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(54) **LAPAROSCOPIC ELECTROSURGICAL ELECTRICAL LEAKAGE DETECTION**

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(57) **ABSTRACT**

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An electrical leakage detection method and system for use with laparoscopic electrosurgical instruments are provided. The present disclosure provides for an electrosurgical unit for providing electrosurgical energy at an active output thereof and for controlling the flow of the energy through the active output; an active electrode coupled to the active output for transmitting electrosurgical energy to a patient in an electrosurgical procedure; a first sensor disposed at a distal end of the active electrode and for outputting a first signal indicative of current measured at the distal end; a second sensor disposed at a proximal end of the active electrode and for outputting a second signal indicative of current measured at the proximal end; and a comparison circuit coupled to the first and second sensors for receiving the first and second signals and determining a difference value, the difference value being indicative of leakage current.

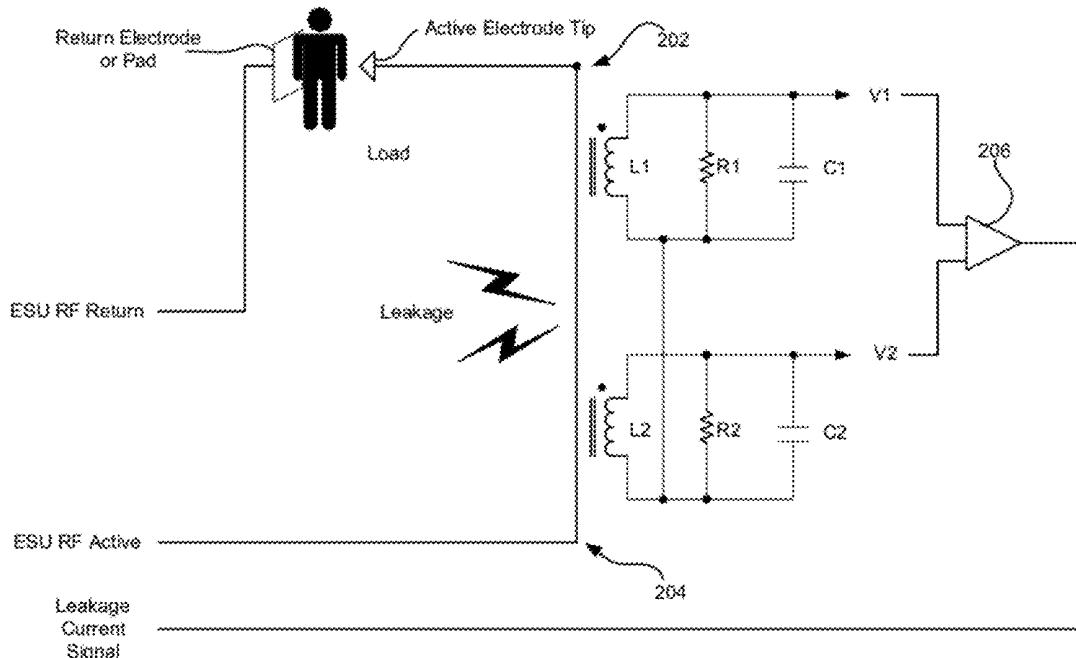
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(63) Continuation of application No. 12/056,436, filed on Mar. 27, 2008, now Pat. No. 8,100,897.



