(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 August 2016 (11.08.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/127178 A1

(51) International Patent Classification:
A61B 18/14 (2006.01) *A61B 18/12* (2006.01)

(21) International Application Number:
PCT/US2016/017014

(22) International Filing Date:
8 February 2016 (08.02.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
14/616,542 6 February 2015 (06.02.2015) US

(72) Inventor; and
(71) Applicant : **COLQUHOUN, Steven, D.** [US/US]; 8900 Beverly Blvd., Los Angeles, CA 90048 (US).

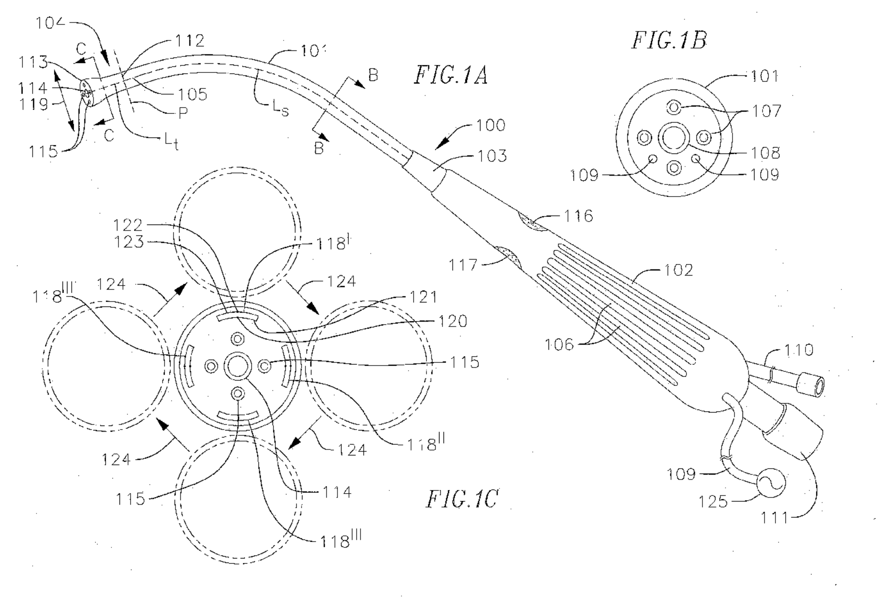
(74) Agent: **HASAN, Art**; Lewis Roca Rothgerber Christie LLP, P.O. Box 29001, Glendale, CA 91209 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: ELECTROCAUTERY DEVICE



(57) Abstract: An electrocautery device for use in a surgical operation to coagulate tissue and/or organs in a patient. The cautery device includes a sheath defining a longitudinal axis, a handle coupled to a proximal end of the sheath, a cauterizing tip coupled to the distal end of the sheath, and at least one actuator configured to move the cauterizing tip relative to the sheath. The movement of the cauterizing tip is configured to mitigate the risk of tissue or organ adherence to the cauterizing tip during a cauterizing operation.

WO 2016/127178 A1

ELECTROCAUTERY DEVICE

FIELD

[0001] The present disclosure relates generally to electrocautery devices and, more particularly, electrocautery devices with one or more of an oscillating or rotating tip, controlled irrigation and suction.

BACKGROUND

[0002] Electrocautery devices are commonly used in a variety of surgical operations to control bleeding from tissue and organs. Electrocautery devices typically include a conducting element configured to deliver high-frequency current (e.g., 100 kHz to 4 MHz) to tissues sufficient to generate intracellular heat, tissue desiccation and/or protein denaturation. In this manner, electrocautery devices are configured to cauterize tissues and small vessels, thereby achieving hemostasis. Suction devices are commonly used in conjunction with electrocautery devices to draw blood away from tissues to allow the target bleeding site to be located and cauterized. Suction is also used as an adjunct to cautery inasmuch as flowing blood can overwhelm the effectiveness of cautery.

[0003] Used as separate instruments, the use of cautery and suction as described above require two or more hands of operating surgeons. For example, one operating hand may aspirate pooling or flowing blood with a suction device, while a second hand grasps the point of bleeding with conductive forceps and a third hand is required to apply electrocautery energy to the forceps with a conventional electrocautery device. Accordingly, conventional devices require both hands of a surgeon or multiple surgeons or other medical professionals to simultaneously use the electrocautery and suction functions, which can be inefficient and cumbersome. Combined suction/cautery devices are currently available; however, such devices appear to provide these functions in a mutually exclusive manner i.e., the functions are not complementary, and each must be used independent of the other function.

