BLOCKING OSCILLATOR HAVING SELECTIVELY ADJUSTABLE R-C CIRCUIT

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This invention relates to an electric high-frequency surgical apparatus having a tube oscillator for producing electric oscillations of high frequency.

Previously known high-frequency surgical apparatus of this type comprise a self-excited tube generator producing undamped high-frequency oscillations. The high-frequency signal from the generator is coupled to actuate several parts of the tissue by cutting, using a cutting electrode, for instance a wire loop or snare. However, for coagulation such high-frequency currents are less suitable. Therefore, especially in the resection of the prostate by electro-surgical means where it is additionally required to alternately cut to and coagulate by means of one and the same electrode, and mostly by a wire loop, as a rule high-frequency surgical apparatus fitted with spark gap generators are used. Such spark gap type surgical apparatus operate with damped high-frequency oscillations, that is, high-frequency oscillations the amplitude of which decreases periodically within a short period from a high initial value to zero. Such apparatus, however, have decidedly poorer cutting characteristics than surgical apparatus operating with tubes, and moreover they have the other known disadvantages of spark gap generators, such as high wear, generation of broadcast disturbances and the like. High-frequency surgical apparatus have accordingly been proposed which comprise a tube generator for producing undamped high-frequency oscillations adapted for cutting and a spark gap generator for producing a damped high-frequency current adapted for coagulating. Such combined apparatus, however, equipped with two different high-frequency generators, are relatively expensive, heavy and bulky.

It is an object of the present invention to provide an apparatus adapted to carry out coagulating and cutting operations in a single high-frequency generator, that is, with a tube generator. With this and further objects in view, the present invention is based on the recognition of the fact that a blocking oscillator—that is, a feed-back or regenerative oscillator in which the combination of resistances and condenser means inserted in the control grid circuit of the generator tube are so selected that the value of the potential at the control grid changes periodically up to a high negative value that this potential impedes the flow of current through the valve to produce oscillations of high frequency which, similar to high-frequency oscillations produced by spark gap generators, start periodically with a large amplitude and then decrease quickly in amplitude down to zero, and by a change of only the time constants of its resistance-condenser combination in the control grid circuit connection may be effected into a self-excited valve generator for the production of undamped oscillations.

Therefore, according to the invention in an apparatus for high-frequency surgery comprising a tube generator for producing the electric oscillations of high frequency, a blocking oscillator is used as a tube generator which contains in its control grid circuit a resistance-condenser combination the time constant of which can be brought to such low values, by the operation of switching means, that the above mentioned periodical decrease of the amplitude of oscillations is prevented, thus permitting the generation of continuous high-frequency oscillations of constant amplitude. This change of the time constants can be effected for instance by disconnecting a capacity normally connected in parallel to the capacity of the resistance-condenser member of the grid circuit. Such a disconnection can be effected by means of a relay which is connectible and disconnectible through a manual switch arranged on the handle for the surgical electrode, or by means of a foot pedal switch.

As a rule the output required for coagulating is different from that required for cutting is it necessary, in case of alternating coagulating and cutting operations, to manually readjust the regulator for the output each time the resistance-condenser member is switched over from "cutting" to "coagulating" or vice versa. According to a preferred form of the invention, such an additionally required manual readjustment of the regulator for the output is achieved in such a way that the relay effecting the change of the resistance-condenser member also effects the required change of the regulator for the output. Advantageously separate regulators are provided for controlling the output during coagulating operations and for controlling the output during cutting operations and the relay acts to change over from one of the two regulators to the other.

Other and further objects, features and advantages of the invention will be pointed out in the following detailed description and will be apparent from the appended claims forming part of the application.

The accompanying drawing shows an example of a now preferred embodiment of the invention.

FIG. 1 is a circuit diagram of an apparatus embodying the present invention;

FIG. 2 is an oscillogram showing the amplitude of the high-frequency oscillations produced, plotted against time, when the apparatus is adjusted for cutting operations; and

FIG. 3 is a similar view but showing the amplitude of the oscillations when the apparatus is adjusted for coagulating operations.

