

- [54] **CONTROL CIRCUIT FOR ELECTROSURGICAL UNITS**
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- [52] **U.S. Cl.** 128/303.14; 323/6; 323/56; 330/8; 336/155
 [51] **Int. Cl.²** **A61B 17/36**
 [58] **Field of Search**..... 128/303.14, 303.13, 303.17; 330/8; 336/155; 323/56, 6

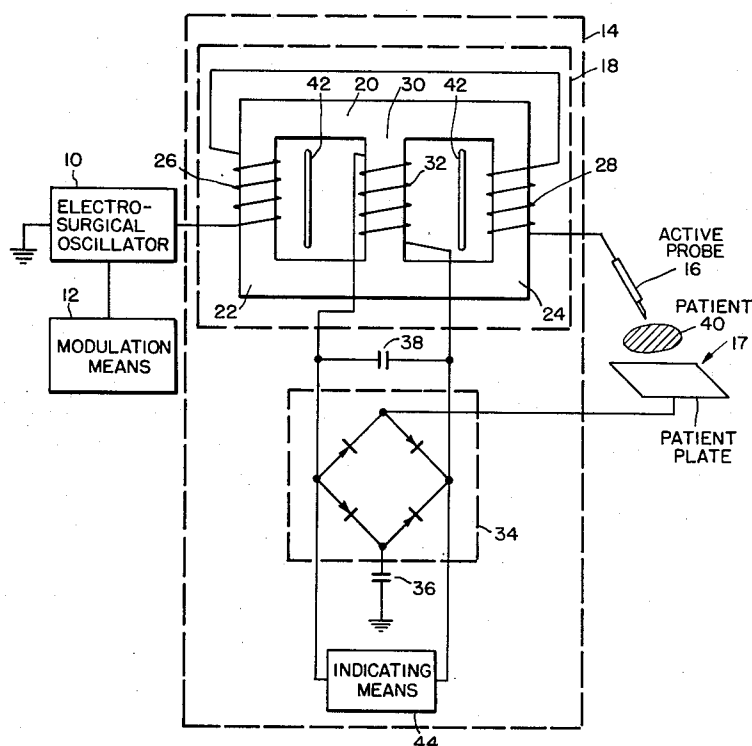
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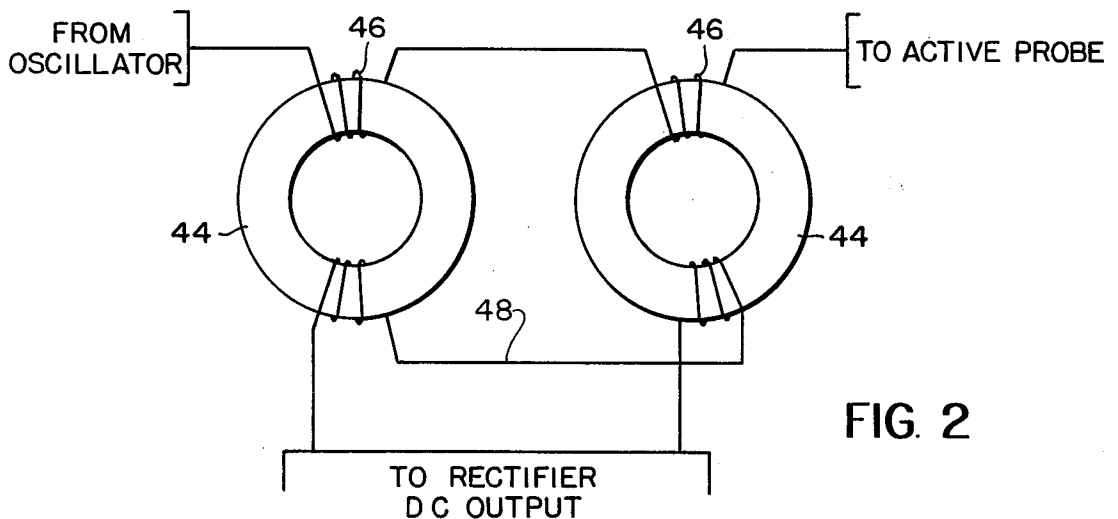
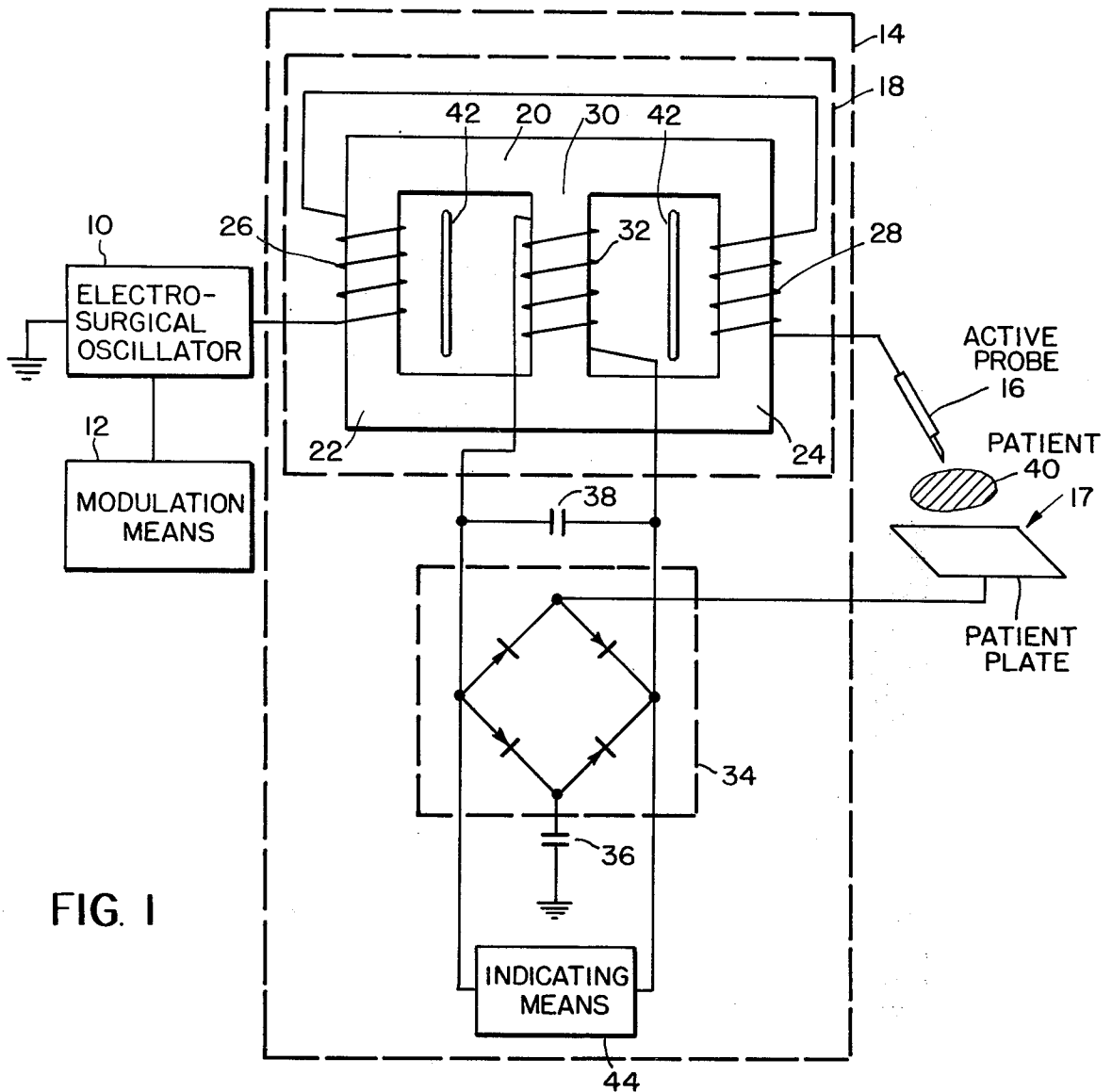
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[57] ABSTRACT

A control circuit for electrosurgical units which controls power levels to patient electrode in response to load conditions thereof. A saturable reactor is connected in series between the output of the electrosurgical unit and the patient electrodes. The saturable reactor is biased by a control coil activated by a rectified current corresponding to the alternating current flowing between the patient electrodes which is an indication of the area of contact between the patient and one of the electrodes.

