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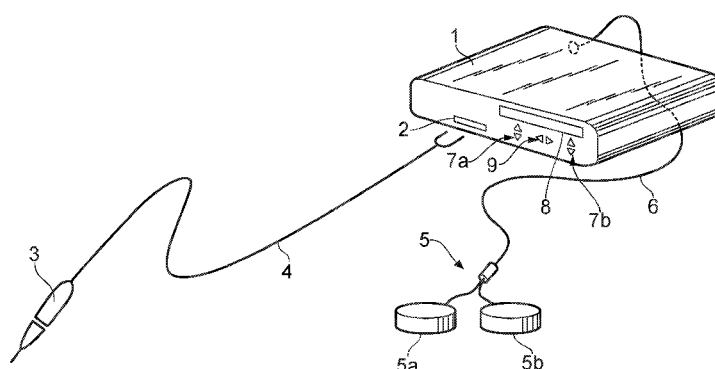


FIG. 1

(57) Abstract: An electrosurgical system comprises at least a first unit (1) and a second unit (3), the second unit (3) being detachably connectible to the first unit (1) and including an electrode assembly (15). The first unit comprises a power supply (10), an RF oscillator circuit (11) for generating a radio frequency output, and an output stage (13) adapted to supply an RF output to the electrode assembly (15). The second unit (3) comprises an identification circuit (16) presenting, in an alternating manner, a parameter with a first finite non-zero value for a first time period, and a parameter with a second finite value for a second time period. The first unit (1) includes a sensing circuit (18) and a controller (12) adapted to detect a characteristic of the identification circuit and provide an output signal, the controller (12) connected to the sensing circuit and receiving the output signal, adjusts the RF output so as to suit the particular electrode assembly (15).

Electrosurgical System

This invention relates to an electrosurgical system for use in the treatment of tissue. Such systems are used in endoscopic or “keyhole” surgery, as well as more traditional “open” surgery.

Many electrosurgical systems have some form of identification system, such that when an electrosurgical instrument is connected to an electrosurgical generator, the generator is able to detect which type of instrument is present, and even use settings such as power and voltage settings which are appropriate for that particular instrument or type of instrument. Our US patent 6,074,386 is one example of such an identification system, although other types are also known.

Embodiments of the present invention attempt to provide an alternative to such identification systems, with increased complexity so as to make it more difficult for non-authorised instruments to be used. Accordingly, in one aspect of the present invention, there is provided an electrosurgical system comprising: a first unit including: a) a power supply; b) an RF oscillator circuit for generating a radio frequency output; and c) an output stage adapted to supply an RF output to an electrode assembly; and a second unit detachably connectible to the first unit and being associated with the electrode assembly, the second unit including an identification circuit configured to present to the first unit whilst the second unit is connected to the first unit, in an alternating manner, a parameter with a first finite non-zero value for a first time period, and a parameter with a second finite value for a second time period; wherein the first unit further includes: d) a sensing circuit adapted to detect a characteristic of the identification circuit and provide an output signal; and e) a controller connected to the sensing circuit and configured to receive the output signal, the controller being configured to adjust the RF output in response to the output signal from the sensing circuit so as to suit the particular electrode assembly.

Another aspect of the invention provides a method of operating an electrosurgical system comprising at least a first unit and a second unit, the second unit being detachably connectible to the first unit and being associated with an electrode assembly, the method comprising, whilst the second unit is connected to the first unit:

presenting from the second unit to the first unit, in a time-varying manner, a parameter with a first finite non-zero value for a first time period, and a parameter with a second finite value for a second time period; detecting the parameters in the first unit; providing an RF output signal from the first unit to the second unit; and adjusting the RF output signal of the first unit in response to the detection so as to suit the particular electrode assembly; wherein the time-varying nature of providing the parameters provides for identification of the particular electrode assembly.

The first unit conveniently comprises an electrosurgical generator, and the second unit comprises an electrosurgical instrument detachably connected to the generator, typically by means of a cable and a connector. The electrosurgical instrument conveniently integrally includes the electrode assembly, in a “one piece” configuration. Alternatively, the electrosurgical instrument comprises a handpiece and a separate electrode assembly which is selectively attached and detached with respect to the handpiece, a so-called “two piece” configuration. The reference above to the second unit being “associated with” an electrode assembly is specifically intended to include both of these arrangements, and also a further arrangement in which the second unit comprises an adaptor unit, connected in between the electrosurgical instrument and the electrosurgical generator.

In a further alternative arrangement, the first unit comprises a handheld electrosurgical handpiece, and the second unit comprises an electrode unit detachably connected to the electrosurgical handpiece. Conveniently, the electrode unit comprises an elongate shaft having the electrode assembly at one end of the shaft and a connector at the other end of the shaft, for connecting the electrode unit to the handpiece. Whichever arrangement is employed, the sensing circuit within the first unit helps to identify the electrode assembly in question and sends an output signal to the controller, which in turn adjusts the RF output to suit the particular electrode assembly.

According to one convenient arrangement, the first unit is adapted to detect the frequency of alternating between the first time period and the second time period. Alternatively, the first unit is adapted to detect the ratio between the first time period and the second time period. According to a further alternative arrangement, the first unit is adapted to detect the difference between the value of the parameter during the

first and second time periods. Whichever arrangement is used, the characteristic used to identify the second unit to the first unit is a dynamic one, based on the alternating between the first and second values. This added complexity makes the identification harder to duplicate, and ensures that only known suitable electrode assemblies are able to be used in connection with the first unit.

