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Ikuno et al.

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[54] **ELECTROSURGICAL APPARATUS AND METHOD OF OPERATING SAME**

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[52] **U.S. Cl.** **128/303.14;** 128/303.17; 128/422

[51] **Int. Cl.** **A61b 17/36**

[58] **Field of Search** 128/303.14, 303.17, 303.13, 128/421–423

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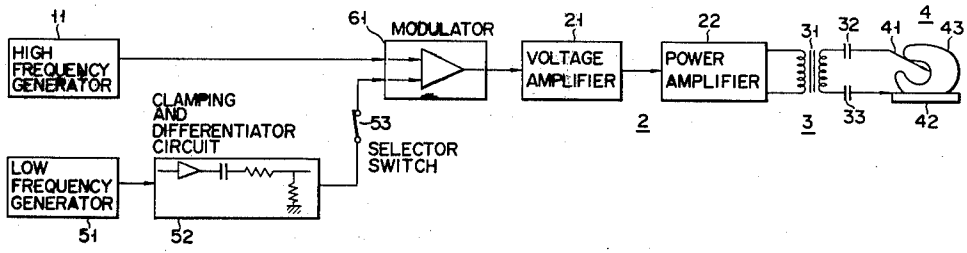
[57] **ABSTRACT**

An electrical surgical knife device for use with an endoscope comprises a singular power source means which includes a high frequency signal generator for generating a high frequency signal, a low frequency signal generating means for generating a damped low frequency signal and an amplitude modulator for amplitude-modulating the high frequency signal by the damped low frequency signal. A selector means is provided with a switch coupled between the modulator and the low frequency signal generator, to cause the modulated damped high frequency signals to be supplied to the active and fixed electrodes of an electrical surgical knife when the switch is in the on state and to cause the unmodulated high frequency signal to be supplied to the electrodes when the switch is in the off state.

