No. 874,178. PATENTED DEC. 17, 1907.

L. DE FOREST.

CAUTERY.

APPLICATION FILED MAR. 1, 1907.

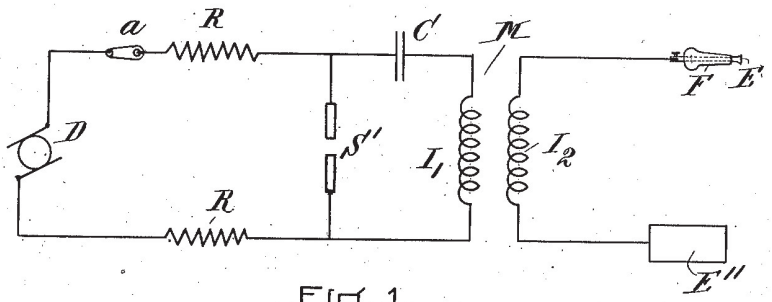

Fig. 1.

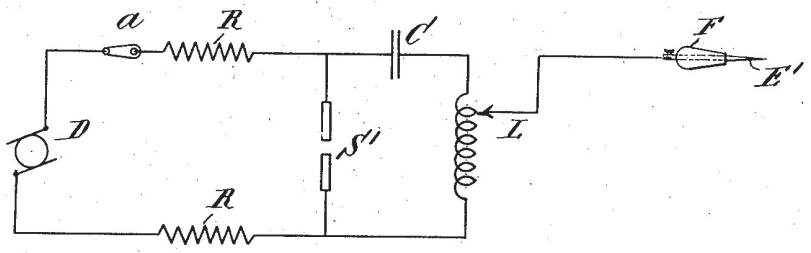

Fig. 2.

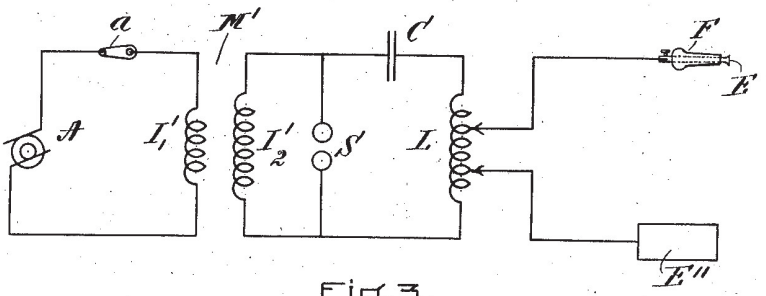

Fig. 3.

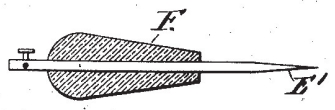

Fig. 4.

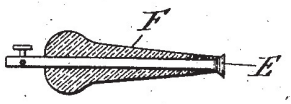

Fig. 5.

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UNITED STATES PATENT OFFICE.

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CAUTERY.

No. 874,178. Specification of Letters Patent. Patented Dec. 17, 1907.

Application filed March 1, 1907. Serial No. 359,968.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Cauteries, of which the following is a specification.

My invention relates to devices for producing burning effects by means of high frequency electrical currents, and more particularly to cauteries employed in surgery and to instruments for burning leather, marking on glass, glass-cutting, &c.

I have discovered that when a conductor is attached to any part of a high frequency oscillating circuit, the high frequency electrical current passing into a body, for example, a human body, will produce a heating or burning effect at the point of contact of the electrode conveying such currents to said body, and that the intensity of said heating or burning effect is inversely proportional to the terminal area of said electrode. If therefore the electrode end in a fine point or cutting edge, or relatively small area of other shape, an extremely intense burning effect may be obtained. Although an ordinary oscillating circuit including a capacity, which may be a condenser, an inductance and a discharger for said capacity may be employed, I find that the aforesaid burning effect is especially pronounced when a practically continuous train of undamped electrical oscillations is employed, such for example as the oscillations produced by a singing-arc circuit.

For the purpose of more fully disclosing my invention I have illustrated in the drawings which accompany and form a part of this specification several forms of apparatus and circuit arrangements which I have found to be efficient in practice; but it is to be understood that various modifications in such apparatus as well as in the circuit arrangements may be made by those skilled in the art without departing from the principle of my invention.

