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(54) MICROWAVE TISSUE RESECTION TOOL

(76) Inventors: **Daniel Warren van der Weide**, Madison, WI (US); **Fred T. Lee JR.**, Madison, WI (US)

Correspondence Address:
Patula & Associates, P.C.
14th Floor
116 S. Michigan Ave.
Chicago, IL 60603 (US)

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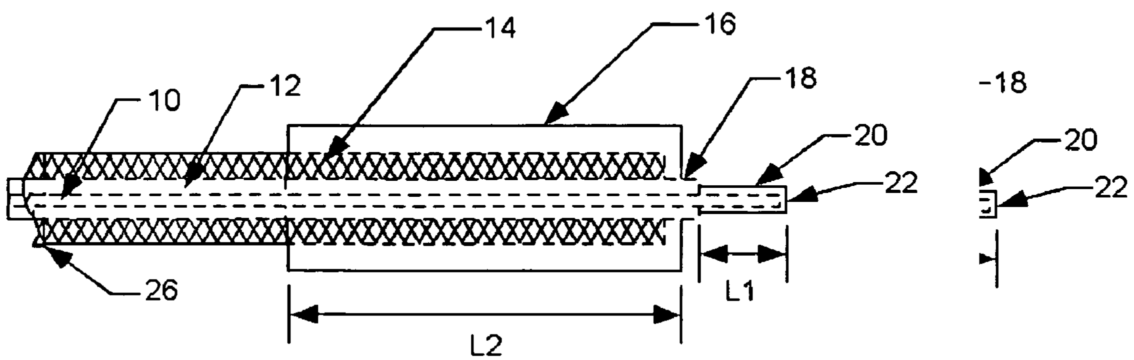
(57) **ABSTRACT**

A medical instrument or device is used for resonant delivery of microwave power to tissue for the purpose of resection and coagulation of vessels during surgery and/or other medical procedures. The device enables delivery of large amounts of power to tissue without the need for ground pads by accomplishing an impedance match between tissue and the characteristic impedance of the waveguide that feeds power to it. The device includes a semi-rigid coaxial cable having a center conductor which protrudes from an outer conductor by a length set to be a $\lambda/4$ (quarter-wavelength) at the frequency of excitation in the dielectric environment of the tissue of interest. The coaxial cable is shrouded by a dielectric sleeve that provides both thermal and electrical insulation. Fitted against this sleeve is a conductive sleeve whose length is set to be a $\lambda/4$ (quarter-wavelength) at the frequency of excitation in the dielectric environment of the dielectric sleeve and the shroud. The device is connected to a feed cable at its proximal end, and can be connected to a source of microwave power. A directional coupler or other wave-sampling mechanism in combination with a power sensor and feedback circuit can be used to monitor reflected power from the device during the procedure, and to control the amount of power supplied to the device.