11 Claims, 8 Drawing Figures



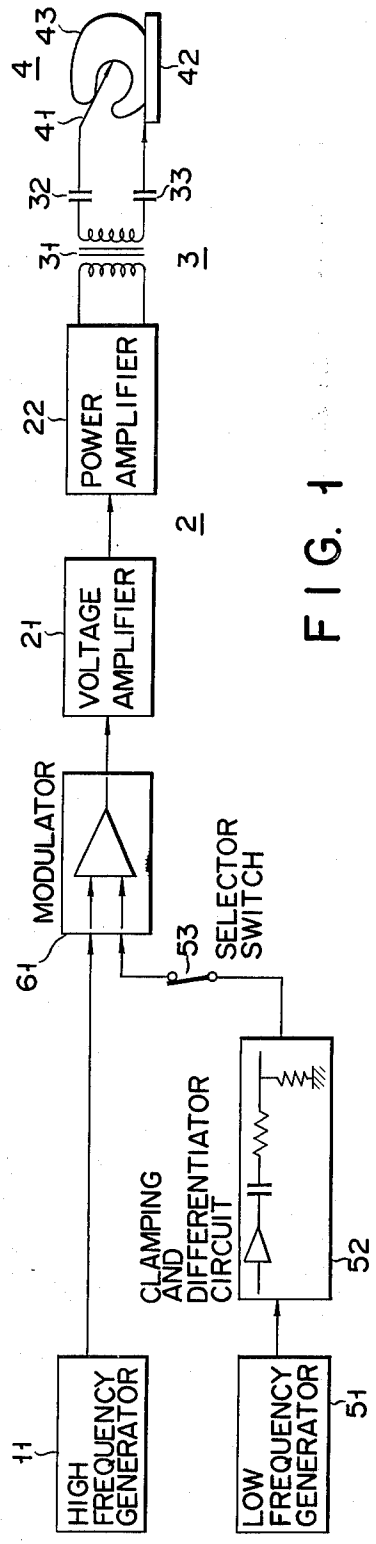


FIG. 1

FIG. 2E

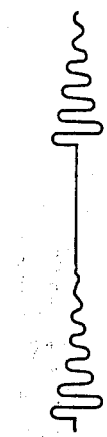


FIG. 2F

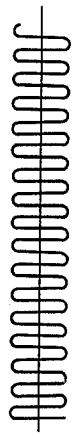


FIG. 2C

FIG. 2D

FIG. 2A

FIG. 2B

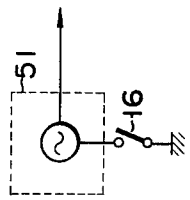


FIG. 3

ELECTROSURGICAL APPARATUS AND METHOD OF OPERATING SAME

BACKGROUND OF THE INVENTION

This invention relates to an electrical surgical apparatus, and, more particularly to an electric power source for operating the apparatus and a method of operating same.

An electrosurgical apparatus is known wherein an active electrode which is like an end of a needle or a blade and has a very small contact area with a patient's body contacts a fixed electrode which is a plate electrode and has a large contact area with the patient's body, causing a high frequency signal to flow between the active electrode and the fixed electrode through the patient's body. In such a known surgical apparatus, the electric current which is concentrated around the end of the active electrode whose contact area is very small causes Joule heat to be generated and this Joule heat introduces an explosion of a gas in a histology, thereby enabling an operation or a cutting of a body tissue and a thermocoagulation of the tissue protein at an operated or cut surface to close a lymphatic vessel and a fine vessel, thereby enabling an hemostasis.

In known electrosurgical devices, there is provided a first power source for supplying a high frequency signal to the electrodes of the surgical apparatus for performing an operation and cutting having a high frequency generator, a high frequency output signal from which is amplified in voltage and power amplifiers to supply its output to the surgical apparatus. A second power source is provided for hemostasis, having a high frequency generator which generates a high frequency signal repeating a damped oscillation with a certain period.

As the electric power sources for operations and for the hemostasis are provided separately in the prior art, high frequency generators and amplifiers are needed for each of the respective power sources and the electrosurgical apparatus becomes large, needs a large power supply and is difficult to operate. In addition, particularly, the prior art high frequency oscillator included in the second power source for hemostasis is complicated in construction, thus increasing the cost of manufacture and reducing the operational reliability thereof. Further, as the prior art power sources mentioned above are bulky and need a large source of input power, it is difficult to assemble the above-described power sources in an endoscope through which the surgical knife device is introduced into the abdominal cavity.

The object of the present invention is to provide an electrosurgical apparatus and a method of operating same, wherein a singular electric power source can be used for both the source for performing the operation and cutting and the source for hemostasis, thereby reducing the size and complexity of the power source and enabling the power source to be assembled in the endoscope which is to be inserted into a space inside of a patient's body.

SUMMARY OF THE INVENTION

According to the present invention, there is provided an electrosurgical apparatus comprising active and fixed electrodes which comprise a surgical knife, a high frequency signal generator, a low frequency signal supplying means for supplying a damped wave signal of lower frequency than the high frequency signal, and an amplitude-modulator for selectively amplitude-modulating the output signal from the high frequency signal generator with the output signal from a damped low frequency signal supplying means, the output of the modulator being coupled to the electrodes. Further provided is a selector means for selectively causing the high frequency signal to be amplitude-modulated by the damped low frequency signal. Power and voltage amplifiers are provided for amplifying the output signal from the modulator to supply the output signal to the electrodes. Further, there is provided a method of operating the surgical apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of one embodiment of the present invention;

FIGS. **2A** to **2F** show the waveforms at respective points in the block diagram of FIG. **1**; and

FIG. **3** is a circuit for a low frequency generator used in another embodiment of this invention.