In said drawings, Figure 1 represents in diagram a singing-arc circuit having a conductor, provided at one end with a cutting edge electrode and at the other end with an electrode of relatively large area, inductively related to said circuit. Fig. 2 represents a singing-arc circuit having a conductor, provided with a needle point electrode, conductively connected to said circuit. Fig. 3 represents a sonorous circuit having connected thereto by auto-transformer connections a cutting edge electrode and an electrode of relatively large area, said electrodes by virtue of their connections with said sonorous circuit being connected to the terminals of a conductor. Figs. 4 and 5 show details of electrodes which may be employed.

In the figures, D represents a source of unidirectional electromotive force which may be, for example, a direct current generator capable of developing 220 volts.

C is a condenser.

M is an oscillation transformer, of which the primary and secondary respectively are I_1 and I_2.

L is an inductance.

S is a spark-gap.

S′ represents the arc-electrodes of a singing-arc circuit.

R is a resistance.

A is a source of vibratory current, such for example, as an alternating current generator.

M′ is a transformer, which may be a step-up transformer, and of which I_1' and I_2' are respectively the primary and secondary windings.

a is a switch.

The circuits S′ C I_1 and S′ C L are singing-arc circuits.

S C L is a sonorous circuit.

I prefer to so design the oscillation circuits shown in Figs. 1, 2 and 3, that currents having frequencies from 500,000 to 1,000,000 cycles per second may be developed. By properly choosing the capacity and inductance of the sonorous circuit shown in Fig. 3, the natural period of said circuit may be made as small as desired; but in order to develop undamped electrical oscillations having the frequencies above referred to by means of the circuits shown in Figs. 1 and 2, certain precautions will be found necessary. I find that by separating the electrodes S′ of the discharger for the condenser C a distance of about 1 mm. and inclosing said electrodes in an atmosphere of steam, as described in my U. S. Letters Patent No. 850,917, dated April 23, 1907, or by employing other suitable arrangements I can, by suitably choosing the electromagnetic constants of the circuit, obtain practically-continuous or undamped oscillations of frequency from 500,000 to 1,000,000 p. p. s. and of relatively large amperage and small voltage.

An insulated conductor associated in any

suitable manner with one of the sources of high frequency electrical oscillations above described, and ending in a fine wire or needle, or else in a sharp edge, of platinum or other suitable material, will conduct a high frequency current of sufficient amperage into the body of a person to which such wire, needle, or cutting edge is applied to burn the flesh exactly at the point of contact, in a manner similar to a white-hot wire except that the effect is absolutely localized and is restricted to the point of contact, while at the same time the electrode itself remains absolutely cold except at the exact point of contact. The burning effect is enhanced if the surface of the flesh has previously been slightly moistened.

In Figs. 4 and 5, E′ represents a needle electrode and E represents a cutting edge electrode, each electrode being provided with an insulating handle F which may be of glass.

In the operation of the apparatus shown in Fig. 1, the electrode E″ may be applied to any suitable portion of the patient's body and the cauterizing electrode E is applied to that portion of the body on which the operation is to be performed. The function of the electrode E″ is to increase the burning effect produced by the oscillations which pass from E to the body of the patient. The electrode E″ however is not necessary inasmuch as the electrostatic capacity of the patient's body is sufficiently large to enable the high frequency currents to produce any ordinary cautery effect. The operation of the device shown in Fig. 2 is the same as that above set forth in connection with Fig. 1, except that only one electrode is employed. The operation of the device shown in Fig. 3 is the same as that above set forth in connection with Fig. 1.

I prefer to eliminate the large area contact E″ because when the cauterizing electrode only is employed there is practically no current passing through any portion of the patient's body except in the region directly surrounding the seat of the operation. I prefer also to employ a source of practically continuous or undamped high frequency electrical oscillations as shown in Figs. 1 and 2, because in such case there is no electric shock produced by the passage of the currents into the body, whereas with the usual sonorous circuit employing an energizing circuit including a source of vibratory electromotive force, the cauterizing effects are in general accompanied by a pulsating effect causing an involuntary contractile effect upon the muscles and disturbing the nervous equilibrium which may seriously interfere with the operation. Another reason for preferring a source of undamped oscillations is that the heating effects are much more intense.

