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ELECTROSURGICAL APPARATUS

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Fig. 1

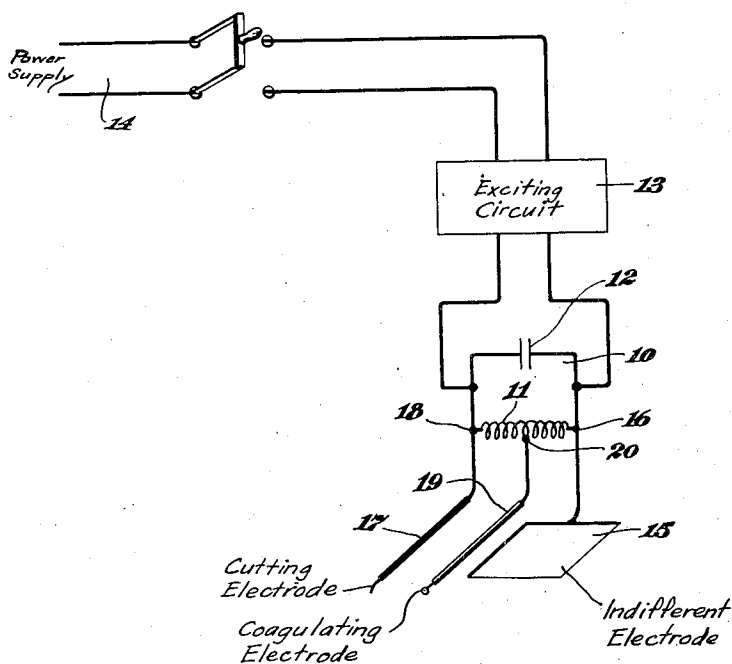
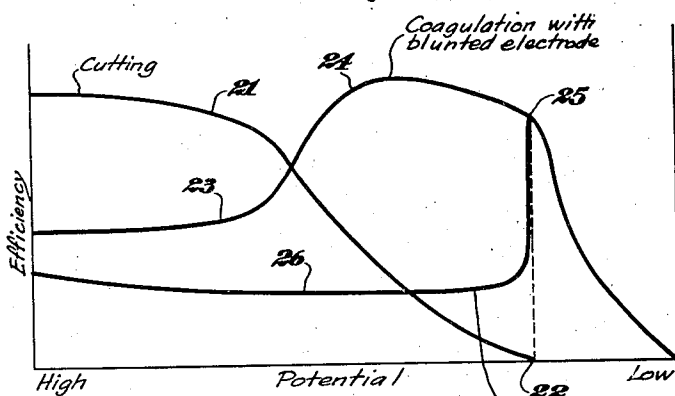


Fig. 2



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ELECTROSURGICAL APPARATUS

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3 Claims. (Cl. 174-177)

My present invention relates generally to the electrosurgical art, and has particular reference to a new and improved method and apparatus for treating body tissue or the like with high-frequency currents.

While the characteristics and capabilities of high-frequency alternating currents, with respect to their effects upon the body tissue, are not as yet fully or thoroughly understood by those skilled in the art, certain unique abilities of high-frequency currents, when properly generated and applied to the body, are of definite and recognized effectiveness in performing various surgical operations. Apart from the purely heat-generating powers of such currents, the profession is steadily coming to look with more and more favor and approval upon the two types of phenomena generally referred to as "cutting" and "coagulation".

It is generally perceived that a cutting effect is usually best accomplished by means of an attenuated type of electrode; that the effect is accompanied by more or less violent sparking; and that in all probability the results achieved are due to extreme concentration of high-frequency current. The so-called "coagulation" effect is generally looked upon as a milder case of the same phenomenon, but whether this is so is at least open to question. The effect is usually produced with relatively blunted instruments or electrodes; it has been heretofore often accompanied by a degree of sparking; and it produces a sort of penetrative desiccation of tissue which is less than a sear or burn and which is akin to the change which tissue undergoes when it is cooked.