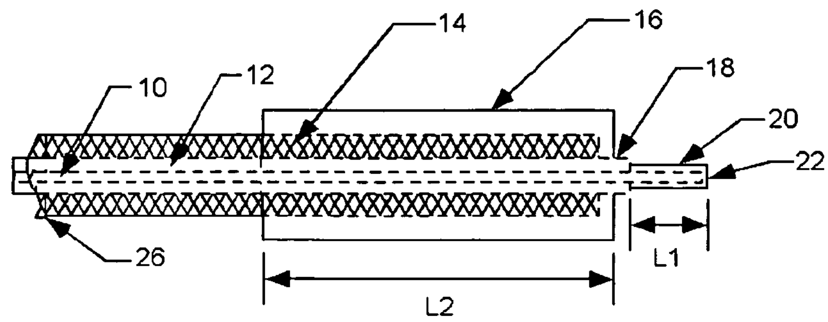


Figure 1

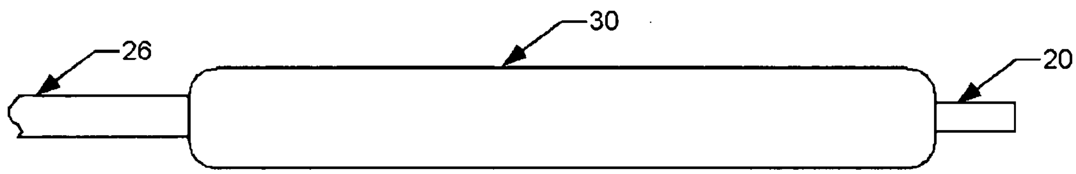


Figure 2

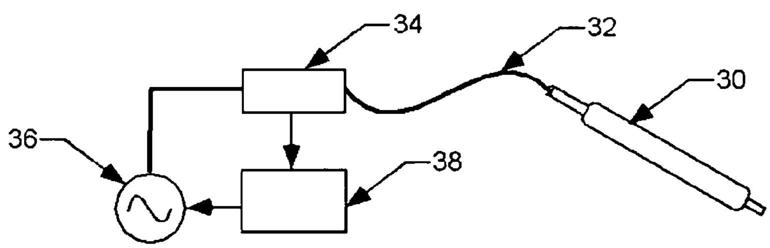


Figure 3

MICROWAVE TISSUE RESECTION TOOL

CLAIM OF PRIORITY

[0001] This application is a Continuation-In-Part of co-pending U.S. Non-Provisional Patent Applications entitled "Triaxial Antenna for Microwave Tissue Ablation" filed Apr. 29, 2004 and assigned U.S. application Ser. No. 10/834,802; "Segmented Catheter for Tissue Ablation" filed Sep. 28, 2005 and assigned U.S. application Ser. No. 11/237,136; "Cannula Cooling and Positioning Device" filed Sep. 28, 2005 and assigned U.S. application Ser. No. 11/237,430; "Air-Core Microwave Ablation Antennas" filed Sep. 28, 2005 and assigned U.S. application Ser. No. 11/236,985; and "Microwave Surgical Device" filed May 24, 2006 and assigned U.S. application Ser. No. 11/440,331; the entire disclosures of each and all of these applications are hereby herein incorporated by reference.

[0002] This application further claims priority to U.S. Provisional Patent Applications entitled "Segmented Catheter for Tissue Ablation" filed May 10, 2005 and assigned U.S. application Ser. No. 60/679,722; "Microwave Surgical Device" filed May 24, 2005 and assigned U.S. application Ser. No. 60/684,065; "Microwave Tissue Resection Tool" filed Jun. 14, 2005 and assigned U.S. application Ser. No. 60/690,370; "Cannula Cooling and Positioning Device" filed Jul. 25, 2005 and assigned U.S. application Ser. No. 60/702,393; "Intralumenal Microwave Device" filed Aug. 12, 2005 and assigned U.S. application Ser. No. 60/707,797; "Air-Core Microwave Ablation Antennas" filed Aug. 22, 2005 and assigned U.S. application Ser. No. 60/710,276; and "Microwave Device for Vascular Ablation" filed Aug. 24, 2005 and assigned U.S. application Ser. No. 60/710,815; the entire disclosures of each and all of these applications are hereby herein incorporated by reference.

CROSS-REFERENCE TO RELATED APPLICATIONS

[0003] This application is related to co-pending U.S. Non-Provisional Patent Applications entitled "Triaxial Antenna for Microwave Tissue Ablation" filed Apr. 29, 2004 and assigned U.S. application Ser. No. 10/834,802; "Segmented Catheter for Tissue Ablation" filed Sep. 28, 2005 and assigned U.S. application Ser. No. 11/237,136; "Cannula Cooling and Positioning Device" filed Sep. 28, 2005 and assigned U.S. application Ser. No. 11/237,430; "Air-Core Microwave Ablation Antennas" filed Sep. 28, 2005 and assigned U.S. application Ser. No. 11/236,985; and "Microwave Surgical Device" filed May 24, 2006 and assigned U.S. application Ser. No. 11/440,331; and to U.S. Provisional Patent Applications entitled "Segmented Catheter for Tissue Ablation" filed May 10, 2005 and assigned U.S. application Ser. No. 60/679,722; "Microwave Surgical Device" filed May 24, 2005 and assigned U.S. application Ser. No. 60/684,065; "Microwave Tissue Resection Tool" filed Jun. 14, 2005 and assigned U.S. application Ser. No. 60/690,370; "Cannula Cooling and Positioning Device" filed Jul. 25, 2005 and assigned U.S. application Ser. No. 60/702,393; "Intralumenal Microwave Device" filed Aug. 12, 2005 and assigned U.S. application Ser. No. 60/707,797; "Air-Core Microwave Ablation Antennas" filed Aug. 22, 2005 and assigned U.S. application Ser. No. 60/710,276; and "Microwave Device for Vascular Ablation" filed Aug. 24, 2005 and assigned U.S. application Ser. No. 60/710,815; the entire disclosures of each and all of these applications are hereby herein incorporated by reference.