[0004] When a conductive suction device is used, cautery energy can be directly applied thereby eliminating one step described above. However, in that circumstance, tissues tend to adhere or "weld" to the suction tip as the point of electrocautery energy delivery. In this specific instance, upon removal of the suction device the hemostatic eschar resulting from cautery is displaced which re-initiates bleeding and is therefore counterproductive. Accordingly, in such a circumstance, to prevent tissue adherence, the surgeon or other medical professional manipulating the metal suction device to which cautery energy is applied, would be required to rapidly and continuously move the instrument against the target site, while a third hand provides saline drip irrigation. Thus, in this circumstance, multiple hands are still required to achieve hemostasis. This latter technique is not well known, is cumbersome, difficult to master and prone to error.

SUMMARY

[0005] The present disclosure is directed to various embodiments of an electrocautery device and method for its use. In one exemplary embodiment, this device may provide a conductive suction tip with single handed control of both cautery with motion and drip irrigation at the tip, with the goal of integrating several steps as described above into a single efficient tool. In one embodiment, the electrocautery device includes a sheath defining a longitudinal axis, a handle coupled to a proximal end of the sheath, a cauterizing tip coupled to a distal end of the sheath, and at least one actuator configured to move the cauterizing tip relative to the sheath and a second to provide drip irrigation. In one embodiment, the actuator may include at least one piezoelectric transducer in the cauterizing tip. When an alternating current is applied to the piezoelectric transducer, the cauterizing tip oscillates about an axis perpendicular to the longitudinal axis of the sheath. The piezoelectric transducer may be comprised of any suitable active material, such as a piezoceramic material, a magnetostrictive material, or a piezoelectric crystal. In one embodiment, the alternating current may have a frequency from approximately 100 kHz to approximately 4 MHz. Alternatively the actuator may include a micro-motor in the cauterizing tip. The actuator may include a switch in the handle and a transmission member coupling the switch to the cauterizing tip. In one embodiment, the electrocautery device may also include a suction tube extending from the handle to the tip through the sheath configured to draw fluid away from the tip. In one embodiment, the electrocautery device may also include an irrigation tube extending from the handle to the tip through the sheath configured to deliver fluid to the tip. The electrocautery device may also include a manual actuator on the handle configured to simultaneously or concurrently activate the actuator to move the tip and to deliver high-frequency energy to the cauterizing tip. The electrocautery device may also include a second actuator on the handle configured to deliver the fluid through the irrigation tube. Alternatively, the device may include at least one turbine in the sheath. The turbine may be actuated by fluid or air flowing through the suction tube and/or the irrigation tube. At least a portion of the cauterizing tip may include an electrically conductive material and the sheath may include an electrically insulating material.

[0006] This summary is provided to introduce a selection of concepts that are further described below in the detailed description. One or more of the described features may be combined with one or more other described features to provide a workable device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] These and other features and advantages of embodiments of the present disclosure will become more apparent by reference to the following detailed description when considered in conjunction with the following drawings. In the drawings, like reference numerals are used throughout the figures to reference like features and components. The figures are not necessarily drawn to scale, nor is every feature in the drawings necessarily required to fall within the scope of the described invention.

[0008] FIG. 1A is a side view of an electrocautery device according to one embodiment of the present disclosure including a cauterizing tip, a sheath, and a handle;

[0009] FIG. 1B is a cross-sectional view of the electrocautery device illustrated in FIG. 1A taken along line B--B;

[0010] FIG. 1C is a cross-sectional view of the electrocautery device illustrated in FIG. 1A taken along line C--C showing a plurality of piezoelectric transducers configured to move the cauterizing tip;

[0011] FIG. 2 is a cross-sectional view of the electrocautery device illustrated in FIG. 1A taken along line C--C showing a turbine configured move the cauterizing tip according to one embodiment of the present disclosure;

[0012] FIG. 3 is a perspective view of an exemplary micro-motor configured to move the cauterizing tip according to one embodiment of the present disclosure; and

[0013] FIG. 4 is a cross-sectional view of an exemplary actuator in the handle configured to move the cauterizing tip according to one embodiment of the present disclosure.