It is common for several generations of electrosurgical instrument to be used over the lifetime of an electrosurgical generator, or for a combination of first and second generation generators to be in the field at any one time. This means that some generators may be capable of detecting the dynamic identification characteristics, while other older versions are not. Thus, the first unit is conceivably adapted to detect the value of the parameter during the first time period, or the second time period, or both. In this way, those first units capable of detecting the dynamic identification characteristics can do so for added security, while those older versions incapable of detecting the dynamic identification characteristics can still be used in connection with second units exhibiting a dynamic identification characteristic, even though only the value of the parameter and not its changing characteristics is detected in such older versions.

For added sophistication, the first unit may detect a combination of the features detailed above, for example the value of the parameter during either the first or second time period together with the frequency at which the time periods alternate. Other combinations will be apparent to those skilled in the art such that each and every combination does not need to be listed here.

Within the above, where the first unit is adapted to detect a value of the parameter, or a difference therein, or a ratio of time periods, or frequency of alternating between time periods, etc, as described above, in a preferred embodiment it is a combination of the sensing circuit and the controller that make the final identification of the second unit that has been connected to the first unit. Specifically, the sensing circuit may output a sensing signal indicative of the parameter, difference, ration, frequency, etc. the sensing signal then being interpreted by the controller to make the identification and then preferably control the first unit appropriately.

In a preferred arrangement, the identification circuit includes at least first and second passive electrical identification components having a parameter of a finite non-zero value, the value of the first identification component being different from the value of the second identification component. The identification circuit conveniently also
5 includes switching means for switching between first and second combinations of the first and second identification components. In one arrangement, the switching means switches between a first combination of solely the first identification component and a second combination of solely the second identification component. In an alternative arrangement, the switching means switches between a first combination of solely the
10 first identification component and a second combination of both the first and second identification components. Whichever arrangement is employed, as the values of the parameter are different between the first and second identification components, the result is a repeating high/low/high/low value for the parameter. This alternating value is sensed by the sensing circuit within the first unit, in order for the first unit to identify
15 the second unit and set appropriate output characteristics.

Preferably, the parameter with the first and second finite values is capacitance, such that the first and second identification components are capacitors. Our US patent 6,074,386 describes how the value of the capacitor can be established by setting up a resonant circuit between the first and second units, and detecting the resonant
20 frequency of such a resonant circuit. This method, or alternatives readily known to those skilled in the art, may be employed for sensing the capacitances associated with the dynamic identification circuit within the second unit.

Conveniently, the switching means comprises a transistor. However, other switching components are known to those skilled in the art, and the use of such
25 switching components may depend on the sterilization method used to sterilize the second unit.

Also described herein is an electrosurgical instrument, or an electrode assembly for an electrosurgical instrument, comprising a connection interface and an identification circuit. The identification circuit is arranged to present at the connection
30 interface a time-varying electrical parameter, the time-varying electrical parameter serving as an identification signature determinative of at least one property of the

electrosurgical instrument or electrode assembly. The property may be for example the identity of the instrument or assembly, or one or more electrical characteristics or input signal requirements.

5 In one embodiment the identification circuit comprises a network of electrical components, and a switching device to switch one or more of the electrical components in and out of the network whereby to vary the electrical parameter. Preferably the network of electrical components comprises one or more reactive components, a resonant frequency of the network altering as the switching device switches the one or more reactive components in and out of the network.

10 In one specific embodiment the network comprises at least two reactive components arranged in parallel, the switching device, preferably being a transistor, being arranged to switch periodically one of the components in and out of the network, whereby the time-varying electrical parameter switches between a larger and smaller reactance or impedance. In some embodiments of the invention, the reactive
15 components are conveniently capacitors.

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings, in which;

20 Figure 1 is a schematic diagram of an electrosurgical system according to the present invention,

Figures 2 is a schematic diagrams of the system of Figure 1, showing various internal components,

Figure 3 is a schematic circuit diagram of an identification circuit used within the system of Figure 1,

25 Figure 4 is a more detailed circuit diagram of the identification circuit of Figure 3,

Figure 5 is a schematic diagram of an alternative electrosurgical system according to the invention; and

30 Figure 6 is a circuit diagram of a sensing circuit that may be used in an embodiment of the invention.

Referring to the drawings, Figure 1 shows a conventional electrosurgical apparatus including a first unit in the form of a generator 1 having an output socket 2 providing a radio frequency (RF) output, for a second unit in the form of an instrument 3, via a connection cord 4. Activation of the generator 1 may be performed by means of a footswitch unit 5 connected separately to the rear of the generator 1 by a footswitch connection cord 6. In the illustrated embodiment, the footswitch unit 5 has two footswitches 5a and 5b for selecting a desiccation mode and a vaporisation mode of the generator 1 respectively. The generator front panel has push buttons 7a and 7b for respectively setting desiccation and vaporisation power levels, which are indicated in a display 8. Push buttons 9 are provided as an alternative means for selection between the desiccation and vaporisation modes.

Figure 2 shows a schematic version of Figure 1 showing some of the internal components of the generator 1 and instrument 3. The generator 1 includes a power supply 10, RF oscillator 11, and controller 12, all designed to provide an RF output to output stage 13. The instrument 3 includes a handpiece 14 and an electrode assembly 15. In some arrangements the electrode assembly 15 is detachable from the handpiece 14 so that the same handpiece can be used with different electrode assemblies. In other arrangements, the handpiece 14, electrode assembly 15 and connection cord 4 are all formed as a single one-piece assembly.