It is desirable to have both of these phenomena available and under control during almost any operation. While a certain amount of coagulation is effected by a cutting electrode during a cutting procedure, an electrode is usually thought of as primarily delivering a cutting current or a coagulating current; and where a cutting electrode is sought to be used for a coagulation effect, it has been customary heretofore to modify the current delivered by it whenever the effect desired is primarily coagulative in character.

It is therefore not surprising to find that a number of attempts have heretofore been made, and sometimes successfully, to provide a means for quickly and effectively altering the characteristics of current fed to an electrode to permit the operator to use a single electrode, at will, for either cutting or coagulation.

It has been found satisfactory, for example, to interpose an impedance, at will, into series with the cutting electrode. While this permits the electrode to be used, after a fashion, as a coagulating tool, it is obvious that this type of arrangement is essentially a wasteful and inefficient one. Sometimes, the input power to the oscillating or tank circuit of the high-frequency generator has been reduced to permit an electrode, used primarily for cutting, to be utilized at will as a coagulating tool. In other instances, apparatus has been devised for completely altering the characteristics of the oscillating or tank circuit and for simplifying the facility with which such a complete change-over can be accomplished by the operator.

Circuits have also been devised, as, for example, in the Bauer Patent No. 1,645,215, to permit a cutting procedure to be effected with one adjustment of the apparatus, and a coagulating procedure to be effected at another portion of the apparatus and by making various adjustments therein.

So far as I am aware, nobody has ever hitherto been successful in devising an apparatus or method whereby a cutting electrode and a coagulating electrode could be simultaneously utilized in association with a single generating apparatus; and it is a general object of my present invention to provide a method and apparatus of this character.

Stated otherwise, it is an object of my present invention to provide a method and apparatus whereby adjustments of the generating apparatus, either by interposition or withdrawal of impedances, reduction or modification of input power, alterations in essential characteristics, or other modifications of hook-up or operation, are utterly unnecessary and are dispensed with, while cutting and coagulating effects may nevertheless be simultaneously capable of accomplishment. The advantages achieved will, of course, be obvious to those skilled in the art. Stability and simplicity of operation are enhanced; substantial economies in manufacture are effected; manipulations and adjustments by a surgeon, usually not thoroughly familiar with electrical phenomena and apparatus, are rendered unnecessary; and the operative procedures themselves are caused to be simpler, more efficient, and safer. With a single apparatus of my present character, it is possible, for example, for a surgeon to wield a cutting electrode while his assistant may at the same time wield the coagulating electrode and thereby effect hemostasis at the point

or points required, as the main operation proceeds. Similarly, a single tool may be feasibly provided with two operative heads or electrodes thereon, one being primarily and continually a cutting tool, while the other is simultaneously and continually available as a coagulating tool.

A particular feature of my invention lies in providing an apparatus which permits these desirable effects to be accomplished without impairment of the stability or efficiency of either the cutting or the coagulating. So far as I am aware, all previous attempts simultaneously to produce these two effects from a single apparatus have been uniformly unsuccessful; the drainage of current from a coagulating electrode has always seemed to impair the current fed from the cutting electrode, and vice versa, as a result of which the cutting electrode has been caused to balk or sputter, the coagulating electrode has been seriously slowed up in its effect, and neither electrode has served to accomplish its desired effect with any sort of satisfactory efficiency.

My invention is predicated upon a thorough study and analysis of the characteristics of an oscillating or tank circuit under the conditions which obtain when currents are drained therefrom for cutting and/or coagulating purposes; and it is as a result of such an analysis that I have discovered the existence of a definite and critical range within which the available current is primarily useful for cutting, and the existence of another definite and critical range within which the currents available are primarily useful for coagulation. I have also discovered that there is a critical locality of intermediate potential in an oscillating or tank circuit at which optimum coagulation may be effected without in the least impairing or interfering with the stability or efficiency of optimum cutting within the cutting range.

I achieve the foregoing objects, and such other objects as may hereinafter appear or be pointed out, in the manner illustratively exemplified in the accompanying drawing, wherein—

Figure 1 is a diagrammatic representation of an electrosurgical apparatus embodying the features of my present invention; and

Figure 2 is a graph depicting the characteristics which I have found to exist in an oscillating circuit of an apparatus of the present character.