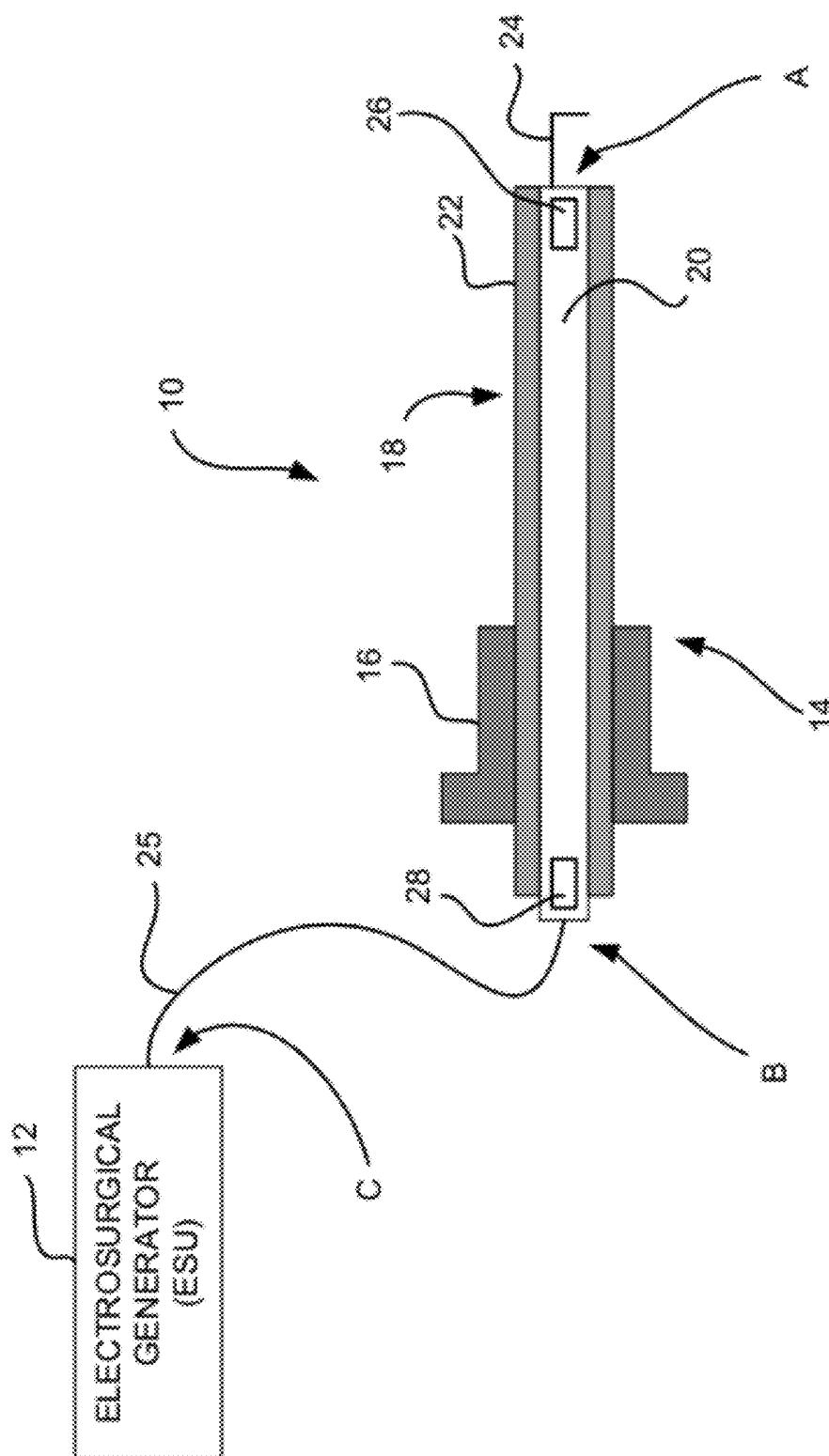


FIG. 1

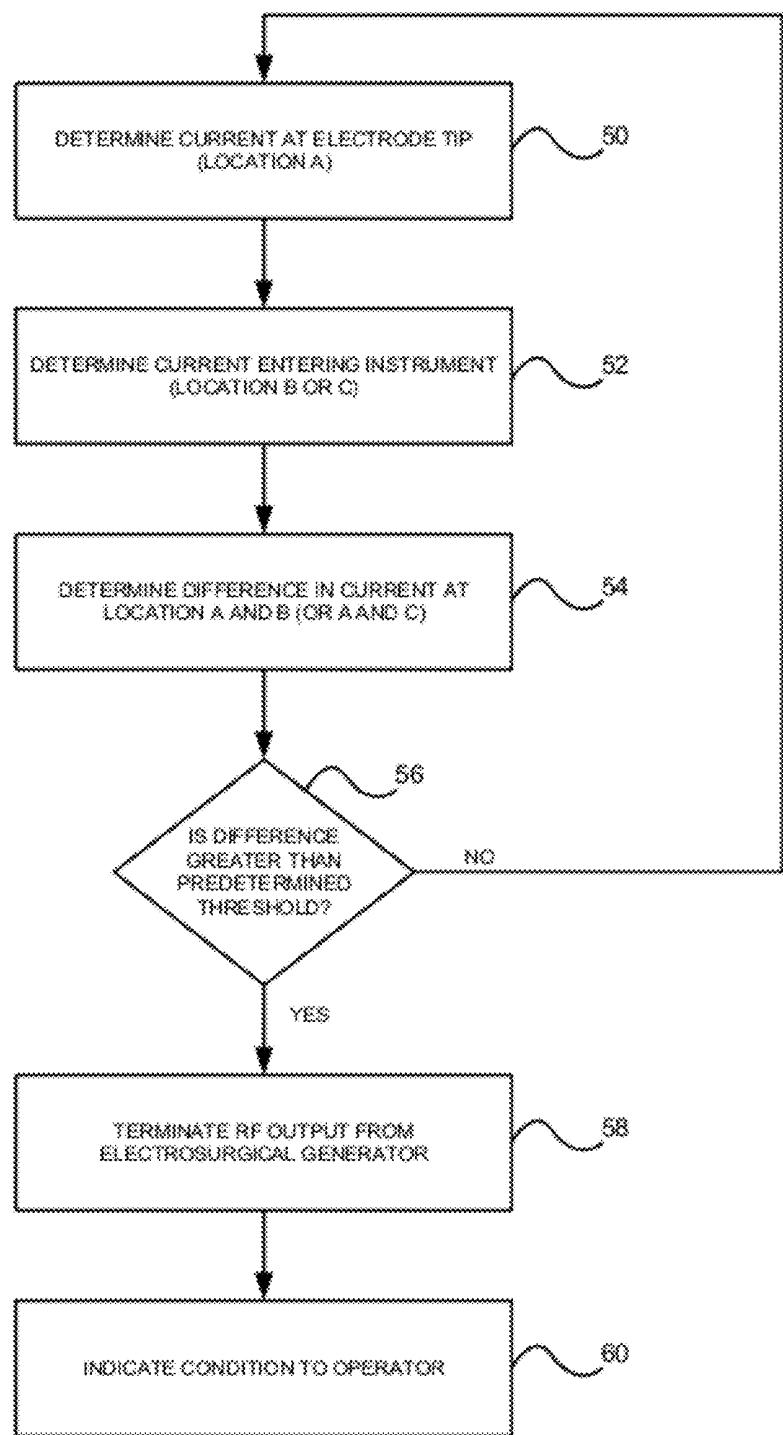
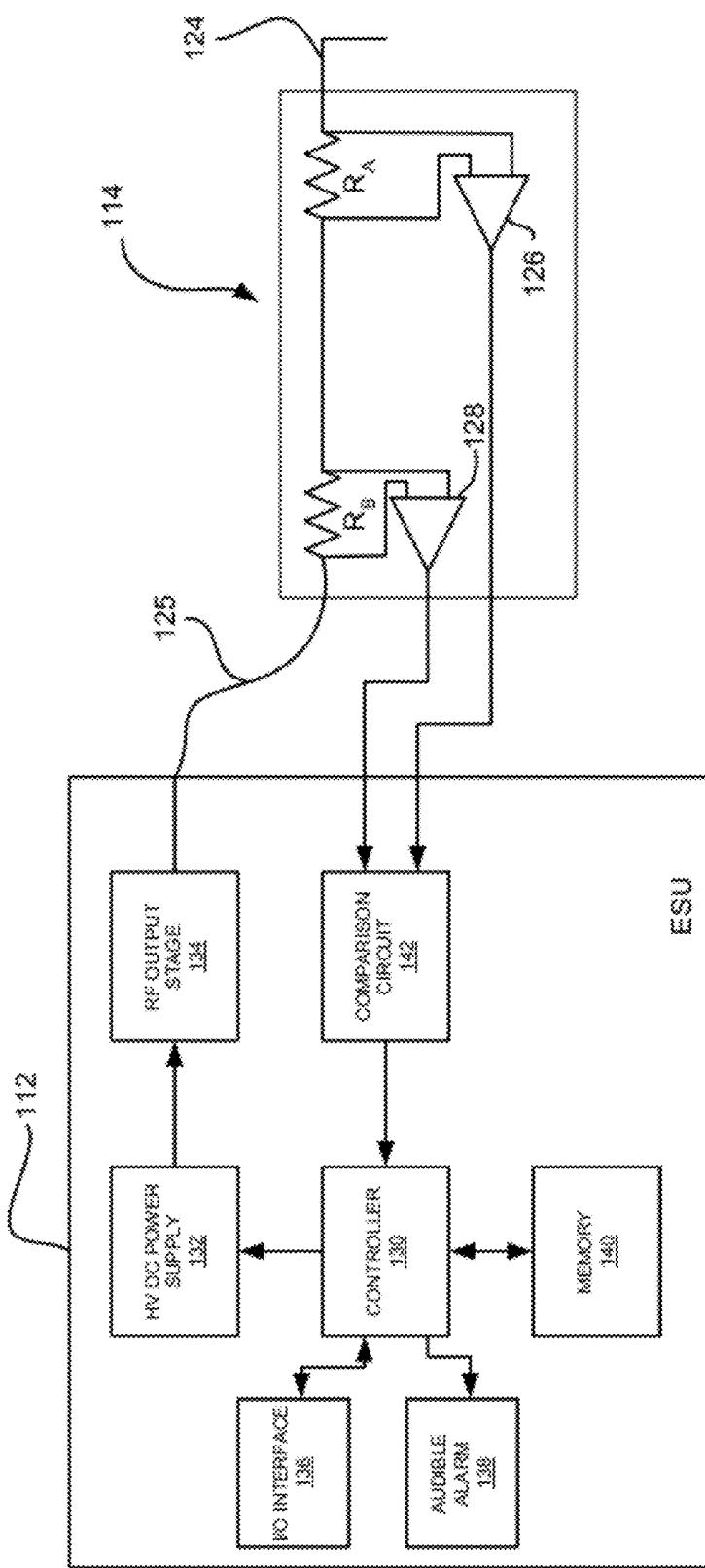