FIELD OF INVENTION

[0004] The present disclosure relates generally to medical instruments, and in particular to medical instruments in the field of tissue resection, coagulation, and hemostasis. Specifically, the present disclosure relates to a medical tool or device for resonant delivery of microwave power or energy to tissue for the purpose of resection and coagulation of vessels.

BACKGROUND

[0005] Use of energy to ablate, resect or otherwise cause necrosis in diseased tissue has proven beneficial both to human and to animal health. Electrosurgery is a well-established technique to use electrical energy at DC or radio frequencies (i.e. less than 500 kHz) to simultaneously cut tissue and to coagulate small blood vessels. Radio-frequency (RF) ablation of tumor tissue was developed from the basis of electrosurgery, and has been used with varied success to coagulate blood vessels while creating zones of necrosis sufficient to kill tumor tissue with sufficient margin.

[0006] Limitations of the above techniques center on the need for ground pads on the skin of the patient to provide a return path for the current, as well as the undesirable stimulation of the nervous system as cuts are being made; this usually requires injection of a temporary paralyzing agent. Limitations of tissue impedance, particularly as the tissue becomes desiccated or charred during the course of the procedure, limit the amount of current, and hence the amount of ablative power, that can be applied to the tissue. This in turn limits the size of vessels that can be effectively shut down.

[0007] Thus current procedures are limited when applied to resection of tumors from highly-vascularized organs, e.g. liver. Furthermore, the limitations of current and power limit the speed at which these procedures can be performed. Accordingly, there is a need for a device which overcomes the problems and disadvantages associated with current procedures, and which is an improvement thereover. The present disclosure fulfills this need.

SUMMARY

[0008] The present disclosure relates to delivery of microwave (e.g. approximately 800 MHz and higher frequencies) power to tissue for the purpose of ablating tissue or resecting tissue with little or no loss of blood.

[0009] The device enables delivery of large amounts of power (e.g. greater than 100 Watts) to tissue without the need for ground pads since it accomplishes an impedance match between tissue and the characteristic impedance of the waveguide that feeds power to it. This is accomplished in a hand-held format similar to many surgical tools. It can accept a variety of tips for different cutting and coagulation purposes. Furthermore, because of the impedance matching, reflected power from the tool is minimized. Reflected power can further be monitored at the generator or along the feed cable to use as feedback to the generator power control.

[0010] Numerous other advantages and features of the disclosure will become readily apparent from the following

detailed description, from the claims and from the accompanying drawings in which like numerals are employed to designate like parts throughout the same.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] A fuller understanding of the foregoing may be had by reference to the accompanying drawings wherein:

[0012] FIG. **1** is a cross-sectional view of a preferred embodiment of the present disclosure, showing the arrangement of an impedance-matching sleeve and the tip.

[0013] FIG. **2** is a plan view of the preferred embodiment of the present disclosure encapsulated in a ceramic or plastic housing.

[0014] FIG. **3** is a schematic circuit diagram for a microwave power delivery and control system in accordance with the preferred embodiment of the present disclosure.

DESCRIPTION OF DISCLOSED EMBODIMENT(S)

[0015] While the invention is susceptible of embodiment in many different forms, there is shown in the drawings and will be described herein in detail one or more embodiments of the present disclosure. It should be understood, however, that the present disclosure is to be considered an exemplification of the principles of the invention, and the embodiment(s) illustrated is/are not intended to limit the spirit and scope of the invention and/or the claims herein.

[0016] With reference to the drawings, an example of the preferred embodiment of the energy delivery device or microwave tissue resection tool of the present disclosure is shown in FIG. **1**.