DETAILED DESCRIPTION

[0014] The present disclosure is directed to various embodiments of an electrocautery device. In one embodiment, the electrocautery devices of the present disclosure may include a cauterizing tip configured to deliver high-frequency current during a surgical operation to coagulate tissue and/or organs in a patient and thereby achieve hemostasis. The electrocautery devices of the present disclosure may also include a cauterizing tip configured to be actuated in an oscillatory and/or rotary manner to mitigate the risk of tissue adherence to the cauterizing tip during a cauterizing operation. The electrocautery devices of the present disclosure may also be configured to deliver an irrigation fluid to the tip to further mitigate the risk of tissue adherence to the cauterizing tip during a cauterizing operation and to provide cooling to parenchymal tissues at high cautery settings. The electrocautery devices of the present disclosure may also be configured to draw fluid (e.g., blood or excess irrigation fluid) away from the tip and the cauterization site in the patient simultaneously or concurrently with a cauterizing operation. Accordingly, all or some of suction, cautery, oscillatory/rotary, and irrigation functions of the electrocautery device of the present disclosure may be operated by a single surgeon with one hand.

[0015] With reference now to FIGS. 1A and 1B, an electrocautery device **100** according to one embodiment of the present disclosure includes an elongated sheath **101**, a handle portion **102** coupled to a proximal end **103** of the sheath **101**, and a cauterizing tip **104** coupled to a distal end **105** of the sheath **101**. The handle portion **102** and the sheath **101** may be integrally formed (e.g., by injection molding) or separately formed and coupled together by any suitable process, such as, for instance, friction stir welding. In the illustrated embodiment, the sheath **101** is a thin-walled, hollow member that functions as a conduit for delivering a plurality of lines and/or tubes from the handle to the cauterizing tip **104**, as described in more detail below. The sheath **101** also defines a longitudinal axis $\mathbf{L_s}$. Additionally, in the illustrated embodiment, the handle portion **102** is tapered and may include a plurality of ridges or grooves **106** to facilitate ergonomic handling and prevent mishandling, respectively, of the electrocautery device **100** by a surgeon or other medical professional.

[0016] With reference to the embodiment illustrated in FIG. 1B, the sheath **101** houses a plurality of irrigation tubes **107** configured to deliver irrigation fluid (e.g., saline) to the cauterizing tip **104**, a suction tube **108** configured to draw fluid (e.g., blood or excess irrigation fluid) away from the cauterizing tip **104**, and at least one electrical line **109** (e.g., a cable) configured to deliver electrical current (e.g., high-frequency current from approximately 100 kHz to approximately 4 MHz) to the cauterizing tip **104**. Delivery of the irrigation fluid to the cauterizing tip **104** is configured to mitigate the risk of tissue adherence to the cauterizing tip **104** during a cauterizing operation. The suction tube **108** is configured to draw fluid away from the cauterizing tip **104** and the target site in the patient to allow the surgeon or other medical professional to locate the source of the bleeding to be cauterized. Although in the illustrated embodiment the electrocautery device **100** includes a single suction tube **108** and four irrigation tubes **107**, in one or more embodiments, the electrocautery device **100** may include any other suitable number of suction tubes **108** and any other suitable number of irrigation tubes **107**. Additionally, in one or more embodiments, the electrocautery device **100** may be provided without the irrigation tubes **107**. Furthermore, although in the illustrated embodiment the electrocautery device **100** includes irrigation and suction tubes **107**, **108** that are separate from the sheath **101** and the handle **102**, in one or more embodiments, the irrigation tubes **107** and/or the suction tube **108** may be integrally defined in the sheath **101** and the handle **102**. For example, the sheath **101** and the handle **102** of the electrocautery device **100** may define a plurality of lumens (e.g., smooth bores) through which irrigation fluid is pumped to the cauterizing tip **104** and/or through which fluid is drawn away from the cauterizing tip **104**.

[0017] With reference now to the embodiment illustrated in FIG. 1A, proximal ends of the irrigation tubes **107** are coupled to an irrigation port **110** configured to facilitate quick-release connection to and disconnection from an irrigation supply source (e.g., a saline source). A proximal end of the suction tube **108** is coupled to a connector **111** (e.g. a port) configured to facilitate quick-release connection to and disconnection from a suction device (e.g., a pump or a vacuum). Additionally, a proximal end of the electrical line **109** is coupled to an electrical connector configured to facilitate quick-release connection to and disconnection from a standard electrosurgical power supply **125**. Accordingly, in the illustrated embodiment, the electrocautery device **100** may be disconnected from the irrigation supply source, the suction device, and the power supply **125** following a surgical operation and disposed of, and a new electrocautery device **100** may then be reconnected to the irrigation supply source, the suction device, and the power supply **125** prior to a subsequent surgical operation. That is, to ensure the electrocautery device **100** is sterile during a surgical operation, the cautery devices **100** of the present application may be disposable such that a new electrocautery device **100** is used for each surgical operation. In one or more alternate embodiments, the electrocautery device **100** may be reused and disinfected in any suitable manner, such as by ultraviolet irradiation, between surgical operations.