The instrument 3 also includes an identification circuit 16, which is associated with the electrode assembly 15 if the electrode assembly is detachable, or otherwise with the handpiece 14 if the instrument is a one-piece assembly. The identification circuit 16 is connected via additional line 17 to a sensing circuit 18 located within the generator 1.

The identification circuit 16 will be further described with reference to Figure 3. The circuit comprises first capacitor 19 (C_{main}), second capacitor 20 (C_{aux}) and a switching circuit 21. The switching circuit 21 alternates between connecting the second capacitor in and out of parallel with the first capacitor, so that the overall

capacitance of the circuit is altered in dependence on the switching of the switching circuit. In particular, because the capacitances of capacitors connected in parallel add together, the operation of the switching circuit 21 causes the overall capacitance to switch between a lower capacitance C_{main} , and a higher capacitance equal to the sum of C_{main} and C_{aux} . When the capacitances are connected into and form part of a resonant circuit with the sensing circuit in the generator, the switching in and out of C_{aux} 21 by the switching circuit 21 will cause the resonant frequency of the whole resonant circuit to change. This change can be detected by circuitry in the generator, and the change used to identify the type of electrosurgical instrument or electrode assembly that is attached, as described further below.

More particularly, generally the frequency of oscillation of a resonant circuit will be given by the formula below;

$$F_o = \frac{1}{2\pi\sqrt{LC}}$$

Hence, as C_{aux} is switched into the circuit by switch 21, the resonant frequency F_o of the resonant circuit will decrease. Detecting changes in the frequency of oscillation therefore gives an indication of the value of the capacitor 20, and for a known inductance the values of both C_{main} and C_{aux} can be found by monitoring the resonant frequency thus obtained. As described further below, the sensing circuit 18 contains an oscillator that oscillates at different frequencies, and the controller 12 detects the frequency of oscillation, both when the first capacitor is connected to the sensing circuit and also when the second capacitor is connected to the sensing circuit. Thus the sensing circuit 18 and controller 12 are hence able to identify the type of handpiece 14 and hence electrode assembly 15 connected to the generator 1. The controller 12 accordingly adjusts the power supply 10 and/or oscillator 11 to supply an RF output to the output stage 13 which is suitable for the particular electrode assembly 15. When a different handpiece is connected to the generator 1, the sensing circuit 18 will oscillate at a different frequency of oscillation caused by the impedances in the identification circuit 16, and hence the controller will arrange for a different RF output, more suitable for the electrode assembly associated with that particular handpiece.

Figure 4 shows a detailed circuit diagram for the identification circuit 16. The identification comprises a reactive output stage 42, and a switch control oscillator circuit 40. The reactive output stage in this circuit is capacitive in nature, and comprises two

capacitors C_3 and C_4 in series (together the equivalent of the first capacitor 19 (C_{main}) of Figure 3), the value of C_4 typically being of the order of 10 times the value of C_3 . A second capacitor 20 (the equivalent of C_{aux}) is designated C_5 , and a transistor M_1 switches the second capacitor 20 in and out of the reactive output stage 42, and more specifically in and out of being connected in parallel with capacitors C_3 and C_4 . Primary and secondary lines 22 & 23 provide power for the transistor M_1 , and also for the switch control oscillator circuit 40. The switch control oscillator circuit 40 comprises an op-amp 24 configured as an oscillator, which produces a square wave output which is fed to the gate of transistor M_1 as a switching signal. The frequency of the square wave output is set to an appropriate frequency (which may be in the range of a few Hz to a few hundred Hz) by the oscillator biasing circuitry C_1 , R_1 , R_2 , R_3 , and R_4 . The square wave output from the oscillator drives the transistor M_1 in and out of saturation in order to switch the capacitor C_5 in and out of the circuit of the reactive output stage 42.

When the transistor M_1 is not conducting, the total value of C that would be seen at the primary input 21 is $\frac{C_3.C_4}{C_3+C_4}$ whereas when the transistor M_1 is conducting, the value of C that would be seen is $\frac{C_3.C_4}{C_3+C_4} + C_5$. This means that the frequency of oscillation will be lower when the transistor is conducting as compared with the time when the transistor is not conducting. The controller 12 monitors the frequency of oscillation of the resonant circuit in the sensing circuit 18 (described further below) during the time when the transistor M_1 is conducting, and also during the time when the transistor M_1 is not conducting. In this way, the sensing circuit 18 and controller 12 determine the values of the capacitors C_3 , C_4 & C_5 , and hence identify the type of instrument 3 connected to the generator 1.

The identification circuit 16 therefore provides multiple parameters that may be altered to provide different identifications. In particular, the values of C_3 , C_4 & C_5 may all be changed, which will give different resonant frequencies. The circuit arrangement provides for two resonant frequencies, $Fo1$ when C_5 is switched out, and $Fo2$ when C_5 is switched in, where $Fo2$ is less than $Fo1$. The values of C_3 , C_4 & C_5 may be selected to give any desired resonant frequencies. Alternatively or additionally, the biasing circuitry of the oscillator circuit 24 may also be altered, to give a different oscillator

frequency, and hence frequency of switching F_s between the two resonant frequencies. The circuit of Figure 4 therefore provides three parameters (F_{o1} , F_{o2} , and F_s) that may be altered to provide an identification signature for the electrosurgical instrument, and many different combinations of these three parameters are possible, resulting in a large
5 number of possible identification signatures.