DETAILED DESCRIPTION OF THE INVENTION

As shown in FIG. **1**, an output signal from a high frequency signal generator **11** is supplied to a modulator **61** whose output signal is supplied to an amplifier circuit **2** comprising the series combination of a voltage amplifier **21** and a power amplifier **22.** The output from the power amplifier **22** is supplied to an electrosurgical knife **4** having an active electrode **41** and a fixed electrode **42** through an output circuit **3** comprising an output transformer **31** and a blocking capacitor **32** for blocking the direct current component from the output of the transformer **31.** An additional blocking capacitor **33** may be provided. A rectangular wave whose positive side is larger than its negative side is generated from the low frequency generator **51** and this rectangular wave output from the generator **51** is differentiated by a clamping circuit and differentiator circuit **52,** the output of which is supplied to the modulator **61** through a selector switch **53.** A clamping and differentiator circuit **52** converts the signal of FIG. **2B** into the signal of FIG. **2D** in a manner well known in the art. The negative level of the output signal from the low frequency generator is cut by the clamping circuit **52.** The output signal from the high frequency generator **11** is selectively amplitude-modulated by the low frequency signal output of the clamping and differentiator circuit **52** when the selector switch **53** is in the "on" state. No modulation is effected when the switch **53** is in the "off" state.

FIG. **2A** shows the wave form of the output signal from the high frequency generator **11,** FIG. **2B** shows the wave form of the output signal from the low frequency generator **51** and FIG. **2C** shows the wave form of the output signal from the output circuit **3** which is supplied to an electrosurgical knife **4,** when the selector switch **53** is open, FIG. **2D** shows the wave form of the output signal from the differentiator circuit **52,** FIG. **2E** shows the wave form of the output signal from the modulator **61** when the selector switch **53** is closed. FIG. **2F** shows the wave form of that output signal from the output circuit **3** which is supplied to the surgical knife **4.**

The high frequency signal generated in the high frequency signal generator **11** has a frequency of **5** KHz

and the low frequency signal generated in the low frequency signal generator **51** has a frequency of **500** Hz.

The operation of the apparatus of this invention shown in FIG. **1** is as follows.

1. When the selector switch **53** is off, the low frequency signal from the low frequency signal generator **51** is not supplied to the modulator **61** and the high frequency signal from the high frequency signal generator **11** is not amplitude-modulated, is supplied to voltage amplifier **21** to be amplified in voltage and there is amplified in power by the power amplifier **22.** Any direct current component in the output signal from the power amplifier **22** is blocked by capacitors **32** and **33** of the output circuit **3** and the alternating current component is supplied to the electrosurgical knife **4.** Accordingly, when the active electrode **41** of the knife **4** contacts with a diseased or other desired part of a patient **43,** a high frequency current flows through the body of the patient **43** and the high frequency current concentrates at the contacting end of the active electrode **41,** thereby enabling the operation to be performed.

2. When the selector switch **53** is closed, the output signal from the low frequency oscillator **51** (FIG. **2B**) is differentiated at its positive-going edge by the differentiative circuit **14,** to be converted to a damped repetitive wave (FIG. **2D**) which has a repetition rate or frequency equal to the frequency of the rectangular wave signal from the low frequency generator **51.** The damped wave (FIG. **2D**) is supplied to the modulator **61,** in which the high frequency output signal (FIG. **2A**) from the high frequency oscillator **11** is amplitudemodulated by the damped wave to produce a damped train of pulses (FIG. **2E**) which repeat the damping cycle at a repetition rate or frequency equal to the frequency of the damped wave (FIG. **2D**). The damped pulse train (FIG. **2E**) is amplified in the voltage amplifier **21** and power amplifier **22** and, after the direct current component of the output signal from the power amplifier **22** is blocked by the output circuit **3,** the alternative component of the output signal (FIG. **2F**) from the output circuit **3** is supplied to the electrosurgical knife **4.** Accordingly, when an active electrode **41** of the electrosurgical knife contacts a part of a patient **43** such as a diseased part of the patient **43,** a high frequency amplitude-modulated current comprising a damped pulse train (FIG. **2F**) flows in the body of the patient, enabling the contacted part to be hardened or coagulated to thereby cause an hemostasis.