[0018] With continued reference to an exemplary embodiment illustrated in FIG. 1A, the cauterizing tip **104** is generally frusto-conical and includes a narrower proximal end **112** that tapers to a wider distal end **113**. The cauterizing tip **104** also defines a longitudinal axis $\mathbf{L_t}$. In the illustrated embodiment, the longitudinal axis $\mathbf{L_t}$ of the cauterizing tip **104** is coaxial with the longitudinal axis $\mathbf{L_s}$ of the sheath **101**. Additionally, in the illustrated embodiment, the wider distal end **113** of the cauterizing tip **104** is smooth (e.g., rounded). In one or more alternate embodiments, the cauterizing tip **104** may have any other shape suitable for the nature of the surgical operations with which cauterizing device **100** is intended to be used. In the illustrated embodiment, the wider distal end **113** of the cauterizing tip **104** also defines a suction port **114** and a plurality of irrigation ports **115** arranged around the suction port **114**. The suction port **114** and the plurality of irrigation ports **115** are aligned with the suction tube **108** and the irrigation tubes **107**, respectively. In one embodiment, the suction port **114** and the irrigation ports **115** may receive distal ends of the suction tube **108** and the irrigation tubes **107**, respectively. Additionally, in the illustrated embodiment, the suction port **114** is coaxial or substantially coaxial with the sheath **101** (i.e., the suction port **114** is aligned with the longitudinal axis $\mathbf{L_s}$ of the sheath **101**) and the irrigation ports **115** are arranged off of the longitudinal axis $\mathbf{L_s}$ of the sheath **101**. Additionally, in one or more embodiments, the suction and irrigation ports **114**, **115** may be arranged in any other suitable configuration on the cauterizing tip **104**. Although in the illustrated embodiment the cauterizing tip **104** defines one suction port **114** and four irrigation ports **115**, in one or more embodiments, the cauterizing tip **104** may define any other number of suction ports **114** and irrigation portions **115** corresponding to the number of suction tubes **108** and irrigation tubes **107**. For instance, in one embodiment in which the electrocautery device **100** does not include irrigation tubes **107**, the cauterizing tip **104** may be provided without the irrigation ports **115**.

[0019] With continued reference to the exemplary embodiment illustrated in FIG. 1A, the handle **102** includes an upper actuator **116** (e.g., a button) configured to allow selective delivery of electrical current to the cauterizing tip **104** and a lower actuator **117** (e.g., a button) configured to allow selective delivery of irrigation fluid to the cauterizing tip **104**. As described in more detail below, when the upper actuator **116** is actuated (e.g., depressed), electrical current flows from the power supply to the cauterizing tip **104** and thereby simultaneously or concurrently moves (e.g., oscillates and/or rotates) the cauterizing tip **104** and delivers high-frequency current (e.g., 100 kHz to 4 MHz) to the cauterizing tip **104** to cauterize tissue and/or organs and thereby achieve hemostasis. In one embodiment, the upper actuator **116** is coupled to a mechanical switch (e.g., a push-button switch) such that actuation of the upper actuator **116** closes a circuit and thereby permits electrical current to flow from the power supply to the cauterizing tip **104**. When the lower actuator **117** is actuated (e.g., depressed), irrigation fluid flows from the irrigation fluid source, through the irrigation tubes housed in the handle **102** and the sheath **101**, and out through the plurality of irrigation ports **115** in the cauterizing tip **104** to the cauterization site in the patient. In one embodiment, the lower actuator **117** may be coupled to electrically actuatable valve such that actuation of the lower actuator **117** opens the valve and thereby permits the irrigation fluid to flow through the electrocautery device **100**.

[0020] With reference now to the exemplary embodiment illustrated in FIG. 1C, the cauterizing tip **104** includes one or more piezoelectric transducers **118** configured to move (e.g., oscillate) the cauterizing tip **104** when electrical current is supplied to the piezoelectric transducers **118**. As described in more detail below, the characteristics of the movement of the cauterizing tip **104** depends on the number and arrangement of the piezoelectric transducers **118** in the cauterizing tip **104**, the type of current (e.g., direct current or alternating current) supplied to the piezoelectric transducers **118**, and other characteristics of the current supplied to the piezoelectric transducers **118** (e.g., the input frequency of the current). Each of the piezoelectric transducer **118** includes polarized molecules (i.e., positively charged molecules and negatively charged molecules). The piezoelectric transducers **118** may be made out of any suitable polarized material, such as, for instance, a piezoceramic material (e.g., lead zirconate titanate or barium titanate), a magnetostrictive material, or a piezoelectric crystal (e.g. quartz). Accordingly, when electric current is applied across the oppositely charged portions of the piezoelectric transducers **118**, the piezoelectric transducers **118** mechanically deform as the polarized molecules align themselves with the supplied electric field (i.e., the supplied electric field creates induced dipoles within the piezoelectric transducers **118** that create mechanical strain on the piezoelectric transducers **118**). The displacement of the positive molecules in the direction of the electric field and the displacement of the negative molecules in the opposite direction results in the elongation of the piezoelectric transducers **118** in the direction of the applied electric field and corresponding narrowing in a direction orthogonal to the applied electric field. This electrostriction of the one or more piezoelectric transducers **118** causes the cauterizing tip **104** to move (e.g., oscillate).