7 Claims, 2 Drawing Figures





CONTROL CIRCUIT FOR ELECTROSURGICAL UNITS

BACKGROUND OF THE INVENTION

This invention relates generally to RF control circuits and more particularly concerns RF control circuits that are used in electrosurgical units. Electrosurgical units generate high frequency power for the cutting and coagulation of tissue under surgical conditions. The electrosurgical units supply a high frequency alternating current at power levels up to several hundred watts to electrodes usually consisting of an active probe and a relatively large dispersive plate generally known as a patient plate. The electrodes are available in various configurations to be selected by the surgeon according to the intended use. Alternating current enters at the surgical site from the active probe, passes through the body of the patient to the patient plate and then returns to the low or grounded terminal of the electrical surgical unit. The physiological effects produced by electrosurgery are a result of a very high current density at the interface of the surgical active probe and the body tissue. There are no physiological effects at the patient plate site because the same current flows out of the patient through a relatively large area. During an operation the active probe is placed in contact with the patient. The patient should be in continual electrical communication with the patient plate. In the case of low power coagulators, capacitive coupling between patient and ground is satisfactory. The current levels produced by high powered equipment, such as used in general and transurethral surgery require a direct contact patient plate return connection. In the latter situation there is potential danger associated with electrosurgery should the patient plate be improperly applied or if an initial electrical contact becomes interrupted. If there is no other ground connections and if no other part of the patient is in contact with electrical ground, the available surgical current will be so reduced that in most cases, the surgeon will be immediately aware of the problem and he would either stop the procedure and investigate or request that the power should be increased. The latter could be dangerous as a subsequent return of electrical continuity would result in excessive power being dissipated at the surgical site. Also, should the resistance of the patient plate interface be high, any extraneous ground connection, such as a cardioscope ground lead, would act as a high frequency ground connection. The contact area of such an extraneous ground connection is likely to be too small for the magnitude of current present and a burn at this site is almost a certainty.

It is possible to include a monitoring device that insures high frequency continuity to the patient plate. However, this monitor cannot determine if the patient plate has sufficient area in contact with the patient. If area contact isn't proper, some surgical current could still return by a small area extraneous ground connection and result in a patient burn. Another monitoring circuit has been developed that insures complete patient plate circuit continuity by passing a low voltage direct current through the patient. This current enters the body from the active probe and exists through the patient plate. Only a complete direct current circuit plus foot switch or hand control actuation will enable high frequency output. This type of monitoring system

is effective, but complicated because it requires filter circuits to prevent high frequency from adversely affecting electrosurgical device control circuitry.

It would be, therefore, highly desirable to provide a simpler control circuit, either to be used alone or to supplement one of the prior types of patient plate monitoring systems to additionally determine whether the patient plate electrode is contacting the patient. Such a monitoring system should be passive and be able to reduce high frequency to a low value should there be an impedance condition at the patient plate interface or return cable.

It is the object of this invention to provide a new and improved control circuit for electrosurgical units to monitor the impedance of a patient plate interface and connecting cable.

It is also an object of this invention to provide a new and improved control circuit for electrosurgical units for controlling output as a function of contact area between patient and patient plate.

It is another object of this invention to provide a new and improved control circuit for connection in the output circuit of an electrosurgical unit for reducing high frequency current to a low value for sensing and increasing RF current to normal level only if a complete circuit exists between the active and the patient plate electrodes.