Referring to FIG. 1, there are provided a generator D and a power amplifier E respectively delimited by dot and dash lines. The generator D comprises a three electrode tube or triode V1 having a cathode K1, a control grid G1 and an anode A1. The filament of the tube V1 is indicated by F1 and its source of current by B1. The cathode K1 is connected to the negative pole of the source of anode current B1 and grounded. The anode A1 is connected with a resonance circuit comprising a coil L1 disposed in parallel with a capacity C1 and by way of a switch (not shown) with the positive pole of the source of anode current B1. The control grid G1 is connected to the coil L2 which is coupled to the coil L1. The free end of the coil L1 is connected to the connecting point between the series-connected resistance R1 and condenser C1 of a resistance-condenser combination; the free end of the resistance R1 is connected to the positive pole of the source of anode current B1, while the free terminal of the condenser C1 is grounded. One end of the coil L2 which is coupled with the coils L1 and L2 is grounded while the other end is connected to potentiometers R2 and R3 the other ends of which are grounded. As will be presently explained, high-frequency signals of different sources can be taken from the slide RA of the potentiometer R3 or from the slide RB of the potentiometer R4 and fed to the power amplifier E which comprises a screen-grid amplifier tube V2 the cathode K2 of which is grounded and the filament F2 of which is powered by a heating battery B2. The control grid G2 of the tube V2 is connected, through a protective resistance R4 and a choke L4, with the negative pole of a source of grid voltage B3 the positive pole of which is grounded and which is
bridged by a condenser $C_b$. Connected to the connecting point between the choke $L_4$ and the protective resistance $R_k$ is a coupling condenser $C_4$ to which the voltages which can be taken from the slides $R_9$ or $R_{10}$ can be applied, as will be presently described. The screen grid $G_2$ of the tube $V_3$ is connected on the one hand, through a resistance $R_{16}$, with the positive pole of the source of voltage $B_1$ and on the other hand, through a condenser $C_b$, it is grounded with regard to high frequencies. The anode $A_4$ of the tube $V_3$ is connected to the positive pole of the source of anode voltage $B_2$ over an inductance coil $L_3$ shunted by a condenser $C_7$, and by way of a switch (not shown). The negative pole of the source of anode voltage $B_2$ is grounded and bridged by a condenser $C_b$. The inductance $L_3$ and the capacity $C_7$ shunted thereto form a resonance circuit for the electric high-frequency oscillations produced by the generator $D$. Coupled with the coil $L_4$ is a coil $L_6$ one end is grounded while its other end is connected by way of an isolating condenser $C_9$ with a surgical cutting instrument $K$ which is attached to a handle $J$ to be held by the surgeon. The object to be treated is indicated by $O$ and lies on a metallic base $T$ which is grounded.

In order to change the method of operation of the apparatus and to produce a high-frequency current adapted for coagulation or for cutting, as occasion demands, there is provided a relay $A$ the coil of which is connected with one of its terminals to the positive pole of the voltage source $B_1$, while its other terminal is connected, by push-button switches $F$ and $H$ which are pedal-operated and hand-operated, respectively, with the negative pole of the voltage source $B_1$ that is, grounded. The manually operated switch $H$ may also be accommodated in the handle $J$ of the cutting instrument $K$ as indicated by the dotted line $W$. The relay has an operating or make contact $a_1$ and a make-break contact system $a_2$. The make contact $a_1$ is inserted in the connection of one side of the condenser $C_9$ and the connecting point between the resistance $R_1$ and one side of the condenser $C_3$ the other side of which is grounded. The pivot side $C_6$ of the make-break contact $a_2$ is connected with the condenser $C_9$ by way of conductor $X$. The normally closed side $a_2''$ of the make-break contact $a_2$ is connected through a line $Z$ with the slide $R_{12}$ of the potentiometer $R_8$. The make side $a_2'''$ of the make-break contact $a_2$ is connected through a lead $Y$ with the slide $R_9$ of the potentiometer $R_8$.

The operation of the circuit arrangement is as follows:

If the tubes $V_1$ and $V_2$ are connected, by means of the switch which is not shown, to their sources of current $B_1$ and $B_2$, a positive bias is applied to the control grid $G_1$ of the tube $V_1$ in case of open push-button switches $F$ and $H$, said bias being derived from the series connection of the resistance $R_1$ and the capacity $C_9$. The side of the condenser $C_3$ connected to the grid side of the tube is positively charged, while the cathode side is negatively charged. The positive grid bias permits the production of undamped oscillations or continuous wave through the circuit $D$. In an oscillating state of this circuit, a current tending to change the charge of condenser $C_4$ in such a way that a positive charge is built up on the cathode side and a negative charge is built up on the grid side, flows from the control grid $G_1$ across the grid-cathode space of the tube $V_1$ to the cathode $K_1$. This recharging voltage, however, in view of the small capacity of the condenser $C_4$, is low compared with the positive charging voltage applied through the resistance $R_1$ from the positive pole of the voltage source $B_1$. The grid side of the condenser $C_3$ therefore remains at a positive potential. Through the coil $L_8$ undamped continuous high-frequency oscillations are attenuated and applied to the potentiometers $R_3$ and $R_4$. Through the slide $R_{12}$ of the potentiometer $R_8$, the lead $Z$, the normally closed side $a_2''$ of the make-break contact $a_2$ and the lead $X$, high-frequency voltages of a magnitude adjustable through the slide $R_{12}$ are applied to the power supply $E$ through the coupling condenser $C_4$. These voltages are amplified by the tube $V_3$ and extended by way of the inductance $L_3$ to the surgical instrument $K$.