[0021] In one embodiment, the one or more piezoelectric transducers **118** are arranged on the cauterizing tip **104** such that supplying electric current to the piezoelectric transducers

118 causes the distal end **113** of the cauterizing tip **104** to move/pivot (arrow **119**) about an axis **P** perpendicular to the longitudinal axes L_s, L_t of the sheath **101** and the cauterizing tip **104**. For instance, in one embodiment, the distal end **113** of the cauterizing tip **104** may be configured to pivot (arrow **119**) in a plane extending through the upper and lower actuators **116**, **117**, although in one or more embodiments, the distal end **113** of the cauterizing tip **104** may be configured to pivot in any other suitable plane.

[0022] Additionally, in one exemplary embodiment, alternating current (AC) may be supplied from the power supply **125** to the piezoelectric transducers **118** such that the distal end **113** of the cauterizing tip **104** pivots (arrow **119**) in an oscillatory manner (e.g., the distal end **113** of the cauterizing tip **104** repeatedly pivots up and down). When AC is supplied to the one or more piezoelectric transducers **118**, the piezoelectric transducers **118** vibrate in an oscillatory manner at the same frequency as the input current. Additionally, the cauterizing tip **104** may be configured to oscillate (arrow **119**) at any suitable rate depending, for instance, on the composition of the tissue or organs the electrocautery device **100** is intended to cauterize. For instance, the human liver is particularly prone to adhering to a cauterizing element and to tearing when the cauterizing element is detached from the adhered portion of the liver and therefore the cauterizing tip **104** may be configured to rapidly oscillate when the cauterizing device **100** is intended to be used to cauterize the liver. For instance, in one or more embodiments, the frequency of the input current may be within the radio frequency (RF) range (i.e., from approximately 3 kHz to approximately 300 GHz) such that the cauterizing tip **104** is configured to oscillate (arrow **119**) at a frequency from approximately 3 kHz to approximately 300 GHz. In one embodiment, the frequency of the input current may be within the microwave spectrum (i.e., from approximately 0.3 GHz to approximately 300 GHz) such that the cauterizing tip **104** is configured to oscillate (arrow **119**) at a frequency from approximately 0.3 GHz to approximately 300 GHz. In another embodiment, the frequency of the input current may be from approximately 100 kHz to approximately 4 MHz.

[0023] Additionally, the one or more piezoelectric transducers **118** may be either actuated simultaneously, concurrently or sequentially. In one embodiment, the piezoelectric transducers **118** may be sequentially actuated such that the cauterizing tip **104** is deflected along a desired path. For instance, in the embodiment illustrated in FIG. 1C, the cauterizing tip **104** includes an upper piezoelectric transducer **118'**, a right piezoelectric transducer **118''**, a lower piezoelectric transducer **118'''**, and a left piezoelectric transducer **118''''** arranged in a circular pattern (i.e., four piezoelectric transducers **118'-118''''** arranged in a circumferential or circular array). Additionally, in the illustrated embodiment, each of the electrical lines **109** includes an inner electrode **120** connected to an inner surface **121** of one of the piezoelectric transducers **118'-118''''** and an outer electrode **122** connected to an outer surface **123** of the piezoelectric transducer **118'-118''''**. Accordingly, when the upper actuator **116** is actuated (e.g., the upper button is depressed) current is applied across the inner and outer surfaces **121**, **123** of the piezoelectric transducers **118'-118""**. Thus, when current is supplied sequentially to the upper, right, lower, and left transducers **118'-118""**, respectively, the distal end **113** of the cauterizing tip **104** will deflect or move (arrow **124**) in a circular manner, as illustrated by the dashed lines in FIG. 1C. If the current is rapidly sequenced between the upper, right, lower, and left piezoelectric transducers **118'-118""**, the distal end **113** of the cauterizing tip **104** may rotate smoothly in a circular manner. In one or more embodiments, the piezoelectric transducers **118** may be arranged in any other suitable orientation in the cauterizing tip **104** and the electrodes **120**, **122** may be positioned on the piezoelectric transducers **118'-118""** in any other suitable arrangement depending on the desired movement of the distal end **113** of the cauterizing tip **104** when current is supplied to the piezoelectric transducers **118'-118""**.