FIG. 2



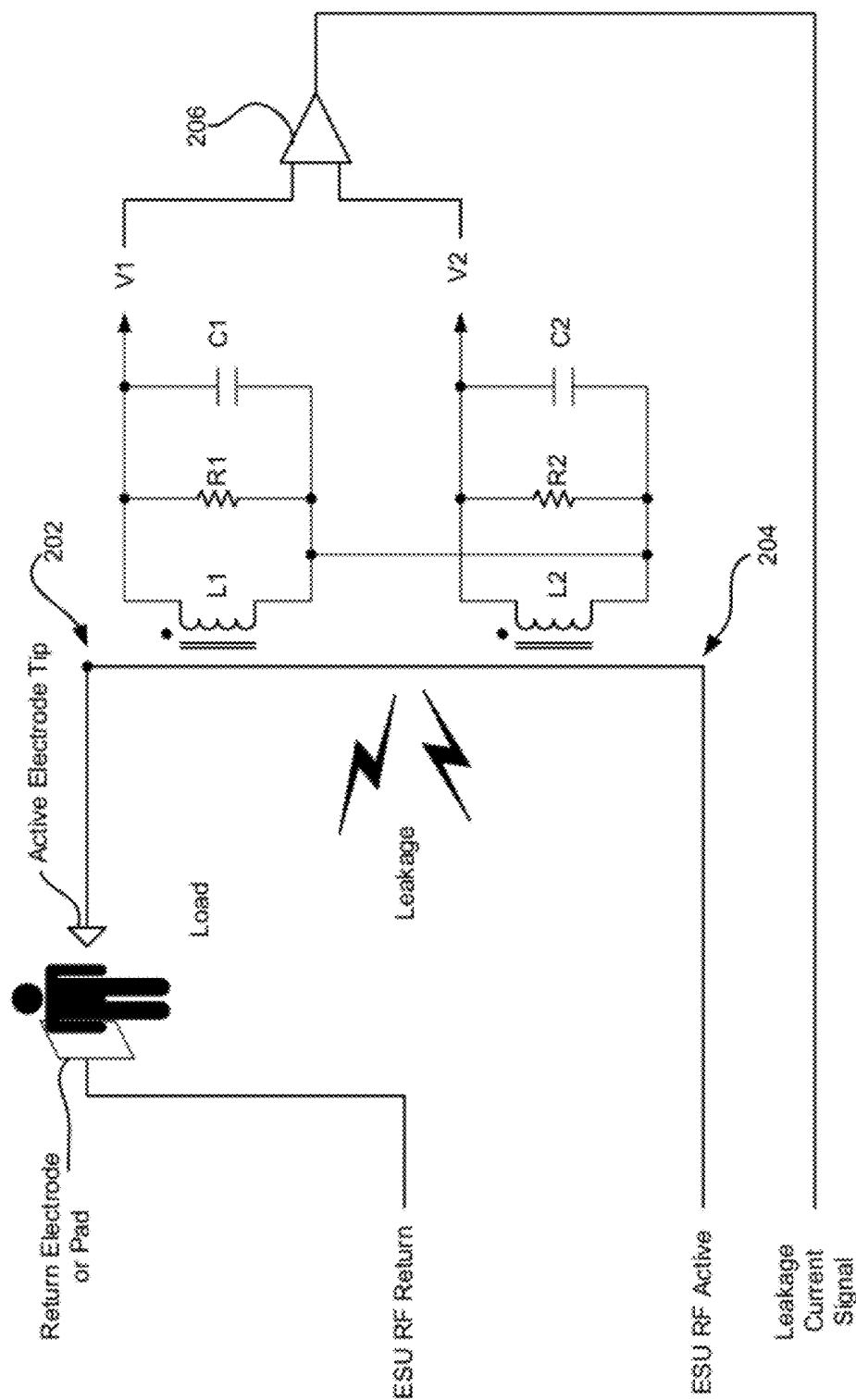
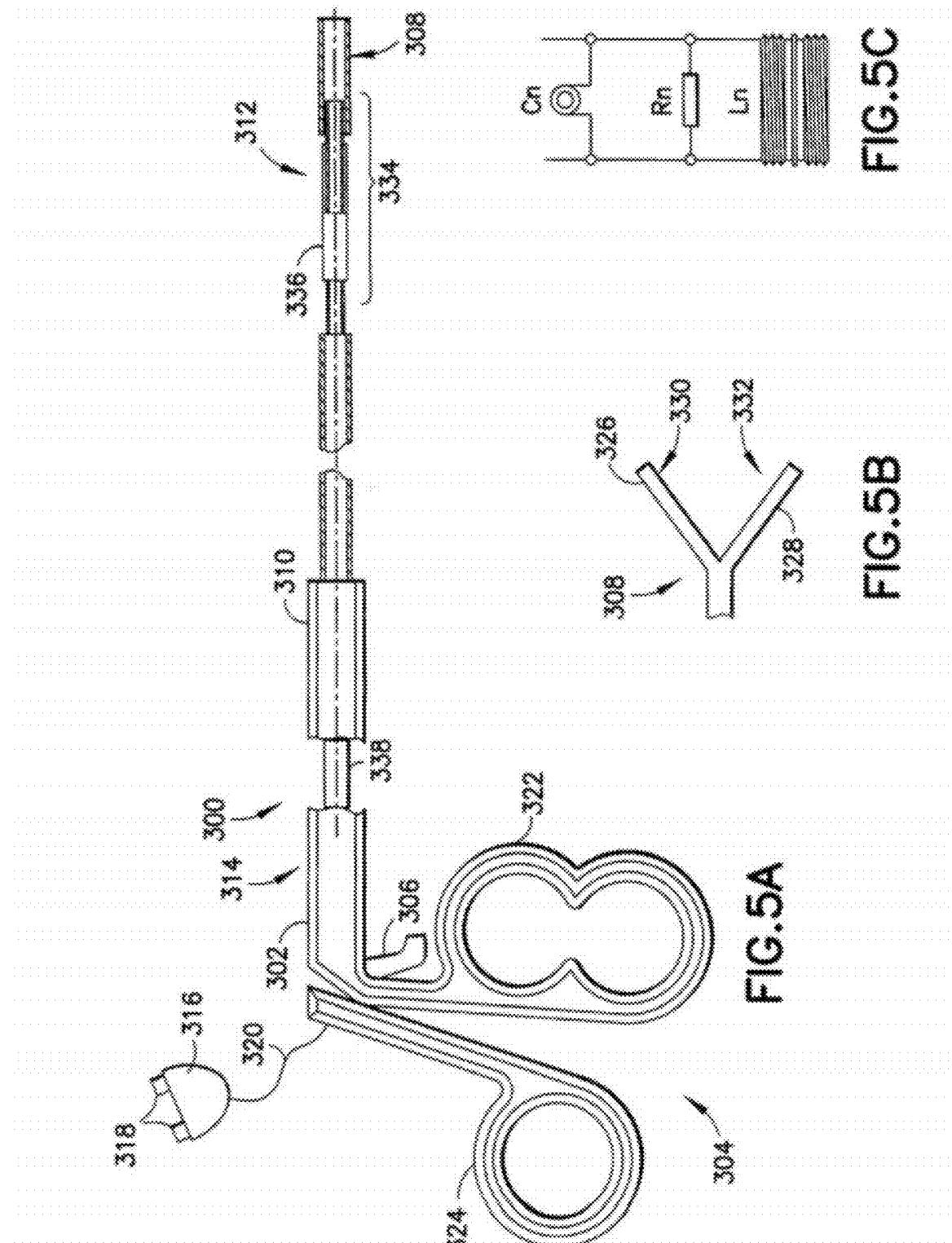