The amplitude of the current thus produced and being particularly adapted for coagulation, either the pedal switch $F$ or the manual switch $H$ is depressed so as to effect energization of the relay $A$. Make contact $a_1$ is thereby actuated to connect the condenser $C_9$ having a relatively large capacity, in parallel to the condenser $C_3$. Moreover, the slide $R_{12}$ of the potentiometer $R_8$ is connected with the condenser $C_6$ of the amplifier circuit $E$ through the lead $Y$, the make side $a_2'''$ of the make-break contact $a_2$ and the lead $X$. By the parallel connection of the capacity $C_9$ with the capacity $C_3$ the effective total capacity is increased. Hence, the current flowing across the grid-cathode space of the tube $V_1$ is effective to change the charge of this capacity in such a way that an increasing negative potential is produced on the control grid $G_1$ of the tube $V_1$, causing the anode current to drop to zero. The generation of oscillations is thus stopped until the charge of the condenser combination $C_3$, $C_9$ is changed to such an extent, through the resistance $R_1$, that a positive bias is again applied to the control grid $G_1$ of the tube $V_1$. Damped high-frequency oscillations quickly decreasing in amplitude and being adapted for coagulation are thus periodically produced in the output circuit of the amplifier with the tube $V_3$, the characteristic of these oscillations being indicated in FIG. 3.

The output of the undamped high frequency currents adapted for cutting is controlled by the potentiometer $R_9$ while the output of the discontinuous damped high frequency currents adapted for coagulation is controlled by the potentiometer $R_8$. The variable or control-resistances $R_9$ and $R_8$ are adjustable in such a way that the desired value of the output of the apparatus is always available for coagulation or cutting operation.

Changes may be made within the scope and spirit of the appended claims which define what is believed to be new and desired to have protected by Letters Patent.

The claim:

1. In a high frequency surgical apparatus having a surgical instrument for alternately performing coagulating and tissue-cutting operations, a self-excited tube generator comprising a blocking oscillator including a control grid circuit and having circuit means forming an output circuit for oscillations produced thereby, a resistance-capacitor combination means for governing said control grid circuit, first switching means adapted in one switching position to selectively adjust the time constant of said resistance-capacitor combination means to such a high value that first distinct high frequency output oscillations are periodically produced and then rapidly reduced to a minimum, and in another switching position adapted to selectively adjust the time constant of said resistance-capacitor combination means to such a low value that second distinct and continuous high frequency output oscillations are produced, second switching means for selectively connecting said first and said second distinct output oscillations to energize said surgical instrument so as to adapt it to alternately perform the respective coagulating and cutting operations, control means connected to said output circuit for selectively respectively governing the magnitude of said first and said second output oscillations, relay means comprising contacts constituting relay means, the said first and said second switching means, circuit means for interconnecting the contacts constituting said second switching means with said control means, and a switch for controlling the actuation of said relay means.

2. In a high frequency surgical apparatus having a surgical instrument for alternately performing coagulating...
lating and tissue-cutting operations, a self-excited tube generator comprising a blocking oscillator including a control grid circuit and having circuit means forming an output circuit for oscillations produced thereby, resistance-capacitor combination means for governing said control grid circuit, first switching means adapted in one switching position to selectively adjust the time constant of said resistance-capacitor combination means to such a high value that first distinct high frequency output oscillations are periodically produced and then rapidly reduced to a minimum, and in another switching position adapted to selectively adjust the time constant of said resistance-capacitor combination means to such a low value that second distinct and continuous high frequency output oscillations are produced, second switching means for selectively connecting said first and second distinct output oscillations to energize said surgical instrument so as to adapt it to alternately perform the respective coagulating and cutting operations, control means connected to said output circuit for selectively respectively governing the magnitude of said first and second output oscillations, relay means comprising contacts constituting respectively said first and second switching means, a break-make contact constituting said second switching means, circuit means for interconnecting said make-break contact with the respective control means for connecting the respective output oscillations to energize said surgical instrument alternately in accordance therewith, and a switch for controlling the actuation of said relay means.

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