[0024] Additionally, in one embodiment, the cauterizing tip **104** may be made out of any suitable electrically conductive material such that the high-frequency current (e.g., 100 kHz to 4 MHz) supplied by the electrosurgical power supply **125** is delivered through the cauterizing tip **104** and to the target site in the patient. In one embodiment, the cauterizing tip **104** may be made out of metal (e.g., stainless steel), although in one or more embodiments, the cauterizing tip **104** may be made out of any other suitable bio-compatible material having a sufficiently high electrical conductivity. In one embodiment, the current supplied to move (e.g., oscillate and/or rotate) the cauterizing tip **104** is delivered to the target site in the patient through the cauterizing tip **104** (e.g., depressing the upper actuator **116** actuates the motion of the cauterizing tip **104** and also delivers high-frequency current through the cauterizing tip **104** to cauterize the target site in the patient). Accordingly, in one embodiment, the movement (e.g., oscillation and/or rotation) of the cauterizing tip **104** and the delivery of high-frequency cauterizing current to the cauterizing tip **104** occur simultaneously or concurrently. In one or more alternate embodiments, the movement of the cauterizing tip **104** and the delivery of high-frequency cauterizing current to the cauterizing tip **104** may be actuated independently (e.g., the electrocautery device **100** may include a separate actuator and separate electrical lines coupled to the cauterizing tip **104** to deliver high-frequency cauterizing current to the cauterizing tip **104**). Additionally, in one embodiment, the electrocautery device **100** may include a voltage/current level adjustment device permitting an operator to adjust the voltage/current supplied to the cauterizing tip **104**, and thereby changing the cauterizing energy supplied to the target site in the patient and/or adjusting the movement of the cauterizing tip **104** (e.g., changing the frequency at which the cauterizing tip **104** moves). Additionally, in one embodiment, the sheath **101** and/or the handle **102** are made of an electrically insulating material, such as, for instance, plastic, to prevent the sheath **101** and/or the handle **102** from conducting the high-frequency current delivered to the cauterizing tip **104** from the electrosurgical power supply **125**. Additionally, in one embodiment, the sheath **101** is made out of a flexible material such that the sheath **101** is configured to bend or flex when the cauterizing tip **104** is actuated to move (e.g., oscillate and/or rotate). For instance, the sheath **101** may be configured to flex about an axis perpendicular to the longitudinal axes $\mathbf{L_s}$, $\mathbf{L_t}$ of the sheath **101** and the cauterizing tip **104**.

[0025] In one or more embodiments, the electrocautery device **100** may have any other suitable type of actuator for actuating the cauterizing tip **104** in an oscillatory or rotary manner. In the embodiment illustrated in FIG. 2, the electrocautery device **100** includes at least one in-line turbine **126** (e.g., an impeller) housed in the sheath **101**. In one embodiment, the turbine **126** may be at least partially within the suction tube **108** such that fluid flowing through the suction tube **108** rotates (arrow **127**) the turbine **126** (e.g., blood and/or excess irrigation fluid drawn through the suction tube **108** actuates the turbine **126**). In one or more embodiments, the turbine **126** may be at least partially within one or more of the irrigation tubes **107** such that irrigation fluid flowing through the one or more irrigation tubes **107** rotates (arrow **127**) the turbine **126**. In one or more embodiments, the turbine **126** may be actuated (arrow **127**) by any other suitable mechanism, such as, for instance, by an electric motor electrically coupled to the turbine **126**. In the illustrated embodiment, the turbine **126** is configured to rotate (arrow **127**) about the longitudinal axis $\mathbf{L_s}$ of the sheath **101**.