In order to determine the above parameters, the sensing circuit 18 couples to the primary input 22. An example sensing circuit 18 is shown in Figure 6, which is almost identical to the sensing circuit described in our prior patent US6074386. Here, sensing circuit 18 is centred on an operational amplifier 52 having a low impedance output 52A
10 driving an excitation primary winding 54A of an isolation transformer 54. A secondary winding 54' of the transformer 54 is coupled between the primary input 22 of identification circuit and ground, so that winding 54' and capacitors 19 and 20 in the identification circuit 16 form a parallel resonant circuit. The resonant frequency of the resonant circuit is typically within the range of from 2 kHz to 150 kHz, depending on
15 the value of capacitors C3, C4, and C5.

The transformer 54 also has a sense winding 54B coupled between an AC ground on one side and the inverting input 52I of the operational amplifier 52, thereby providing a feedback path from the transformer. Since winding 54B is effectively coupled to the excitation winding 54A via the resonant secondary winding 54', the
20 presence of the resonant circuit largely filters out the harmonics of the square wave output of the operational amplifier 52.

Clamp diodes D1 and D2 connected with opposite pluralities across sense winding 54B provide, in conjunction with capacitor C3 and resistor R4, a phase shift network causing a 90 degree phase lag with respect to the excitation winding output.

25 The three windings 54A, 54B and 54' of transformer 54 are wound on a three-section bobbin with a central threaded iron dust core 54C, this material being chosen due to its high curie point and consequent minimal thermal drift. Alternatively, core 54C may be made of a ferrite material with a comparatively large A_l value in conjunction with a calibration reference to allow compensation for thermal drift by, for
30 example, switching in a known capacitance across the resonant winding 54'.

Coupling between the resonant secondary winding 54' and the other windings 54A, 54B of the transformer 54 is comparatively low to limit radio frequency feedback. Typically, the leakage inductance is in the region of 3 mH.

It will be appreciated from the above that operational amplifier 52 acts as an
5 oscillator, oscillating at the resonant frequency of the resonant circuit produced by secondary winding 54' and capacitors 19 and 20 (C3, C4, and C5). The output signal produced by the operational amplifier 52 is amplified in a buffer amplifier 56 and applied to output terminal 50C from where it is fed to the controller 12 (see FIG. 2). Controller 12 contains a counter for determining the frequencies of oscillation (or an
10 equivalent measurement, as discussed further below) from which the identity of the electrode assembly is obtained.

As a safety feature the controller 12 includes means for determining from the output of the identification circuit 16 whether any electrode assembly is connected to the generator. In such an eventuality, the oscillation frequency of the circuit 50 is
15 outside a predetermined range (in this embodiment it is higher than 150 kHz) and the adjusting means generates a signal indicative of no electrode assembly being connected and the supply of RF output power to the handpiece 12 is inhibited.

The sensing circuit 18 and controller 12 may monitor parameters other than the absolute values of the capacitors C₃, C₄ & C₅. The sensing circuit and controller may
20 alternatively calculate the difference in values between two or more of the capacitors, or alternatively the oscillation frequency of the transistor M₁. Alternatively, the sensing circuit and controller may monitor the ratio of the periods during which the transistor M₁ is in each of its two alternating states. Whichever parameter is monitored, the sensing circuit 18 and controller are able to establish a unique identifying characteristic
25 for the type of instrument connected to the generator, such that the controller 12 can ensure that an RF output suitable for the electrode assembly associated with that instrument is provided.

Figure 5 shows an alternative type of system in which the generator 1 is provided within a handheld electrosurgical instrument. The instrument 3 is provided with a first
30 unit in the form of a handle 25 within which the power supply 10, RF oscillator 11, controller 12, output stage 13 and sensing circuit 18 are located. Given that the instrument is handheld, the power supply 10 is typically a battery. A second unit in the

form of a probe 26 is detachably connected to the handle 25, the probe including the identification circuit 16 and an electrode assembly 15. The identification circuit 16 and sensing circuit 18 cooperate as previously described to identify the type of probe connected to the handle 25, and hence the appropriate RF output to be supplied to the
5 electrode assembly 18.

Variations from the above-described arrangements will be apparent to those skilled in the art without departing from the scope of the present invention. For example, greater sophistication is possible by the provision of more than two alternating values for the chosen parameter, conceivably three or even more.
10 Whichever parameter is chosen and however many values are dynamically presented, the key feature of the invention is the provision of a dynamically varying parameter as opposed to a static value that remains constant in time. This dynamic variation in the value for the parameter being monitored allows for a degree of complexity sufficient to make it difficult for unauthorised instruments to duplicate the required signature and
15 "fool" the generator or handheld instrument into accepting an unauthorised electrode assembly. In this way, the integrity of the electrosurgical system, and hence its efficiency and safety, is maintained to an extent greater than if unauthorised instruments are capable of being used without such controls.

The reference in this specification to any prior publication (or information
20 derived from it), or to any matter which is known, is not, and should not be taken as, an acknowledgement or admission or any form of suggestion that that prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavour to which this specification relates.