So far as my investigations have thus far indicated, any convenient or suitable type of generator of high-frequency oscillations may be employed in an apparatus of the present character. Essentially, such a generator will comprise an output oscillating or tank circuit 10 in which an inductance coil 11 and a capacitance 12 are arranged in parallel. Such tank circuit is connected to any suitable type of exciting circuit, which I have diagrammatically indicated by the reference numeral 13. The exciting circuit obtains its power from a suitable power supply 14.

It will be understood that my present invention is not limited to any specific type of high-frequency generator, except in so far as such a generator is provided with an output oscillating circuit of the character indicated at 10. For example, an electrical arrangement of parts of the character shown in my copending application Serial Number 581,908 has proven satisfactory for my present purposes. In this type of generator, the exciting circuit comprises a 3-element vacuum tube, together with such other electrical apparatus, transformers, chokes, and the like

which are necessary or desirable for causing the exciting circuit to draw power from a suitable source of supply and feed it to the oscillating circuit to maintain the latter in a state of oscillation. In the generator described and illustrated in my aforementioned copending application, the power supply is the ordinary commercial current of low-frequency, such as 60-cycle, 110 volt, alternating current.

It will be found that an oscillating circuit of the character designated by the reference numeral 10 will have a portion of relatively low potential and an opposite portion of relatively high potential. In the present drawing, for example, I have shown a relatively large indifferent electrode 15 connected, as at 16, to a point of relatively low or indifferent potential. This indifferent electrode is not always required, but is usually and preferably provided for the purpose of establishing an electrical contact with the body to be treated. I have shown a cutting electrode 17 connected to the oscillating circuit, as at 18, which is at a point of relatively high potential.

It will be understood that the exact difference in potential between the point 18 and the point 16 is very difficult to ascertain by ordinary current-measuring instruments because of the nature of the high-frequency alternating current which flows through the oscillating circuit 10. It will also be understood that the voltage at the point 18 is not necessarily a very high voltage, in the ordinary sense of this term, and is, in fact, relatively low with respect to the magnitudes of voltages which are customarily available and utilized in the electrical art at the present time. The fact is, however, that the point 18 is at a relatively high potential with respect to the point 16; and that between these points, the oscillating circuit will be found to be impressed with a range of intermediate potentials increasing gradually from the point 16 to the point 18.

In accordance with my present invention, a coagulating electrode 19 is connected to the oscillating circuit 10, as at 20, which is a point of intermediate potential. The locality of connection 20 is a critical one, as will be pointed out more clearly hereinafter, and permits both electrodes 17 and 19 to draw the necessary currents from the oscillating circuit 10 for the fulfillment of their respective purposes, without any mutual impairment of effect.

I have illustratively shown the electrode 17 with an attenuated tip or head, since this is usually the type of electrode which is utilized for cutting purposes. Obviously, however, any suitable tip may be provided, as, for example, a loop or the like, the term "cutting electrode" being intended to signify any suitable type of electrode whose function is to produce an effect which is primarily and essentially a "cutting" effect.

Similarly, I have illustrated the electrode 19 as one which is provided with a relatively blunted or thickened head or tip, since this is usually the type of electrode employed for effecting coagulation of tissue. It will be understood, however, that any suitable type of electrode may be utilized for this purpose, and that the term "coagulating electrode" is intended to signify an electrode whose primary and essential effect is to produce desiccation or "cooking" of tissue, as distinguished from "cutting".

The successful achievement of my general objectives and the efficient operation of the apparatus illustrated in Figure 1 is predicated upon a discovery of the existence of certain critical

ranges and phenomena which are more fully illustrated in a graphic manner in Figure 2. The abscissa of Figure 2 represents the gradient potential existing in the oscillating circuit between the points 16 and 18. The potential at the right of Figure 2, for example, is relatively low and has been designated by the term "low"; and the potential increases gradually to the left of Figure 2, at which the term "high" has been used to signify a relatively high potential. The potentials at the opposite extremes of Figure 2 may, for example, correspond to those existing at the points 16 and 18 of Figure 1.