FIG. 4



## LAPAROSCOPIC ELECTROSURGICAL ELECTRICAL LEAKAGE DETECTION

[0001] This application is a continuation application of U.S. application Ser. No. 12/056,436 filed Mar. 27, 2008, the contents of which are hereby incorporated by reference in its entirety.

### BACKGROUND

[0002] 1. Field

[0003] The present disclosure relates generally to electro-surgery and electrosurgical systems and apparatuses, and more particularly, to an electrical leakage detection method and system for use with laparoscopic electrosurgical instruments.

[0004] 2. Description of the Related Art

[0005] The term "laparoscope" comes from two Greek words. The first is *lapara*, which means "the soft parts of the body between the rib margins and hips", or more simply, the "flank or lion". The other Greek root is *skopein*, which means "to see or view or examine". *Skopein* has become scope in English. Therefore, a laparoscope is an instrument through which structure within the abdomen and pelvis can be seen. A small surgical incision is made in the abdominal wall to permit the laparoscope to enter the abdomen or pelvis. A diversity of tubes can be pushed through the same incision or other small incisions permitting the introduction of probes and other instruments. In this way, a number of surgical procedures can be performed without the need for a large surgical incision. Among the instruments used during a laparoscopic procedure are electrosurgical instruments.

[0006] Laparoscopic surgery, a "minimally invasive" procedure, is commonly (but not exclusively) used to treat diseases of the gastrointestinal tract. Unlike traditional surgery on the colon or other parts of the intestines where a long incision down the center of the abdomen is required, laparoscopic surgery requires only a small "keyhole" incision in the abdomen. As a result, the person undergoing the procedure may experience less pain and scarring after surgery, and a more rapid recovery.

[0007] Electrosurgery is a term used to describe the passage of high-frequency (i.e., radio frequency) electrical current through tissue to create a desired clinical tissue effect. Through this technique, the target tissue, acting as a resistor in an electrical circuit, is heated by its conduction of the electrical current. Electrocautery, as distinguished from electrosurgery, uses an electrical current to heat a surgical instrument, which in turn conveys that heat to the target tissue. Electrosurgical electrode tips remain cool while targeted tissues heat up, primarily because the electrodes have much lower impedance than the adjacent targeted tissues. Electrosurgical tissue effects include cutting, coagulation, desiccation and fulguration. In addition, modern electrosurgical generators can create blended modes of operation under which a surgeon can for example, cut and coagulate simultaneously.

[0008] In electrosurgery, there are two types of electrodes: mono-polar and bipolar. Mono-polar electrodes pass RF electrical current from an electrosurgical generator through an active electrode into targeted tissue, through the patient, the dispersive electrode (e.g., a return electrode or pad), and back into the electrosurgical generator. If the return electrode is properly placed relative to the patient and surgical site, the electrosurgical tissue effects occur only at the active electrode

and not the dispersive electrode. On the other hand, bipolar electrodes are arranged in pairs (or poles, "+/-" and "-/+") and form part of the surgical instrument (e.g., electrosurgical forceps) without the need for a separate return electrode (grounding) plate attached to the patient. The intended flow of current is between the pair of bipolar electrodes (from "+/-" to "-/+"), which are usually close together and use relatively low voltage.

[0009] There are a number of well-known complications that may arise during laparoscopic electrosurgery. There are two major types of such complications pertinent to this discussion. The first derive from injuries caused by operator (i.e., surgeon) error such as direct coupling, perforation and laceration of targeted and non-targeted tissues. These injuries are outside the scope of this discussion. The second group of complications occurs when targeted tissues get burned from stray electricity emitting from or caused by other than operator error. There are two primary types of stray electricity applicable here.

[0010] The first type, insulation failure, involves faults in the insulation of the electrosurgical instrument—even a microscopic defect—that permit leakage of electrical current. The coating over metallic electrosurgical instruments intended to insulate them can be weakened by (i) repeated insertions into and removals from the patient, (ii) use of high voltage, (iii) material defects, and (iv) multiple sterilizations. A small hole in the insulation can represent a higher risk of injury from stray current than a larger hole because of its concentrating effect on the current density for such a leakage.

[0011] The second type of stray electricity results from capacitive coupling. Capacitive coupling occurs through instantaneous current induction between instruments, or between an instrument and adjacent tissues. This phenomenon can occur even though the insulation is completely intact. Capacitive coupling requires a capacitor, which is created when two conductors are separated by an insulator. The risk of this type of stray electricity can increase when surgeons use disposable and reusable instruments together during the same laparoscopic electrosurgical procedure.

[0012] The clinical complications from stray current caused by insulation failure and capacity coupling are particularly challenging because their initial presentation often mimics normal post-surgical symptoms of laparoscopy: namely, non-specific abdominal pain and slight to moderate fever. These clinical complications include perforation, blood vessel damage, organ damage, and peritonitis. All of these, particularly fecal peritonitis, can lead to severe or fatal infection. Since injuries resulting from stray current are most often undiscovered until days after surgery, and are often masked by unrelated conditions, prevention of these injuries cannot be overstressed.