In the cauteries heretofore used in surgery it is necessary to employ a platinum or iridium conductor, generally in the form of a fine wire, through which a direct or low frequency alternating current is passed to heat the same to redness or whiteness. These fine wires so heated are exceedingly fragile and pliable and frequently become broken or displaced. Also it is frequently impossible to use a cautery in certain operations because the snare-wire cannot be gotten around the part to be operated upon. All these difficulties are obviated and a great variety of new and difficult cautery operations rendered possible by the form of cautery herein disclosed. For example, the thin chisel or scalpel of steel shown in Fig. 5, may be used to cut and sear at the edge only, so that the surrounding flesh is not scorched and the operation thus rendered bloodless. Again, a fine steel needle such as shown in Fig. 4, may be inserted far into a wound or orifice in the body and produce an extremely localized cautery effect at the point thereof. Also certain delicate operations on the eye which heretofore required the use of the surgeon's knife are rendered possible by cauterization by means of my invention.

I claim:

1. The combination with a source of high frequency electrical oscillations of a conductor associated with said source and an electrode connected with said conductor and so constructed and arranged that the electrical oscillations communicated thereto may be transmitted to a body to produce a burning effect on the surface thereof.

2. The combination with a source of practically continuous or undamped high frequency electrical oscillations of a conductor associated with said source and an electrode connected with said conductor and so constructed and arranged that the electrical oscillations communicated thereto may be transmitted to a body to produce a burning effect on the surface thereof.

3. The combination with a source of high frequency electrical oscillations of a conductor associated with said source and an electrode connected with said conductor, said electrode consisting of a conducting member having its terminal area sufficiently small to permit the electrical oscillations passing therefrom to a body to produce a burning effect on the surface of such body.

4. The combination with a source of high frequency electrical oscillations of a conductor associated with said source and an electrode connected with said conductor, said electrode consisting of a conducting member terminating in a cutting edge.

5. The combination with a source of high frequency electrical oscillations of a conductor associated with said source, an electrode connected with one end of said conductor and so constructed and arranged that the electrical oscillations communicated thereto may be transmitted to a body to produce a

burning effect on the surface thereof, and an electrode of relatively large area connected to the other end of said conductor.

6. The combination with a source of high frequency electrical oscillations of a conductor associated with said source, an electrode connected with said conductor and so constructed and arranged that the electrical oscillations communicated thereto may be transmitted to a body to produce a burning effect on the surface thereof, and an insulating handle for said electrode.

7. The combination with an oscillation circuit including a capacity, an inductance and a discharger for said capacity, of a source of unidirectional electromotive force connected with said circuit through conductors of high resistance, a conductor associated with said oscillation circuit and a cauterizing electrode connected with said conductor.

8. The combination with an oscillation circuit including a condenser and arc electrodes, of a source of electro-motive force, connections from said source of electro-motive force to said circuit, high resistances in said connections, a cauterizing electrode terminating in a small area and means associating said electrode with said oscillation circuit.

9. The combination with a source of high frequency electrical oscillations, of a conductor inductively associated with said source and an electrode connected with said conductor and so constructed and arranged that the electrical oscillations communicated thereto may be transmitted to a body to produce a burning effect on the surface thereof.

10. The combination with a source of practically continuous or undamped high frequency electrical oscillations, of a conductor inductively associated with said source and an electrode connected with said conductor and so constructed and arranged that the electrical oscillations communicated thereto may be transmitted to a body to produce a burning effect on the surface thereof.

11. The combination with a source of high frequency electrical oscillations, of a conductor inductively associated with said source, an electrode connected with one end of said conductor and so constructed and arranged that the electrical oscillations communicated thereto may be transmitted to a body to produce a burning effect on the surface thereof, and an electrode of relatively large area connected to the other end of said conductor.

In testimony whereof, I have hereunto subscribed my name this 20th day of Feb. 1907.

LEE DE FOREST.

Witnesses:
JOHN L. HOGAN, Jr.,
THOMAS I. GALLAGHER.