Throughout this specification and the claims which follow, unless the context
25 requires otherwise, the word "comprise", and variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

Claims

1. An electrosurgical system comprising:
a first unit including:
 - 5 a) a power supply;
 - b) an RF oscillator circuit for generating a radio frequency output; and
 - c) an output stage adapted to supply an RF output to an electrode assembly; anda second unit detachably connectible to the first unit and being associated with the electrode assembly, the second unit including an identification circuit configured to
10 present to the first unit whilst the second unit is connected to the first unit, in an alternating manner, a parameter with a first finite non-zero value for a first time period, and a parameter with a second finite value for a second time period;
wherein the first unit further includes:
 - d) a sensing circuit adapted to detect a characteristic of the identification circuit and
15 provide an output signal; and
 - e) a controller connected to the sensing circuit and configured to receive the output signal, the controller being configured to adjust the RF output in response to the output signal from the sensing circuit so as to suit the particular electrode assembly.
- 20 2. An electrosurgical system according to claim 1, wherein the first unit is adapted to detect a frequency of alternating between the first time period and the second time period.
3. An electrosurgical system according to claim 1 or 2, wherein the first unit is
25 adapted to detect a ratio between the first time period and the second time period.
4. An electrosurgical system according to any one of the preceding claims, wherein the first unit is adapted to detect a value of the parameter during the first time period.
30
5. An electrosurgical system according to any one of the preceding claims, wherein the first unit is adapted to detect a value of the parameter during the second

time period.

6. An electrosurgical system according to any one of the preceding claims,
wherein the first unit is adapted to detect a difference between a value of the parameter
5 during the first time period and a value of the parameter during the second time period.

7. An electrosurgical system according to any of the preceding claims, wherein the
identification circuit includes at least first and second passive electrical identification
components having a parameter of a finite non-zero value, a value of the first
10 identification component being different from a value of the second identification
component.

8. An electrosurgical system according to claim 7, wherein the identification
circuit also includes switching means for switching between first and second
15 combinations of the first and second identification components.

9. An electrosurgical system according to claim 8, wherein the switching means
switches between a first combination of solely the first identification component and a
second combination of solely the second identification component.
20

10. An electrosurgical system according to claim 8, wherein the switching means
switches between a first combination of solely the first identification component and a
second combination of both the first and second identification components.

25 11. An electrosurgical system according to any of the preceding claims, wherein the
parameter with the first finite value and the parameter with the second finite value is
reactance.

12. An electrosurgical system according to any of claims 8 to 10 or claim 11 where
30 appended to any one of claims 8 to 10, wherein the switching means comprises a
transistor.

13. An electrosurgical system according to any of claims 7 to 10 or claim 12 where appended to any one of claims 7 to 10, wherein the first and second identification components are capacitors, and the parameter with the first finite value and the parameter with the second finite value is capacitance.
- 5 14. An electrosurgical system according to any of the preceding claims, wherein the first unit is an electrosurgical generator and the second unit is an electrosurgical instrument detachably connected to the generator.
- 10 15. An electrosurgical system according to any of the preceding claims, wherein the first unit is a handheld electrosurgical handpiece and the second unit is an electrode unit detachably connected to the electrosurgical handpiece.
- 15 16. A method of operating an electrosurgical system comprising at least a first unit and a second unit, the second unit being detachably connectible to the first unit and being associated with an electrode assembly, the method comprising, whilst the second unit is connected to the first unit:
- 20 presenting from the second unit to the first unit, in a time-varying manner, a parameter with a first finite non-zero value for a first time period, and a parameter with a second finite value for a second time period;
- detecting the parameters in the first unit;
- providing an RF output signal from the first unit to the second unit; and
- adjusting the RF output signal of the first unit in response to the detection so as to suit the particular electrode assembly;
- 25 wherein the time-varying nature of providing the parameters provides for identification of the particular electrode assembly.
- 30 17. A method according to claim 16, wherein the presenting comprises switching one or more of electrical components in and out of a network of electrical components whereby to vary the value of the parameters presented.
18. A method according to claim 17, wherein the network of electrical components

comprises one or more reactive components, a resonant frequency of the network altering as the one or more reactive components are switched in and out of the network.

19. A method to claim 18, wherein the network comprises at least two reactive
5 components arranged in parallel, the method further comprising switching periodically
one of the components in and out of the network, whereby the time-varying electrical
parameter switches between a larger and smaller reactance or impedance.