The ordinates of Figure 2 represent efficiency or effectiveness of operation.

The curve 21 is indicative of the cutting effect that may be obtained by the ordinary type of relatively attenuated cutting electrode as the same is connected successively to various points of the oscillating circuit, for example, various points along the coil 11. It has been generally known that a more satisfactory cutting effect is achieved in the area or range of relatively high potentials, but it may not have been fully realized that the cutting effect does not diminish gradually all the way to the low potential or indifferent portion of the circuit, but diminishes with considerable rapidity toward a point 22 below which no cutting effect whatsoever, with even the finest electrode, may be obtained.

At the outset, therefore, I have clearly ascertained that in an oscillating circuit of the present general character, there is a definite potential range within which no cutting at all may be accomplished, and an adjacent range in which the cutting effect or efficiency gradually rises from a barely perceptible one to a substantial and practically useful one.

Within the upper portion of this "cutting" range, even blunted and bulbous electrodes produce effects which are primarily cutting effects, accompanied by a substantial amount of sparking and outright destruction of tissue. When a relatively blunt electrode is successively connected to points of lower and lower potential, the cutting effect diminishes gradually substantially along the line 21, but it will be found that, at the same time, the coagulative effect of such an electrode increases gradually in the manner illustrated by the curve 23 until a point of apparently optimum coagulation 24 is reached. The coagulative effect remains substantial and practically useful until a critical point 25 is reached, below which the coagulative effect diminishes with considerable rapidity toward the low or indifferent end of the oscillating circuit.

All prior attempts, so far as I am aware, to connect a coagulating electrode to an oscillating circuit of the present character have naturally and understandably established connection between the coagulating electrode and the oscillating circuit at a point closely adjacent to the point 24. The utilization of such a coagulating electrode, however, has invariably made it impossible simultaneously to utilize a cutting electrode at the same time. For some reason or other, with such an arrangement, the simultaneous use of a cutting electrode and a coagulating electrode has proven to be unfeasible. Either the coagulating electrode has failed to produce its coagulative effect with satisfactory rapidity, or, more usually, the cutting electrode has been caused to sputter and balk with entirely unsatisfactory and useless results.

My experiments have led me to analyze the

coagulative effects of an extremely fine electrode, and as a result I have made the surprising discovery that the point 24 is only a false or apparent point of optimum coagulative effect, and that the point 25 is the critical point at which optimum pure coagulative effect is capable of achievement. The curve 26 indicates the efficiency or effectiveness of coagulation with the use of a finely attenuated electrode. Starting at the low or indifferent end of the circuit, the coagulative effect is at first almost negligible and practically useless, but it increases with considerable rapidity to the point 25. Unlike the effect produced with a blunted or bulbous electrode, the coagulative effect does not remain substantial and practically useful when connection is made to higher potentials, and the coagulative effect does not increase in apparent value along the line 23, but actually starts to diminish with substantial and remarkable rapidity along the line 26.

The point 25 is, therefore, a critical point at which a finely attenuated electrode will produce an optimum coagulative effect; and this is the point at which the cutting effect is first perceptible.

The remarkable and truly useful characteristic of a connection at the point 25 (or in the locality close to it) lies in the fact that coagulation may be efficiently accomplished even with an electrode of the conventional blunted type, without in the least impairing the cutting effect of a cutting electrode connected to the usual point of relatively high potential. For some reason, which is not entirely clear to me, it appears that a coagulating electrode may draw whatever currents it may need from the locality adjacent to the point 25 to produce an optimum coagulative effect which is entirely practical and useful without in the least impairing the stability or efficiency of cutting effect produced by a cutting electrode operating simultaneously.