It is clarified from the wave forms shown in FIGS. **2A** to **2F** that there are selectively supplied to the electrosurgical knife **4** a series of high frequency current pulses when the selector switch **53** is in the off state and a series of high frequency damped current pulses repeating a damping cycle at the oscillating frequency of the low frequency signal generator **51** when the selector switch **53** is in the on state.

It should be noted that the amplitude modulator **61** may be controlled by controlling the oscillation condition, e.g. by the on-off operation of the switch **16** connected to the generator **51** as shown in FIG. **3** instead of by using the selector switch **53.**

As stated above, by selectively amplitude-modulating the output signal from the high frequency signal generator **11** by the output signal from the low frequency generator **51** which is clamped and differentiated to generate a repetitive damped signal, a singular electric power source device can be used for both the source for the operation (i.e. cutting) and the source for the hemostasis.

What we claim is:

1. An electrosurgical apparatus comprising:

an electrosurgical knife which includes an active electrode and a fixed electrode;

a first oscillator means for generating a high frequency signal to control the knife;

a second oscillator means for producing a damped lowfrequency signal of lower frequency than said high frequency signal, said second oscillator means comprising a low frequency generator and a clamping and differentiator circuit means coupled to the output thereof to clamp the output signal of the low frequency signal generator at a given value and to differentiate it to produce said damped low frequency signal;

a modulator coupled to the output of said first and second oscillator means, the output of said modulator being coupled to said electrosurgical knife; and

a selector means having a first condition to cause said modulator to amplitude-modulate said high frequency signal by said damped low frequency signal and having a second condition to cause said modulator to couple said high frequency signal, unmodulated, to said knife.

2. Apparatus according to claim **1** wherein said selector means comprises a switch connected between the modulator and the second oscillator means.

3. Apparatus according to claim **1** wherein said selector means comprises means coupled to the second oscillator means for controlling the oscillation condition of the second oscillator means.

4. Apparatus according to claim **1** wherein said selector means is coupled to the second oscillator means for selectively turning the second oscillator means on and off.

5. Apparatus according to claim **1** further compirsing a voltage amplifier whose input terminal is connected to the output terminal of said modulator, a power amplifier whose input terminal is connected to the output terminal of said voltage amplifier, a transformer whose input terminals are coupled to the output terminals of said power amplifier and respective direct current component blocking capacitors connected between the output terminals of said transformer and said electrosurgical knife for supplying the alternating current component of the output signal from the transformer to the electrosurgical knife.

6. Apparatus according to claim **1** wherein said clamping and differentiator circuit means clamps the output signal of the low frequency signal generator so that the output signal therefrom has only positive values.

7. A power source for providing an alternating current output signal for operating an electrical surgical knife comprising:

a first oscillator means for generating a high frequency signal;

a second oscillator means for producing a damped low frequency signal of lower frequency than said high frequency signal, said second oscillator means comprising a low frequency generator and a clamping and differentiator circuit means coupled to the output thereof to clamp the output signal of the low frequency signal generator at a given value and to

differentiate it to produce said damped low frequency signal;

a modulator whose input terminals are respectively coupled to the first and second oscillator means and providing said alternating current output signal; and

a selector means to selectively supply the damped low frequency signal to the modulator.

8. A power source according to claim **7** wherein said selector means comprises a switch connected between the modulator and the second oscillator means.

9. A power source according to claim **7** wherein said selector means comprises means coupled to the second oscillator means for controlling the oscillation condition of the second oscillator means.

10. A method of operating an electrosurgical knife apparatus comprising steps of:

generating a high frequency signal;

generating a low frequency signal of lower frequency than said high frequency signal;

clamping and differentiating said low frequency signal to produce a damped low frequency clamped signal;

selectively amplitude-modulating said high frequency signal with said damped low frequency signal to produce a modulated damped signal; and

coupling one of the modulated damped signal and the high frequency signal to said electrosurgical apparatus.

11. The method according to claim **10** wherein said step of selectively amplitude-modulating said high frequency signal comprises selectively coupling said damped low frequency signal to said high frequency signal.

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