### SUMMARY

[0013] An electrical leakage detection method and system for use with laparoscopic electrosurgical instruments are provided. In particular, this disclosure concerns of the unique aspects of laparoscopic electrosurgical electrical leakage detection and the prevention of unintended injuries to non-targeted tissues.

[0014] In one aspect of the present disclosure, an electrosurgical apparatus for use with an electrosurgical generator is provided including a handpiece having a passage extending therethrough, the hand piece having a proximal end and a distal end; an active electrode having a tip and being adapted

for coupling to said electrosurgical generator and extending through the passage for effecting at the tip thereof an electro-surgical procedure; a first sensor disposed at the distal end of the handpiece and for outputting a first signal indicative of current measured at the distal end; a second sensor disposed at the proximal end of the handpiece and for outputting a second signal indicative of current measured at the proximal end; and a differential device coupled to the first and second sensors for receiving the first and second signals and determining a difference value of the first and second signal, the difference value being indicative of leakage current.

[0015] In another aspect of the present disclosure, an electrosurgical system for controlling leakage during electrosurgical procedure is provided. The electrosurgical system includes an electrosurgical unit for providing electrosurgical energy at an active output thereof and for controlling the flow of the energy through the active output, the electrosurgical unit having a return input; an active electrode coupled to the active output for transmitting electrosurgical energy to a patient in an electrosurgical procedure; a return electrode adapted to be coupled to the patient for receiving electrosurgical energy supplied to the patient during the electrosurgical procedure and coupled to the return input for returning it to the return input of the electrosurgical unit; a first sensor disposed at a distal end of the active electrode and for outputting a first signal indicative of current measured at the distal end; a second sensor disposed at a proximal end of the active electrode and for outputting a second signal indicative of current measured at the proximal end; and a comparison circuit coupled to the first and second sensors for receiving the first and second signals and determining a difference value of the first and second signal, the difference value being indicative of leakage current.

[0016] In a further aspect of the present disclosure, an endoscopic forceps for effecting tissue includes an elongated shaft having opposing jaw members at a distal end thereof, the jaw members being movable relative to one another from a first position wherein the jaw members are disposed in spaced relation relative to one another to a second position wherein the jaw members cooperate to grasp tissue therebetween; a handle assembly coupled to a proximal end of the shaft for actuating the jaw members between the first and second positions; each jaw member including an electrically conductive surface and adapted to electrically couple to a source of electrical energy such that the jaw members are capable of conducting energy to tissue held therebetween to effect an electrosurgical procedure; a first sensor disposed at the distal end of the shaft and for outputting a first signal indicative of current measured at the distal end; a second sensor disposed at the proximal end of the shaft and for outputting a second signal indicative of current measured at the proximal end; and a differential device coupled to the first and second sensors for receiving the first and second signals and determining a difference value of the first and second signal, the difference value being indicative of leakage current.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The above and other aspects, features, and advantages of the present disclosure will become more apparent in light of the following detailed description when taken in conjunction with the accompanying drawings in which:

[0018] FIG. 1 is an illustration of a laparoscopic electrosurgical system in accordance with an embodiment of the present disclosure;

[0019] FIG. 2 is a flow diagram of a method for detecting leakage current in an electrosurgical system in accordance with an embodiment of the present disclosure;

[0020] FIG. 3 is a block diagram of an electrosurgical generator and laparoscopic instrument in accordance with an embodiment of the present disclosure;

[0021] FIG. 4 is a schematic diagram of a laparoscopic instrument for detecting leakage current in accordance with an embodiment of the present disclosure; and

[0022] FIG. 5A is a partial cross sectional view of an electrosurgical bipolar forceps in accordance with an embodiment of the present disclosure;

[0023] FIG. 5B illustrates an end effector assembly of the bipolar forceps shown in FIG. 5A in an open position; and

[0024] FIG. 5C is a schematic diagram of a current sensor in accordance with the present disclosure.

#### DETAILED DESCRIPTION

[0025] Preferred embodiments of the present disclosure will be described hereinbelow with reference to the accompanying drawings. In the following description, well-known functions or constructions are not described in detail to avoid obscuring the present disclosure in unnecessary detail. In the drawings and in the description which follow, the term "proximal", as is traditional, will refer to the end of the device, e.g., instrument, handpiece, forceps, etc., which is closer to the user, while the term "distal" will refer to the end which is further from the user. Herein, the phrase "coupled" is defined to mean directly connected to or indirectly connected with through one or more intermediate components. Such intermediate components may include both hardware and software based components.

[0026] An electrical leakage detection method and system for use with laparoscopic electrosurgical instruments are provided. The techniques of the present disclosure provide for: (a) detecting the occurrence of an electrical leakage event (e.g., stray electrical current) during laparoscopic electrosurgery, (b) instantly shutting down the electrosurgical generator to prevent stray electrical current injury to the patient, and (c) warning the operator of an electrical leakage incident. Some in the field have used multiple layers of insulation in an attempt to avoid the electrical leakage problem caused by insulation failure; however, this approach, even if fully effective, does not address the capacitive coupling problem. Others have employed methods to detect a loss of contact between the patient and the grounding pad used in mono-polar electrosurgery. Still others have used methods that rely on measurements within the electrosurgical generator, and not in or near the electrosurgical instruments themselves. However, such measures do not adequately address the specific problem of electrical leakage from laparoscopic electrosurgical instruments.

[0027] Rather than employing such approaches, the system and method of the present disclosure seeks to measure the electrical current at two key points along the path of electrosurgical current created by the electrosurgical generator, the power cord connecting the laparoscopic instrument body, the laparoscopic instrument body, and the electrode tip.

[0028] Referring to FIG. 1, an electrosurgical system 10 is shown including an electrosurgical generator (ESU) 12 and a laparoscopic instrument 14. The electrosurgical generator 12 is configured for supplying electrosurgical energy via a laparoscopic instrument 14 to an operative site of a patient, e.g., tissue. The electrosurgical laparoscopic apparatus 14

includes a trocar sheath or cannula 16 which is conventionally used to provide a conduit through a patient's skin into the peritoneal cavity. Removably insertable through the trocar sheath is an active electrode probe or handpiece 18 which includes an active electrode 20 disposed within a passage of the handpiece and an insulative coating 22 thereon. The distal end of the electrode 20 includes a tip 24 for affecting a surgical procedure at the operative site. The tip 24 of the probe may be of different conventional shapes such as needle-shape, hook-shape, spatula-shape, graspers, scissors, etc. and serve various conventional functions such as suction, coagulation, irrigation, pressurized gas, cutting, etc. Furthermore, the instrument 14 is coupled to the generator 12 via a power cord cable 25.