My present invention lies in harnessing these phenomena to the present useful purpose of providing an apparatus in which coagulation and cutting may be simultaneously effected from a single high-frequency generator; and the point of connection 20 indicated in Figure 1 is intended to signify the locality adjacent to the point designated by the reference numerals 22 and 25 in Figure 2. In ascertaining this locality, it is merely necessary to employ a finely attenuated electrode and to connect it successively to various points within the low potential range of the circuit. At a certain point of connection, indicated by the reference numeral 22 of Figure 2, sparking will suddenly manifest itself, and this point is capable of easy and definite determination by this method. It is thereupon a simple matter to establish the desired electrical connection with the conventional type of coagulating electrode, and in practice the manufacturer will in all probability connect a tap or binding post to the point 20, so that the surgeon will ultimately be required to do nothing more than connect his coagulating electrode to this tap or binding post.

Stated otherwise, I have found that if a coagulating electrode is connected to the circuit at a point of potential substantially higher than the critical point 20, the efficiency at the cutting electrode will be seriously impaired, and either one or the other electrode will have to be used singly. On the other hand, if the coagulating electrode is connected closely adjacent to the upper limit of the low potential range at which no sparking

occurs with even a finely attenuated electrode, the efficiency at the cutting electrode remains entirely unimpaired. Obviously, it may be desirable to connect the coagulating electrode to a point slightly above the upper end of the low potential range last referred to, but care must be taken to prevent the connection from being made at a point of substantially higher potential than this.

Although I have found it preferable in practice to make the connections of the electrodes to respective points along the inductance coil 11, nevertheless it will be understood that the connections might be made with equal facility to the capacitance side of the oscillating circuit, but in such an event the condenser 12 would have to be subdivided into a large number of separate units arranged in series, since it is obviously impossible to locate and make a connection to a critical potential which might, for example, lie within the dielectric of any given condenser.

Furthermore, it will be understood that in practical usage, it may be desirable to provide any one or more of the electrodes with condensers or similar impedances, for purposes of safeguarding the patient. For example, in the electrical apparatus illustrated in my copending application, a variable capacitance is arranged in series with the active electrode.

Other elements of the generator, such as switches or the like, have been omitted from the present showing since they have no direct bearing upon the present invention, and the desirable provision of such auxiliary parts will, it is believed, be readily understood by those conversant with the art.

The essential characteristic of my present invention lies in the simultaneous connection of a cutting electrode to a point of relatively high potential, and a coagulating electrode to a critical point of intermediate potential, whereby both electrodes may be efficiently employed simultaneously without requiring any adjustments, manipulations, or alterations of electrical parts or modes of operation.

In general, it will be understood that changes in the details herein described and illustrated for the purpose of explaining the nature of my invention may be made by those skilled in the art without departing from the spirit and scope of

the invention as expressed in the appended claims. It is, therefore, intended that these details be interpreted as illustrative, and not in a limiting sense.

Having thus described my invention, and illustrated its use, what I claim as new and desire to secure by Letters Patent is—

1. In an electrosurgical apparatus of the character described, a generator of high-frequency current including an output oscillating circuit, said circuit being impressed by said generator with a high-frequency voltage gradient, a cutting electrode connected to said circuit at a point of relatively high potential, and a coagulating electrode connected to said circuit adjacent to the upper end of the low potential range in which no sparking occurs with even a finely attenuated electrode, said coagulating electrode being thereby enabled to draw current for optimum pure coagulative effect without impairment of the cutting effect at the cutting electrode.

2. In an electrosurgical apparatus of the character described, a generator of high-frequency current including an output oscillating circuit, said circuit being impressed by said generator with a high-frequency voltage gradient, an indifferent electrode connected to said circuit at a portion of relatively low potential and adapted to establish contact with a body to be treated, a cutting electrode connected to said circuit at a point of relatively high potential, and a coagulating electrode connected to said circuit between the other electrodes and adjacent to the upper end of the low potential range in which no sparking occurs with even a finely attenuated electrode.

3. In an electrosurgical apparatus of the character described, a generator of high-frequency current including an output oscillating circuit having an inductance coil and a capacitance in parallel, said coil being impressed by said generator with a high-frequency voltage gradient, a cutting electrode connected to said coil at a point of relatively high potential, and a coagulating electrode connected to said coil at the upper end of the low potential range in which no sparking occurs with even a finely attenuated electrode.

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