[0026] In the illustrated embodiment, the turbine **126** includes a plurality of blades **128** radially arranged around a hub **129**. In one embodiment, the turbine **126** may be unbalanced or eccentric such that the rotation (arrow **127**) of the turbine **126** imparts movement (e.g., vibration) to the cauterizing tip **104**. The vibration from the rotating turbine **126** may be transmitted to the cauterizing tip **104** through the sheath **101** and/or the suction tube **108**. In one embodiment, one or more of the blades **128** may be more heavily weighted than the other blades **128** such that the turbine **126** is unbalanced and will impart movement (e.g., vibration) to the cauterizing tip **104** when the turbine **126** is rotated (arrow **127**). In one or more embodiments, the blades **128** may be non-uniformly spaced around the hub **129** such that the turbine **126** is unbalanced and will impart movement (e.g., vibration) to the cauterizing tip **104** when the turbine **126** is rotated (arrow **127**). Accordingly, the cauterizing tip **104** will tend to deflect in the direction of the one or more heavily weighted blades **128** and/or the more closely spaced blades **128** as the turbine **126** is rotated (arrow **127**). In one or more embodiments, the turbine **126** may have any other suitable type or kind of asymmetry or eccentricity configured to impart movement to the cauterizing tip **104** when the turbine **126** is rotated (arrow **127**), such as, for instance, difference shapes and/or sizes of the blades **128**.

[0027] In another embodiment illustrated in FIG. 3, the electrocautery device **100** includes at least one micro-motor **130** in the cauterizing tip **104**. In another embodiment, the micro-motor **130** may be located at any other suitable location within the electrocautery device **100**, such as, for instance, within the sheath **101** proximate the cauterizing tip **104** or in the handle **102**. In the illustrated embodiment, the micro-motor **130** includes a motor **131**, an output shaft **132** configured to be driven by the motor **131**, and an eccentric cam or lobe **133** coupled to the output shaft **132**. When the output shaft **132** is driven by the motor **131**, the cam **133** is rotated (arrow **134**) about a longitudinal axis of the output shaft **132**. The eccentricity of the cam **133** is configured to impart movement (e.g., vibration) to the cauterizing tip **104** when the cam **133** is rotated (arrow **134**) by the motor **131**. The micro-motor **130** may be electrically coupled to the upper actuator **116** such that the actuation (e.g., depression) of the upper actuator **116** simultaneously delivers high-frequency current to the target site in the patient to achieve hemostasis and actuates the micro-motor **130** to move the cauterizing tip **104** to mitigate the risk of tissue or organ adherence to the cauterizing tip **104** during the cauterizing operation.

[0028] In a further embodiment illustrated in FIG. 4, the electrocautery device **100** includes a mechanical actuator **135** coupled to the handle **102**. In one embodiment, the actuator **135** may be a wheel or switch rotatably coupled to the handle **102**. In one embodiment, the actuator **135** may include a ratcheting mechanism. In the illustrated embodiment, the actuator **135** is coupled to the cauterizing tip **104** by a transmission member **136** housed in the sheath **101** and the handle **102** (e.g., the transmission member may be a flexible sleeve extending through the handle **102** and the sheath **101**). The transmission member **136** is configured to deliver or transmit the movement of the mechanical actuator **135** to the cauterizing tip **104**. Accordingly, in one embodiment, a surgeon or other medical professional may move the cauterizing tip **104** by moving (arrow **137**) the mechanical actuator **135** back and forth in a reciprocal manner (e.g., rotating the wheel back and forth in opposite directions or flipping the switch back and forth). In one embodiment, the mechanical actuator **135** may be positioned on the handle **102** such that the surgeon can ergonomically and simultaneously or concurrently operate the upper actuator **116** to deliver high-frequency current to cauterize the target site in the patient and operate the mechanical actuator **135** to move the cauterizing tip **104** to mitigate the risk of tissue or organ adherence to the cauterizing tip **104** during the cauterizing operation. For instance, in one embodiment, the upper actuator **116** and the mechanical actuator **135** may be positioned on the handle **102** such that the upper actuator **116** may be depressed by the surgeon's thumb and the mechanical actuator **135** may be actuated by the surgeon's index finger. In another embodiment, the upper actuator **116** may be integrated into the mechanical actuator **135**.

[0029] The described electrocautery devices may beneficially be used for cauterizing a target area of tissue or organ. In one embodiment, the user grasps the handle of the electrocautery device with one hand, applies the cauterizing tip to the target area to be cauterized and concurrently activates the cauterizing tip and the suction device for cauterizing and suctioning fluid from the target area. The user may further concurrently actuate the cauterizing tip to oscillate or move the tip relative to the sheath, thereby reducing or minimizing adherence of the tip to the target tissue or organ, and enabling the user to remove the cauterizing tip from the target area. In another embodiment, the user may use the devices to irrigate the target area with fluid. The various cycles of cauterization, suction, oscillation and irrigation may be performed manually by the user or part of an automated or timed sequence in which two or more of the functions are concurrently actuated via one or more actuating buttons on the device.