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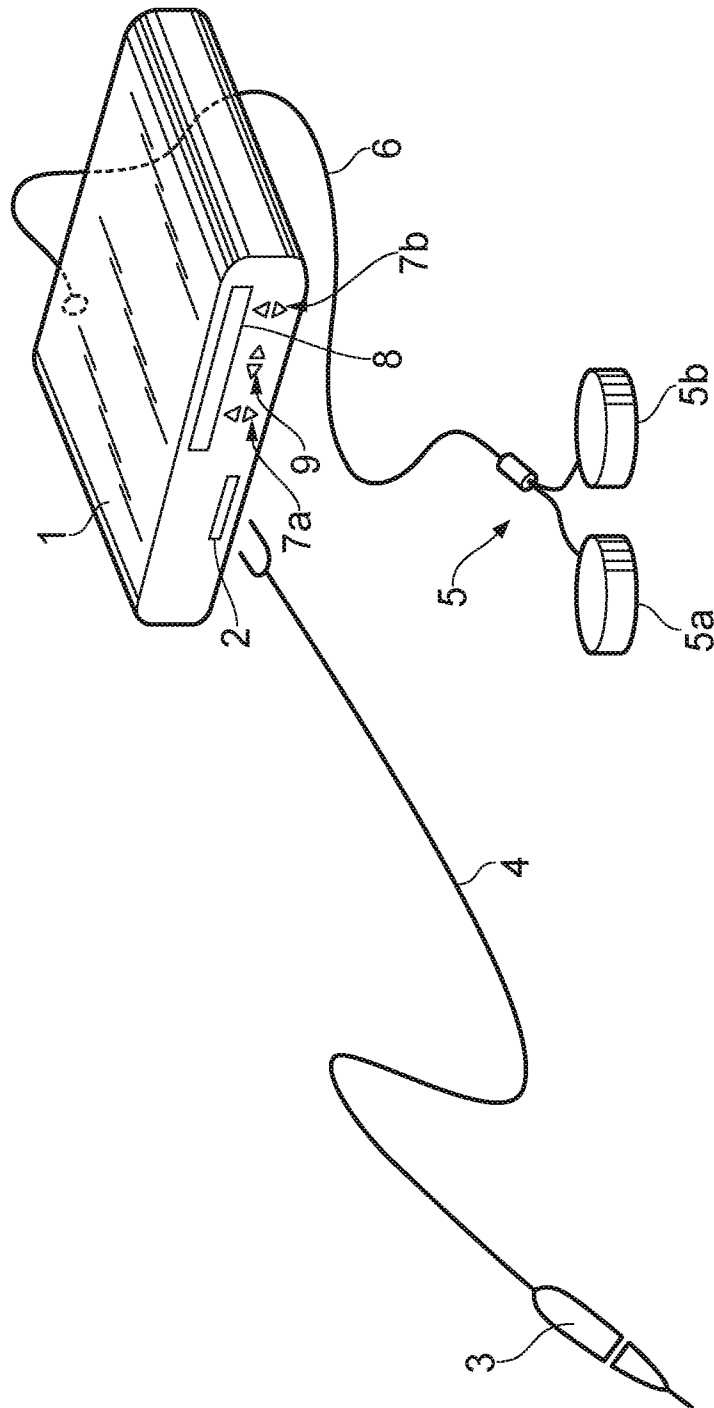


FIG. 1

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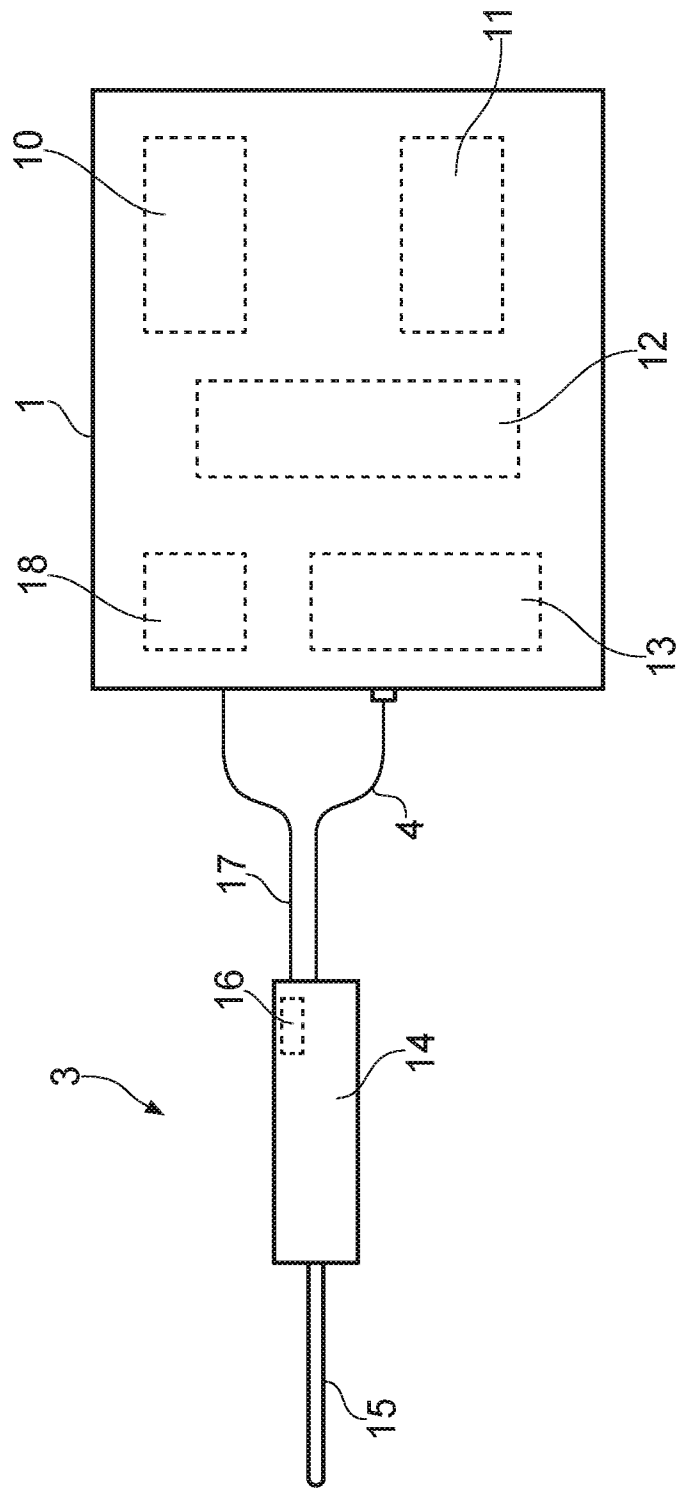