[0017] As illustrated in FIG. **1**, a semi-rigid coaxial cable, preferably constructed of copper or silver with a suitable low-loss dielectric, forms the basis of the device. The cable's center conductor **10** protrudes from the outer conductor **12** by a length L**1**, which is set to be a $\lambda/4$ (quarter-wavelength) at the frequency of excitation (e.g. 915 MHz, 2.45 GHz, or another suitable frequency) in the dielectric environment of the tissue of interest. The cable can be chosen from commercially-available standards, but it should be thick enough to be rated for the power delivered.

[0018] The coaxial cable is shrouded by a dielectric sleeve **14** that provides both thermal and electrical insulation. Fitted against this sleeve is a conductive sleeve (e.g. made of copper or silver or another suitable conductor) whose length is set to be a $\lambda/4$ (quarter-wavelength) at the frequency of excitation (e.g. 915 MHz, 2.45 GHz, or another suitable frequency) in the dielectric environment of the dielectric sleeve **14** and the shroud **30** (FIG. **2**). This conductive sleeve **16** contacts the outer conductor of the coaxial cable **12** at a point **18**, where it is free to slide if necessary to fine-tune the impedance matching effect. It can then be fixed in place with adhesive or other suitable mechanism.

[0019] The protrusion of the coaxial cable's center conductor **10** is shrouded by a non-stick material **20** (e.g. PTFE or Teflon) to minimize adhesion of the device to the tissue. A tip **22** at the distal end of the device can be specially formed to maximize the electric field emanating from it. For example, the tip **22** can be sharpened and optionally exposed directly to the tissue.

[0020] The device is connected to a feed cable at its proximal end **26**. This cable can be optionally connectorized, by attaching any suitable connector known in the art of connecting cable, to simplify exchange of the device.

[0021] As shown in FIG. **2**, the device can be enshrouded in a suitable ceramic or plastic housing **30**, which can contain cooling fluid (e.g. air, nitrogen, water, etc) and microwave absorbing material (e.g. polyiron) to minimize radiation from the tool to the extent necessary or desired.

[0022] As shown in FIG. **3**, the device **30** can be used in a system by which it is connected to a source of microwave power **36** via a cable **32**. A directional coupler or other wave-sampling mechanism **34** in combination with a power sensor and feedback circuit **38** can be used to monitor reflected power from the device during the procedure. If the amount of reflected power exceeds a threshold, power from the generator **36** can be reduced to minimize heating of the device **30**, while if the amount of reflected power is below a threshold, power can be increased to speed the procedure.

[0023] It is to be understood that the embodiment(s) herein described is/are merely illustrative of the principles of the present invention. Various modifications may be made by those skilled in the art without departing from the spirit or scope of the claims which follow.

What is claimed is:

1. A device for delivery of microwave power to tissue, comprising:

a coaxial cable;

a resonant sleeve for impedance matching;

a resonant tip; and

a polymer coating for said tip.

2. The device of claim 1, further comprising a means for controlling the power delivered to the tissue based on monitoring reflected power from the device.

3. The device of claim 1, wherein the device delivers greater than 100 Watts of power to tissue without the need for ground pads.

4. A medical device comprising:

a coaxial cable having a center conductor and an outer conductor;

a dielectric sleeve shrouding the coaxial cable; and

a conductive sleeve fitted against the dielectric sleeve and contacting the outer conductor;

wherein the center conductor protrudes from the outer conductor by a length, and wherein the device accomplishes an impedance match between tissue of interest and a characteristic impedance of the waveguide that feeds power to the device.

5. The device of claim 4, wherein the conductive sleeve is positionable to adjust the impedance matching effect.

6. The device of claim 4, wherein the length that the center conductor protrudes from the outer conductor is set to be a quarter-wavelength at the frequency of excitation in the dielectric environment of the tissue.

7. The device of claim 4, wherein the conductive sleeve has a length set to be a quarter-wavelength at the frequency of excitation in the dielectric environment of the dielectric sleeve and a shroud which houses the device.

8. The device of claim 7, wherein the shroud includes cooling fluid.

9. The device of claim 7, wherein the shroud includes microwave absorbing material.

10. A method of delivering microwave power to tissue, comprising the steps of:

feeding power to a microwave delivery device;

accomplishing an impedance match between the tissue and a characteristic impedance of the waveguide that feeds power to the device; and

delivering microwave power to tissue.

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