 to a filter condenser 31 of approximately eight plates, the other terminal of which is connected to the machine terminal 32 from which extends the lead wire 33 on the end of which is the electrode 34 or small knife preferably having a blunt or dull edge which is used in directing the cutting current into the patient. A plate 35 preferably of large area makes the other contact with the patient and is likewise connected to a terminal 36 of the machine by means of a lead wire 37. This terminal 36 is also connected with a filter condenser 38 of eight plates, the other terminal of which is connected by a wire 39 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 24, 25.

It is to be noted that the plate 35 is connected save for the filter condenser directly to a power supply wire. The filter condenser 38 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 which are spaced usually about 3/4–1/1000 of an inch apart apiece.

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 9, 10, and 12, are of different capacities to provide different circuit conditions which produce different degrees of damping of the high frequency oscillations. The two plate condenser 12 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 9, 10, 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 9 provides still more capacity, still less continuous discharge, and still greater damping.

The purpose of the second multiple contact switch 22 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 out-put current. Two voltage adjustments are therefore provided. First, the multiple contact switch 22 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.

It will be observed that the variometer primary serves as an inductance for the oscillating circuit and thereby performs a dual function.

In using this machine in a surgical operation, the surgeon uses the light dehydration as is represented by the use of the two plate condenser 12 for cutting through fat or through tissue not particularly inclined to bleed. After areas are reached which are more inclined to bleed, condenser 10 or 9 is switched into circuit in place of condenser 12 thereby increasing the dehydration and permitting the continuance of the cutting and the sealing of the walls of the incision simultaneously.

Having described my method of performing surgical operations and my surgeon's scalpel, I desire to be limited only by the following claims:

1. A surgeon's instrument for dissecting tissue, comprising, a surgical circuit including means for discharging a series of sparks into the patient, a control circuit adapted to produce high frequency oscillations, said control circuit including a spark gap, an inductance and a plurality of capacities selectively incorporable in said control circuit to provide variable circuit capacity and corresponding oscillation damping, and means associating said surgical and control circuits so that the control circuit determines oscillations in the surgical circuit.

2. A surgeon's instrument for dissecting tissue, comprising, a surgical circuit including means for discharging a series of sparks into the patient, a control circuit adapted to produce high frequency oscillations, said control circuit including a spark gap, an inductance and a plurality of condensers selectively incorporable in said control circuit to provide variable circuit capacity and corresponding oscillation damping, means associating said surgical and control circuits so that the control circuit determines oscillations in the surgical circuit, and filter condensers in said surgical circuit to protect the patient from low frequency surges.

3. A surgeon's instrument for dissecting tissue, comprising, a surgical circuit having means for discharging sparks into the patient located therein, a control circuit adapted to produce high frequency oscillations, said control circuit including a spark gap, an inductance and a plurality of condensers selectively incorporable in said control circuit to provide variable circuit capacity and corresponding oscillation damping, a variometer associating said surgical and control circuits so that the control circuit determines the oscillations in the surgical circuit, filter condensers in said surgical circuit to protect the patient from low frequency surges, and a transformer for supplying said circuits with high potential electrical current.

4. A surgeon's instrument, comprising, a surgical circuit having means disposed therein adapted to direct a tissue cutting electric current into the patient, a control circuit adapted to determine high frequency oscillations in said surgical circuit, a variometer associating said surgical and control circuits, and means in the control circuit adapted to dispose different numbers of turns of the variometer primary in circuit to provide a plurality of voltage ranges.

5. A surgical instrument, comprising, an instrument-electrode adapted to discharge a tissue cutting electric current into the patient, means for charging said electrode with high frequency oscillating current, and means for varying the damping of said oscillations.

6. A surgical instrument, comprising, an instrument-electrode adapted to discharge a tissue cutting electric current into the patient, means for charging said electrode with high frequency oscillating current, means for varying the damping of said oscillations, and means for varying the voltage of said current.

7. A surgical instrument, comprising, an instrument-electrode adapted to discharge a tissue cutting electric current into the patient, means for charging said electrode with high frequency oscillating current, means for varying the damping of said oscillations, means for varying the voltage of said current minutely, and means providing a plurality of voltage ranges.

8. Apparatus for dissecting tissue, comprising, an electrode adapted to discharge an arc, mechanism for supplying said electrode with high potential high frequency partially damped current, and means for varying the damping of said current.

9. Apparatus for severing tissue, comprising, an instrument adapted to discharge a severing arc, mechanism for providing a high frequency electrical current, means for varying the damping of said current, and a device connecting said instrument and said mechanism, said device adapted to determine the power of the arc discharged by the instrument.

10. Apparatus for severing tissue, comprising, an instrument adapted to discharge a tissue severing arc, a spark gap, an inductance and a plurality of capacities selectively connectable with said spark gap and said

inductance to provide a high frequency current predeterminably damped, and means associating said instrument with said current-producing mechanism.

11. Apparatus for severing tissue, comprising, an instrument adapted to discharge a tissue severing arc, a spark gap, an inductance and a plurality of capacities selectively connectable with said spark gap and said inductance to provide a high frequency current predeterminably damped, and power controlling means associating said instrument with said current-producing mechanism.

In witness whereof, I hereunto subscribe my name.

JOHN G. H. LIEBEL.