An additional object of this invention is to provide a new and improved control circuit for monitoring circuit conditions between active and patient plate electrodes and having a switching time in microseconds.

SUMMARY OF THE INVENTION

A control circuit is disclosed that controls the high frequency output current of an electrosurgical unit as applied across patient electrodes in response to the load between said patient electrodes.

The control circuit includes a saturable reactor means having variable reactance windings connected in series between the electrosurgical unit and the active patient electrode. The high frequency return current is conducted through a bridge rectifier which produces a DC current which passes through a control winding of the saturable reactor. Under normal high frequency current flow the DC current will be sufficient to saturate the reactor, minimizing the impedance thereof. Should the high frequency current be less than normal the DC current will be correspondingly reduced, causing the reactor to appear as a series inductive reactance, further reducing the high frequency current flow. Since the reactor reactance is a function of patient to patient plate impedance, the control sequence requires that sufficient area of contact be made between the patient and the patient plate electrode for the application of full power.

The saturable reactor means can include a three legged ferromagnetic core, with the variable reactance winding wound on the outer legs and connected so as to null out induced voltages that would adversely effect the control winding which is wound about the middle leg.

Electrostatic shield material may be used between windings to prevent capacitive coupling.

An alternate construction of the variable reactor is to use two cores, which may be cup, "U," or toroid cores, each core having a variable reactance winding and a control coil.

Indicating means can be provided to alert the operator of the state of the variable reactor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram of an electrosurgical unit which includes the control circuit of the invention.

FIG. 2 is an alternative embodiment of the control circuit of the invention.

DETAILED DESCRIPTION OF THE DRAWING

FIG. 1, an electrosurgical unit having an oscillator 10 generates RF signals at hectowatt power levels. Such an oscillator may be a spark gap, a vacuum tube oscillator, or a solid state oscillator. Modulation means 12 are used by the surgeon to select the desired amplitude and modulation mode suitable to the surgical functions of the cutting, hemostasis, and coagulation which are dependent upon the shape of the output wave form. The oscillator 10 means also includes a activating switch which may be hand or foot operated. The output of the oscillator 10 goes to the control circuit 14 of the present invention and therefrom to patient electrodes comprising of an active probe 16 and a patient plate 17.

A saturable reactor 18 is used in the control circuit 14. The reactor 18 includes a three-legged magnetic core 20 substantially symmetrical. About the two outer legs 22, 24 of the core 20 are wound variable reactance windings 26, 28 having substantially equal number of turns. The variable reactance windings 26, 28 are wound and interconnected so as to cancel any induced voltage caused by magnetic flow in the core 20. The two variable reactance windings 26, 28 are connected in series with the output oscillator 10 of the electical surgical unit and the active probe 16.

About the center leg 30 of the core is wound a control winding 32.

The leads of the control winding 32 are connected to the DC terminals of a high frequency bridge rectifier 34. The AC terminals of the high frequency bridge rectifier are connected in series from the patient plate 17 to electrical ground through a first capacitor 36. A second capacitor 38 is placed across control winding 32 to level the ripple on the DC voltage. The amount of RF current passing through the patient will be dependent upon the impedance between the active probe 16 and the patient plate 17. The impedance is the sum of the patient resistance, typically between 400 and 500 ohms, and the interface resistance between the patient and the patient plate electrode 17. Should the patient plate 17 be improperly attached so as to have insufficient contact area between the patient and the patient electrode, the interface resistance will be high and the current at a given setting will be low compared to what it would be if the patient plate was correctly applied. The alternating RF current flows from the active probe 16 through the patient 40 to the patient plate 17, through the high frequency rectifier 34 across the capacitor 36 to ground. The higher the amplitude of the RF current, the higher will be the rectified DC current passing through the control winding 32. Conversely, a poor connection will reduce the alternating RF current. The rectified DC current will be correspondingly lower reducing the current flowing through the control winding 32. When no DC current is present, the core material is unsaturated, and inductively loads the variable reactance windings 26, 28, effectively introducing a series reactance into the output circuit. This limits the

output current to a low value typically 50 to 80 milliamps when no DC control current is present. When a completed high frequency circuit is established, returning current passes through the rectified circuit 34, causing a DC current to flow through the reactor control winding 32 partly saturating the core 20. This lowers the impedance of the reactance winding 26, 28 and increases the output current. The higher output current passes through the rectifier 34 further increasing the control winding current which completely saturates the reactor minimizing the reactance.