[0029] In FIG. 1, the first test point is at or very near the electrode tip 24 (Location "A"), e.g., a distal end of the instrument 14. The second test point is at the connection power cord's entry point into the laparoscopic instrument or just before it (Location "B"), e.g., a proximal end of the instrument 14. Then, by comparing the measured current at these two test points "A" and "B", the electrosurgical generator 12 can determine if there is a drop in output current, impliedly indicating electrical leakage. Conventional electrosurgical generator systems are capable of measuring output voltage (and other electrosurgical parameters such as tissue impedance) at the rate of 5 KHz. Given that very high rate, an automated decision to shut down the generator could occur very rapidly—virtually instantaneously—and thereby protect the patient from stray electrical current.

[0030] It is to be appreciated that the measurements taken at points "A" and "B" can be measured by a sensor 26 disposed adjacent the distal end of instrument 14 and sensor 28 disposed adjacent the proximal end of the instrument 14. As will be described below, the sensors 26, 28 may include a current sensor, resistor, or the like. The sensors 26, 28 will transmit the measured values to the electrosurgical generator 12 via hardwire or wireless means. In one embodiment, conductors carrying the measured values at Locations A and B are disposed in cable 25. In a further embodiment, the sensors 26, 28 will transmit the measured values via an RF signal to a receiver disposed in the electrosurgical generator 12.

[0031] In a further embodiment, the instrument 14 will include a differential device, e.g., a comparator, differential amplifier, etc., that determines the difference value and transmits a single difference value to the electrosurgical generator 12.

[0032] It is further to be appreciated that the second test point may be measured at the electrosurgical generator 12 (Location "C"). In this embodiment, the sensor is disposed in the electrosurgical generator 12 and measured the current leaving the generator 12. The leakage current is then determined by calculating the difference between the current measured at Location A and Location C. In this embodiment, only sensor 26 is disposed in the instrument 14 resulting in a lower cost instrument.

[0033] Referring to FIG. 2, a method for detecting leakage current in an electrosurgical system is illustrated. Initially, at step 50, current is determined at the electrode tip 24, i.e., Location A. Next, the current entering the instrument, i.e., Location B, is determined in step 52. It is to be appreciated that in certain embodiments the current entering the instrument will be measured as current leaving the electrosurgical generator 12, i.e., Location C. Next, in step 54, a difference in the current measured at Locations A and B is determined.

[0034] In step 56, it is determined if the difference is greater than a predetermined threshold. If the difference is less than the predetermined threshold, no leakage current has been detected, or an acceptable amount of leakage current has been detected, and the method will revert to step 50 to continue to monitor the current at Locations A and B. If the difference is greater than the predetermined threshold, leakage current has been detected. When leakage current has been detected, the RF output from the electrosurgical generator 12 will be terminated in step 58. Furthermore, in step 60, the electrical leakage condition will be indicated to the operator, e.g., a surgeon, via the electrosurgical generator 12 or laparoscopic instrument 14. It is to be appreciated that steps 58 and 60 may be performed simultaneously and/or step 60 may be performed before step 58.

[0035] Alternative embodiments for the system of the present disclosure will be described below. The various embodiments focus on the technique of measuring voltage, calculating current, and comparing those values between Locations "A" and "B", as described above.

[0036] Referring to FIG. 3, one embodiment of the system contemplates placement of a series resistor ( $R_A$ ) at Location "A" in instrument 114. Using Ohm's Law (i.e.,  $V=IR$ , where  $V$  is voltage,  $I$  is current, and  $R$  is resistance), the current  $I_A$  for a measured voltage  $V_A$  can be calculated. Thus,  $I_A = V_A/R_A$ . The challenge with this design is the need to transfer the calculated value of current at Location A ( $I_A$ ) back to the generator. One solution is to place means of converting  $I_A$  from an analog to a digital value, which can then be transmitted back to the generator, free from electrical or magnetic interference. In one embodiment, an analog to digital converter ADC 126 may be coupled to resistor  $R_A$  for transmitting the measured voltage across resistor  $R_A$  to electrosurgical generator 112. The digital signal will be sent to a controller 130, e.g., a microprocessor, which can determine a current value from the measured voltage. Thus, by converting the value to the digital domain, rapid and accurate monitoring of current can be maintained. The same technique could be employed at Location B with a second series resistor  $R_B$  and second ADC 128. As described above, the measured values may be transmitted to the generator 112 via conductors or other known transmission means in cable 125, or alternatively, may be bundled in a second cable separate from the power cable 125. If a leakage condition is detected, the controller 130 will control the HV DC power supply 132 to terminate the electrosurgical energy being output from the RF output stage 134. Furthermore, as described above, the electrosurgical generator 112 will indicate the condition to an operator via an I/O interface 136 such as a touch screen or an audible alarm 138.

[0037] In a further embodiment, the electrosurgical generator 112 includes a comparison circuit 142 that receives the signals from the sensors disposed in the instrument 114. The comparison circuit 142 determines the difference between the received signals and transmits a single difference value to the controller 130. The controller 130 then determines if the difference value is greater than a predetermined threshold. If so, the controller 130 will terminate the output of electrosurgical energy by controlling the HV DC power supply 132.

[0038] It is expected that each combination of generator 112 and connecting power cord 125 to the instruments 114 will exhibit some inherent resistance. Accordingly, there will be a correction factor for that combination stored in a memory 140 of the generator 112. Differences between calculated

current values at Locations A and B, adjusted by the correction factor, indicate a loss of current suggesting electrical leakage. Based on preset thresholds, the generator 112 can detect a threshold difference, set an alarm and shut down the generator. In this way, the patient can be protected from unintended injury (e.g., burns) from stray current.

[0039] In another embodiment, a dual current sensing transformer arrangement, both with the same turns ratio, is used in combination with means for converting analog measurements to digital values, as shown in FIG. 4. In this embodiment, a first distal coil L1 can be constructed from the conductor material itself within the instrument body at a distal end 202. A second proximal coil L2 is then formed and placed at a proximal end 204 of the instrument. The induced current in the coil L1 is converted to voltage V1 via resistor R1 and capacitor C1 which are coupled in parallel. Similarly, induced current in coil L2 is converted to voltage V2 via resistor R2 and capacitor C2. The difference between voltage V1 (indicative of the current induced in the distal coil L1) and voltage V2 (indicative of the current induced in the proximal coil L2) can then be measured, digitized and transmitted back to the generator via analog-to-digital converter ADC 206. By using two identical transformers and passing high current through them, the system of the present disclosure can achieve improved noise immunity and measurement accuracy.

[0040] Another embodiment according to the present disclosure includes a monopolar forceps for affecting tissue having an elongated shaft with opposing jaw members at a distal end thereof. The jaw members are movable relative to one another from a first position wherein the jaw members are disposed in spaced relation relative to one another to a second position wherein the jaw members cooperate to grasp tissue therebetween. By utilizing an electrosurgical forceps, a surgeon can either cauterize, coagulate/desiccate and/or simply reduce or slow bleeding, by controlling the intensity, frequency and duration of the electrosurgical energy applied through the jaw members to the tissue. The electrode of each jaw member is charged to the same electric potential such that when the jaw members grasp tissue, electrical energy can be selectively transferred to the tissue.