FIG. 2

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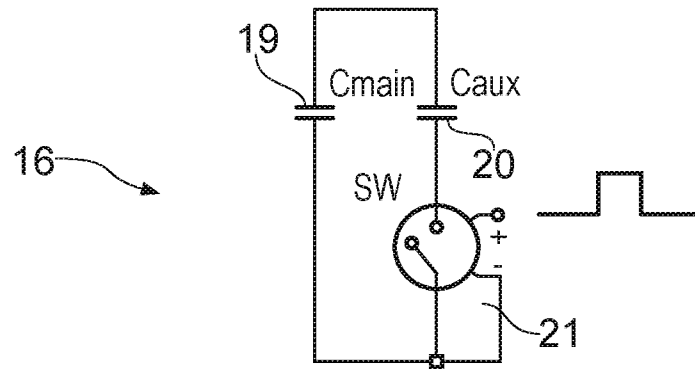


FIG. 3

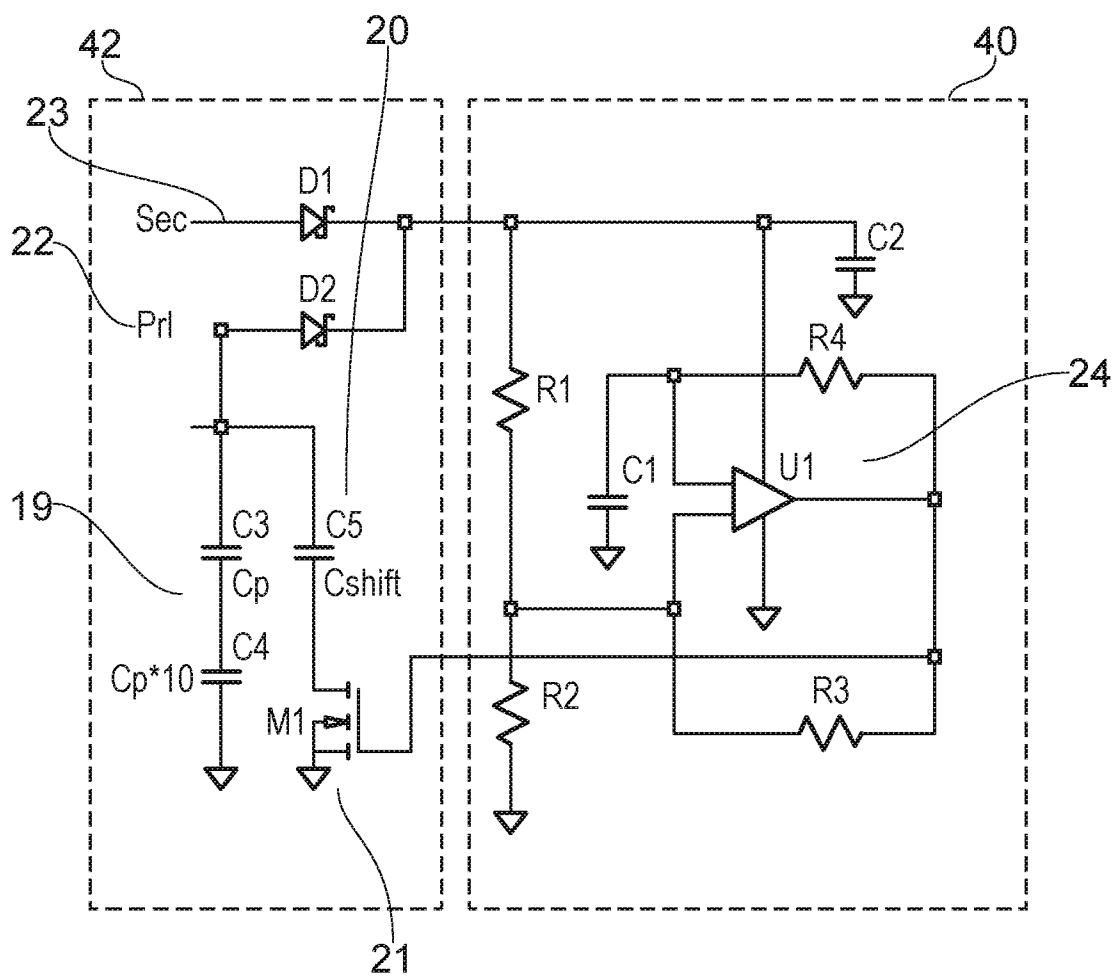


FIG. 4