The core may be made of suitable ferromagnetic material such as ferrite. Unlike the usual saturable reactor it is not necessary for the core material to exhibit a square hysteresis loop.

Details of the RF variable reactance windings include that the two coils are series connected but opposed so as to cancel any induced voltages in the DC control circuit. It is also important that the variable reactance windings 26, 28 are not coupled to the bias control circuit as RF passing through these windings could conceivably be coupled into the control winding 32 to be rectified by the high frequency rectifier 34 and affect the reactor. Therefore, electrostatic shield material 42 may be interposed between the outer 26, 28 and inner 30 legs to prevent capacitive coupling.

It would be desirable for the surgeon to be made aware of the condition of the control circuit. Indicating means 44 may be provided across the DC leads of the rectifier bridge circuit so as to be responsive to the amount of DC voltage and to provide indication thereof.

As shown in FIG. 2, an alternative method of making the saturable reactor is to use two cup cores 44, each having one RF winding 46 and one control winding 48 wherein the RF windings are connected so to cancel the induced voltage in the DC control winding. As herein defined, cup cores include "U" and toroid shaped cores.

The control circuit for disclosed units is a simple passive device that when connected in the output circuit of an electrosurgical unit, reduces high frequency current to a low value for sensing and increases to normal level only if a complete circuit exists between the active probe and the patient plate. Switching time is in microseconds. Tests have been conducted with actual electrosurgical units using tubes, solid state and spark gap technologies over the frequency range of 500 kilohertz to 2.3 megahertz and the control circuit has been found to be both reliable and efficient.

I claim:

1. In combination with an electrosurgical unit having an oscillator applying variable high frequency current to a plurality of patient electrodes, a control circuit comprising:

a saturable reactor connected between said oscillator and at least one of said patient electrodes; and bias means responsive to current flow through said patient electrodes for biasing said saturable reactor to control the impedance thereof, whereby for a first range of current flow through said patient electrodes said saturable reactor represents an inductive reactance to said oscillator and during a second range of current flow through said patient electrodes substantially greater than said first current flow said reactor represents a lower inductive reactance to said oscillator.

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2. A control circuit as defined in claim 1, wherein said saturable reactor includes:
a ferromagnetic core;
a plurality of variable reactances windings, and
a control winding.

3. A control circuit as defined in claim 2, wherein said bias means includes:

a diode rectifying bridge connected between one of said patient electrodes and said control winding, said bridge having a DC current output corresponding to the amplitude of AC current flow, said DC output being applied to said control winding for biasing said saturable reactor.

4. A control circuit as defined in claim 3 which further includes an indicator means connected across said bias means so as to be indicative of said bias current and load conditions across said patient electrodes.

5. A control circuit as defined in claim 2, wherein

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said variable reactance windings are interconnected so as to nullify any induced voltage in said control winding.

5 6. A control circuit as defined in claim 5, which further includes an electrostatic shield means interposed between said variable reactance windings and said control windings.

10 7. A control circuit defined in claim 1, wherein said saturable reactor is comprised of:

two cup cores;
at least one variable reactance winding wound about each of said cup cores; and
at least one DC control bias winding wound about each of said cup cores, whereas said variable reactance windings are connected in series so as to nullify the effect on said DC control coils winding.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,913,583

Dated October 21, 1975

Inventor(s) William T. Bross

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 64 "exists" should be --exits--.

Column 2, line 63 "sheild" should be --shfield--.

Column 3, line 53 "campared" should be --compared--.

Signed and Sealed this

tenth Day of February 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

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