[0041] Referring to FIG. 5, one embodiment of a monopolar forceps 300 is shown for use with various surgical procedures and generally includes a housing 302, a handle assembly 304, a trigger assembly 306 and an end effector assembly 308 which mutually cooperate to grasp, seal and divide tubular vessels and vascular tissue. More particularly, forceps 300 includes a shaft 310 which has a distal end 312 dimensioned to mechanically engage the end effector assembly 308 and a proximal end 314 which mechanically engages the housing 302.

[0042] Forceps 300 also includes an electrical interface or plug 316 which couples the forceps 300 to a source of electrosurgical energy, e.g., a generator. Plug 316 includes a pair of prong members 318 which are dimensioned to mechanically and electrically couple the forceps 300 to the source of electrosurgical energy. An electrical cable 320 extends from the plug 316 to the forceps 300. Cable 320 is coupled to conductor 334 which extends along the shaft and is further coupled to the conducting surfaces of the end effector assembly 308.

[0043] Handle assembly 304 includes a fixed handle 322 and a movable handle 324. Fixed handle 322 is integrally

associated with housing 302 and handle 324 is movable relative to fixed handle 322 to effect operation of the forceps 300.

[0044] As mentioned above, end effector assembly 308 is attached to the distal end 312 of shaft 310 and includes a pair of opposing jaw members 326 and 328. Movable handle 324 of handle assembly 304 is ultimately coupled to an actuation assembly (not shown) which, together, mechanically cooperate to impart movement of the jaw members 326 and 328 from an open position wherein the jaw members 326 and 328 are disposed in spaced relation relative to one another, to a clamping or closed position wherein the jaw members 326 and 328 cooperate to grasp tissue therebetween. Once the tissue is grasped, electrosurgical energy will be applied in response to trigger 306 or a footswitch coupled to the generator.

[0045] As mentioned above, the cable lead extend through the shaft 310 conducting electrosurgical energy from the generator to the jaw members 326, 328 of the end effector assembly 308. As illustrated in FIG. 5B, each jaw member 326, 328 includes an internal conducting surface 330, 332 respectively for contacting tissue therebetween. In one embodiment, the cable 334 is coupled to and supplies electrosurgical energy to the two conducting surfaces 330, 332. In this manner, the conducting surfaces 330, 332 are the active electrode and a return electrode, e.g., a return pad, is coupled to the patient for returning electrosurgical energy to the generator.

[0046] Referring back to FIG. 5A, a first current sensor 336, i.e., distal current sensing transformer, is disposed around the cable 334, i.e., the active electrode conductor, adjacent the distal end 312 of the shaft 310. A second current sensor 338, i.e., proximal current sensing transformer, is disposed around the cable 334 adjacent the proximal end 314 of the shaft 310. Referring to FIG. 5C, the first and second current sensors 336, 338 include a capacitor Cn, a resistor Rn and a toroidal or hollow cylindrical core inductor Ln. It is to be appreciated the capacitor Cn, resistor Rn and inductor Ln will be disposed in the housing 302. The first and second current sensors 336, 338 will operate in cooperation to determine the difference in current, i.e., leakage current, between the distal end of the instrument and proximal end in accordance with the various embodiments described above.

[0047] It is envisioned that the forceps 300 may be designed such that it is fully or partially disposable depending upon a particular purpose or to achieve a particular result. For example, end effector assembly 308 may be selectively and releasably engageable with the distal end 312 of the shaft 310 and/or the proximal end 314 of shaft 310 may be selectively and releasably engageable with the housing 302 and the handle assembly 304. In either of these two instances, the forceps 300 would be considered "partially disposable" or "reposable", i.e., a new or different end effector assembly 308 (or end effector assembly 308 and shaft 310) selectively replaces the old end effector assembly 308 as needed.

[0048] In a further embodiment, the instrument shown in FIG. 5A will be configured as bipolar forceps. Although not shown, in the bipolar embodiment, cable 320 is internally divided into two cable leads, e.g., first and second cable leads, which transmit electrosurgical energy through their respective feed paths through the forceps 300 to the end effector assembly 308. Here, the electrode of each jaw member is charged to a different electric potential such that when the jaw members grasp tissue, electrical energy can be selectively transferred through the tissue.

[0049] In the bipolar embodiment, the first and second cable leads extend through the shaft 310 conducting electro-

surgical energy from the generator to the jaw members 326, 328 of the end effector assembly 308. Similar to the embodiment described above in relation to FIG. 5B, each jaw member 326, 328 includes an internal conducting surface 330, 332 respectively for contacting tissue therebetween. The first cable 334 is coupled to and supplies electrosurgical energy to conducting surface 330 while the second cable (not shown) is coupled to conducting surface 332 and returns the electrosurgical energy to the generator. In this manner, the conducting surface 330 is the active electrode and the conducting surface 332 is the return electrode, i.e., no additional return pad is necessary.

[0050] In the bipolar embodiment, a first current sensor 336 is disposed around the cable 334, i.e., the active electrode conductor, adjacent the distal end 312 of the shaft 310 and a second current sensor 338 is disposed around the cable 334 adjacent the proximal end 314 of the shaft 310, similar to the embodiment described above in relation to the monopolar embodiment. The first and second current sensors 336, 338 are configured as shown in FIGS. 5A and C. The first and second current sensors 336, 338 will operate in cooperation to determine the difference in current, i.e., leakage current, between the distal end of the instrument and proximal end in accordance with the various embodiments described above.

[0051] While the disclosure has been shown and described with reference to certain preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the disclosure as defined by the appended claims.

[0052] Furthermore, although the foregoing text sets forth a detailed description of numerous embodiments, it should be understood that the legal scope of the invention is defined by the words of the claims set forth at the end of this patent. The detailed description is to be construed as exemplary only and does not describe every possible embodiment, as describing every possible embodiment would be impractical, if not impossible. One could implement numerous alternate embodiments, using either current technology or technology developed after the filing date of this patent, which would still fall within the scope of the claims.

[0053] It should also be understood that, unless a term is expressly defined in this patent using the sentence "As used herein, the term '\_\_\_\_\_' is hereby defined to mean . . ." or a similar sentence, there is no intent to limit the meaning of that term, either expressly or by implication, beyond its plain or ordinary meaning, and such term should not be interpreted to be limited in scope based on any statement made in any section of this patent (other than the language of the claims). To the extent that any term recited in the claims at the end of this patent is referred to in this patent in a manner consistent with a single meaning, that is done for sake of clarity only so as to not confuse the reader, and it is not intended that such claim term be limited, by implication or otherwise, to that single meaning. Finally, unless a claim element is defined by reciting the word "means" and a function without the recital of any structure, it is not intended that the scope of any claim element be interpreted based on the application of 35 U.S.C. §112, sixth paragraph.