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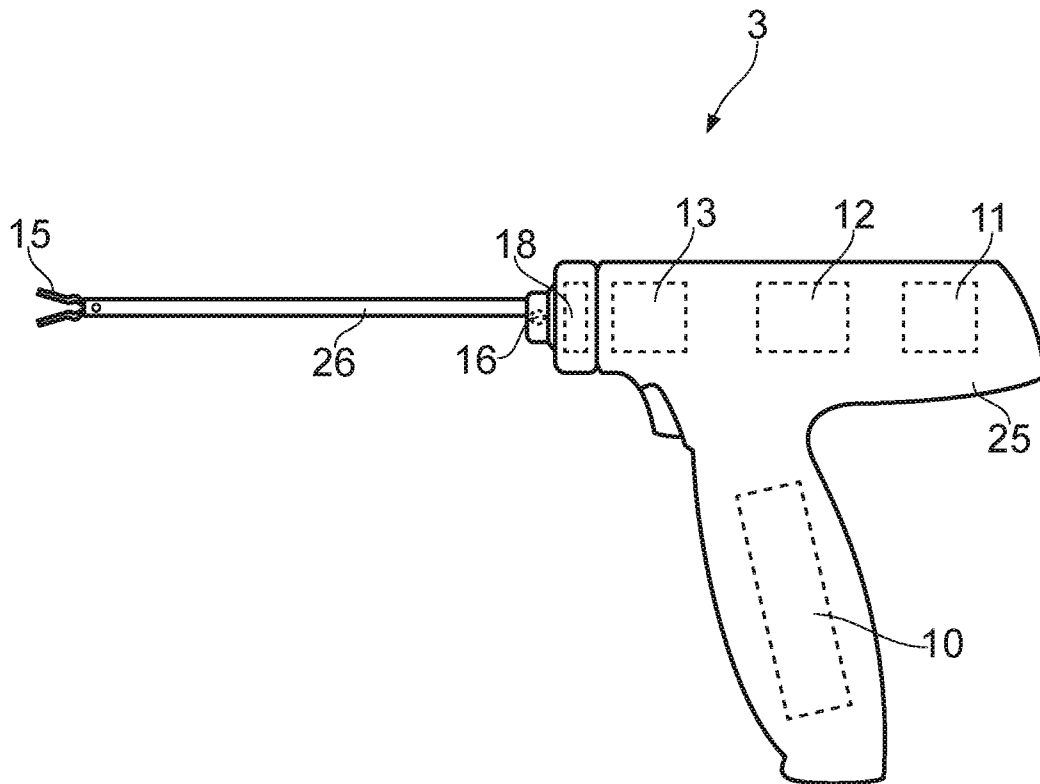


FIG. 5

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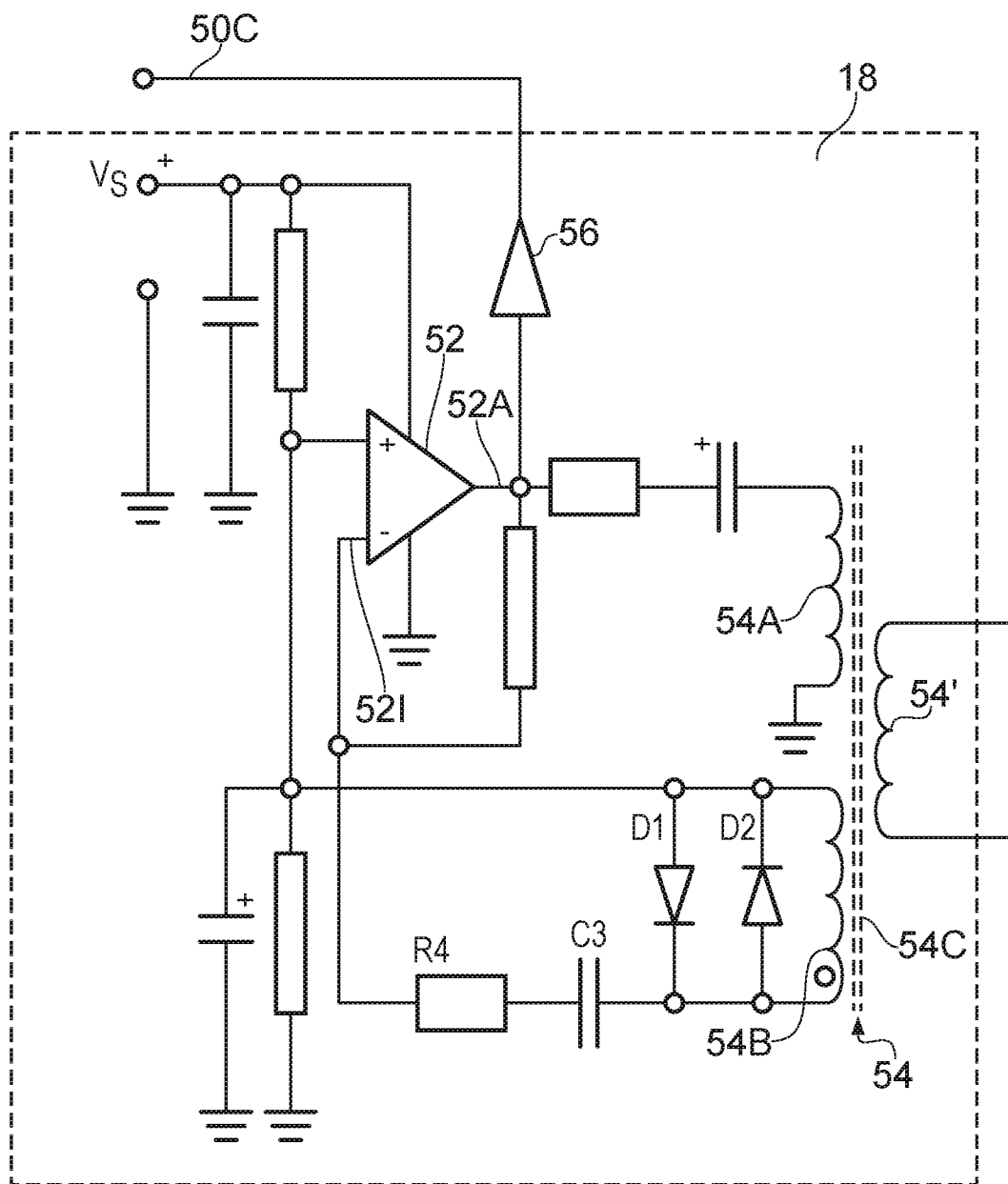


FIG. 6