What is claimed is:

1. An electrosurgical apparatus for use with an electrosurgical generator comprising:

a housing including a shaft having a proximal end and a distal end, the proximal end of the shaft configured to be releasably engageable with the housing;

an active electrode having a tip and being adapted for coupling to said electrosurgical generator and extending through the shaft for effecting at the tip thereof an electrosurgical procedure;

a first sensor disposed within the distal end of the shaft and for outputting a first signal indicative of current measured at the distal end of the active electrode;

a second sensor disposed within the proximal end of the shaft and for outputting a second signal indicative of current measured at the proximal end of the active electrode; and

a differential device coupled to the first and second sensors for receiving the first and second signals and determining a difference value of the first and second signal, the difference value being indicative of leakage of current within the shaft.

2. The electrosurgical apparatus of claim 1, wherein each of the first and second sensors is a resistor in series with the active electrode.

3. The electrosurgical apparatus of claim 2, further comprising an analog to digital converter coupled to each resistor.

4. The electrosurgical apparatus of claim 1, wherein each of the first and second sensors is a current sensor.

5. The electrosurgical apparatus of claim 1, wherein each of the first and second sensors is a transformer.

6. The electrosurgical apparatus of claim 5, wherein each transformer includes a core disposed around the active electrode, wherein the active electrode passes therethrough.

7. The electrosurgical apparatus of claim 1, wherein the first and second sensors are configured as a single transformer, the first sensor being configured as a first coil disposed adjacent the distal end of the shaft and the second sensor being configured as a second coil disposed adjacent the proximal end of the shaft.

8. The electrosurgical apparatus of claim 1, wherein each of the first and second signals is a digital signal.

9. An electrosurgical system for controlling leakage during electrosurgical procedure comprising:

an electrosurgical unit for providing electrosurgical energy at an active output thereof and for controlling the flow of the energy through the active output, the electrosurgical unit having a return input;

an active electrode coupled to the active output for transmitting electrosurgical energy to a patient in an electrosurgical procedure;

a handpiece for supporting the active electrode, the handpiece including a housing and a shaft having a proximal end and a distal end, the proximal end of the shaft configured to be releasably engageable with the housing, wherein the active electrode is disposed within the shaft;

a return electrode adapted to be coupled to the patient for receiving electrosurgical energy supplied to the patient during the electrosurgical procedure and coupled to the return input for returning it to the return input of the electrosurgical unit;

a first sensor disposed at a distal end of the active electrode within the shaft and for outputting a first signal indicative of current measured at the distal end of the active electrode;

a second sensor disposed at a proximal end of the active electrode within the shaft and for outputting a second signal indicative of current measured at the proximal end of the active electrode; and

a comparison circuit coupled to the first and second sensors for receiving the first and second signals and determining a difference value of the first and second signal, the difference value being indicative of leakage of current within the shaft.

**10.** The electrosurgical system of claim 9, further comprising a controller for controlling the output of electrosurgical energy and coupled to the comparison circuit for receiving the difference value, wherein if the difference value is greater than a predetermined threshold, the controller terminates the output of electrosurgical energy.

**11.** The electrosurgical system of claim 9, wherein the comparison circuit is disposed in the handpiece.

**12.** The electrosurgical system of claim 9, wherein the comparison circuit is disposed in the electrosurgical unit.

**13.** The electrosurgical system of claim 9, wherein each of the first and second sensors is a resistor in series with the active electrode.

**14.** The electrosurgical system of claim 9, wherein each of the first and second sensors is a current sensor.

**15.** The electrosurgical system of claim 9, wherein each of the first and second sensors is a transformer.

**16.** The electrosurgical system of claim 9, wherein the first and second sensors are configured as a single transformer, the first sensor being configured as a first coil disposed adjacent the distal end of the shaft and the second sensor being configured as a second coil disposed adjacent the proximal end of the shaft.

**17.** The electrosurgical system of claim 9, wherein each of the first and second signals is a digital signal.

**18.** The electrosurgical system of claim 9, further comprising an indicator device for indicating to an operator when the difference value is greater than a predetermined threshold.

**19.** An endoscopic forceps for effecting tissue, comprising: an elongated shaft having opposing jaw members at a distal end thereof, the jaw members being movable relative to one another from a first position wherein the jaw members are disposed in spaced relation relative to one

another to a second position wherein the jaw members cooperate to grasp tissue therebetween;

a handle assembly coupled to a proximal end of the shaft for actuating the jaw members between the first and second positions, the proximal end of the shaft configured to be releasably engageable with the handle assembly;

each jaw member including an electrically conductive surface and adapted to electrically couple to a source of electrical energy such that the jaw members are capable of conducting energy to tissue held therebetween to effect an electrosurgical procedure;

a first sensor disposed within the distal end of the shaft and for outputting a first signal indicative of current measured at the distal end of the shaft;

a second sensor disposed within the proximal end of the shaft and for outputting a second signal indicative of current measured at the proximal end of the shaft; and a differential device coupled to the first and second sensors for receiving the first and second signals and determining a difference value of the first and second signal, the difference value being indicative of leakage of current within the shaft.

**20.** The endoscopic forceps of claim 19, wherein each of the first and second sensors is a transformer including a core disposed around a conductor supplying electrosurgical energy to at least one conductive surface of at least one jaw member, wherein the conductor passes through each core.

**21.** A shaft for use with electrosurgical apparatus for effecting at one end thereof an electrosurgical procedure, the shaft including a proximal end and a distal end, comprising:

a first sensor disposed within the distal end of the shaft and for outputting a first signal indicative of current measured at the distal end;

a second sensor disposed within the proximal end of the shaft and for outputting a second signal indicative of current measured at the proximal end; and

a differential device coupled to the first and second sensors for receiving the first and second signals and determining a difference value of the first and second signal, the difference value being indicative of leakage of current within the shaft.

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|                |   |         |            |
|----------------|---|---------|------------|
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### 摘要(译)

提供了一种用于腹腔镜电外科器械的漏电检测方法和系统。本公开提供了一种电外科单元，用于在其有效输出处提供电外科能量并且用于控制通过有源输出的能量流动;耦合到有源输出的有源电极，用于在电外科手术中将电外科能量传输给患者;第一传感器，设置在有源电极的远端，用于输出表示在远端测量的电流的第一信号;第二传感器，设置在有源电极的近端，并输出表示在近端测量的电流的第二信号;以及比较电路，其耦合到第一和第二传感器，用于接收第一和第二信号并确定差值，该差值表示泄漏电流。