[0030] While this invention has been described in detail with particular references to embodiments thereof, the embodiments described herein are not intended to be exhaustive or to limit the scope of the invention to the exact forms disclosed. Persons skilled in the art and technology to which this invention pertains will appreciate that alterations and changes in the described structures and methods of assembly and operation can be practiced without meaningfully departing from the principles, spirit, and scope of this invention. Although relative terms such as “outer,” “inner,” “upper,” “lower,” and similar terms have been used herein to describe a spatial relationship of one element to another, it is understood that these terms are intended to encompass different orientations of the various elements and components of the invention in addition to the orientation depicted in the figures. Additionally, as used herein, the term "substantially," "generally," and similar terms are used as terms of approximation and not as terms of degree, and are intended to account for the inherent deviations in measured or calculated values that would be recognized by those of ordinary skill in the art. Furthermore, as used herein, when a component is referred to as being "on" or "coupled to" another component, it can be directly on or attached to the other component or intervening components may be present therebetween. Further, any described feature is optional and may be used in combination with one or more other features to achieve one or more benefits.

WHAT IS CLAIMED IS:

1. A cautery device, comprising:

a sheath having a distal end and a proximal end opposite the distal end, the sheath defining a longitudinal axis;

a handle coupled to the proximal end of the sheath;

a cauterizing tip coupled to the distal end of the sheath; and

at least one actuator configured to move the cauterizing tip relative to the sheath.

2. The cautery device of claim 1, wherein the at least one actuator comprises at least one piezoelectric transducer in the cauterizing tip, and wherein, when an alternating current is applied to the at least one piezoelectric transducer, the cauterizing tip oscillates about an axis perpendicular to the longitudinal axis of the sheath.

3. The cautery device of claim 2, wherein the at least one piezoelectric transducer comprises an active material selected from the group of materials consisting of a piezoceramic material, a magnetostrictive material, and a piezoelectric crystal.

4. The cautery device of claim 2, wherein the alternating current has a frequency from approximately 100 kHz to approximately 4 MHz.

5. The cautery device of claim 1, wherein the at least one actuator comprises a micro-motor in the cauterizing tip.

6. The cautery device of claim 1, wherein the at least one actuator comprises:

a switch in the handle; and

a transmission member coupling the switch to the cauterizing tip.

7. The cautery device of claim 1, further comprising a suction tube extending from the handle to the tip through the sheath, the suction tube configured to draw fluid away from the tip.

8. The cautery device of claim 7, further comprising an irrigation tube extending from the handle to the tip through the sheath, the irrigation tube configured to deliver fluid to the tip.

9. The cautery device of claim 8, further comprising a first actuator on the handle configured to simultaneously actuate the actuator to move the tip and to deliver high-frequency energy to the cauterizing tip.

10. The cautery device of claim 9, further comprising a second actuator on the handle configured to deliver the fluid through the irrigation tube.

11. The cautery device of claim 10, wherein the at least one actuator comprises at least one turbine in the sheath.

12. The cautery device of claim 11, wherein the at least one turbine is actuated by fluid flowing through at least one of the suction tube and the irrigation tube.

13. The cautery device of claim 1, wherein at least a portion of the cauterizing tip comprises an electrically conductive material.

14. The cautery device of claim 1, wherein the sheath comprises an electrically insulating material.

15. The cautery device of claim 1, wherein the at least one actuator comprises a plurality of piezoelectric transducers arranged in a circular array, and wherein, when electric current is sequentially applied to the plurality of piezoelectric transducers, a distal end of the cauterizing tip rotates in a circular path about the longitudinal axis.

16. A method of using an electrocautery device for cauterizing a target area of tissue or organ, the electrocautery device including a sheath having a distal end and a proximal end opposite the distal end; a handle coupled to the proximal end of the sheath; a cauterizing tip coupled to the distal end of the sheath; at least one actuator configured to move the cauterizing tip relative to the sheath; and a suction tube extending to the tip through the sheath, the suction tube configured to draw fluid away from the tip, the method comprising:

grasping the handle of the electrocautery device with one hand;

applying the cauterizing tip to the target area;

concurrently activating the cauterizing tip and the suction device for cauterizing and suctioning fluid from the target area; and

concurrently actuating the cauterizing tip to move the tip relative to the sheath, and moving the cauterizing tip away from the target area.

17. The method of claim 16 wherein the electrocautery device further comprises an irrigation tube have an end directed in the vicinity of the cauterizing tip, the method further comprising directing fluid toward the target area.

18. The method of claim 16 wherein the electrocautery device includes a piezoelectric transducer for oscillating the cautery tip, the method further comprising oscillating the tip while removing the tip from the target area.

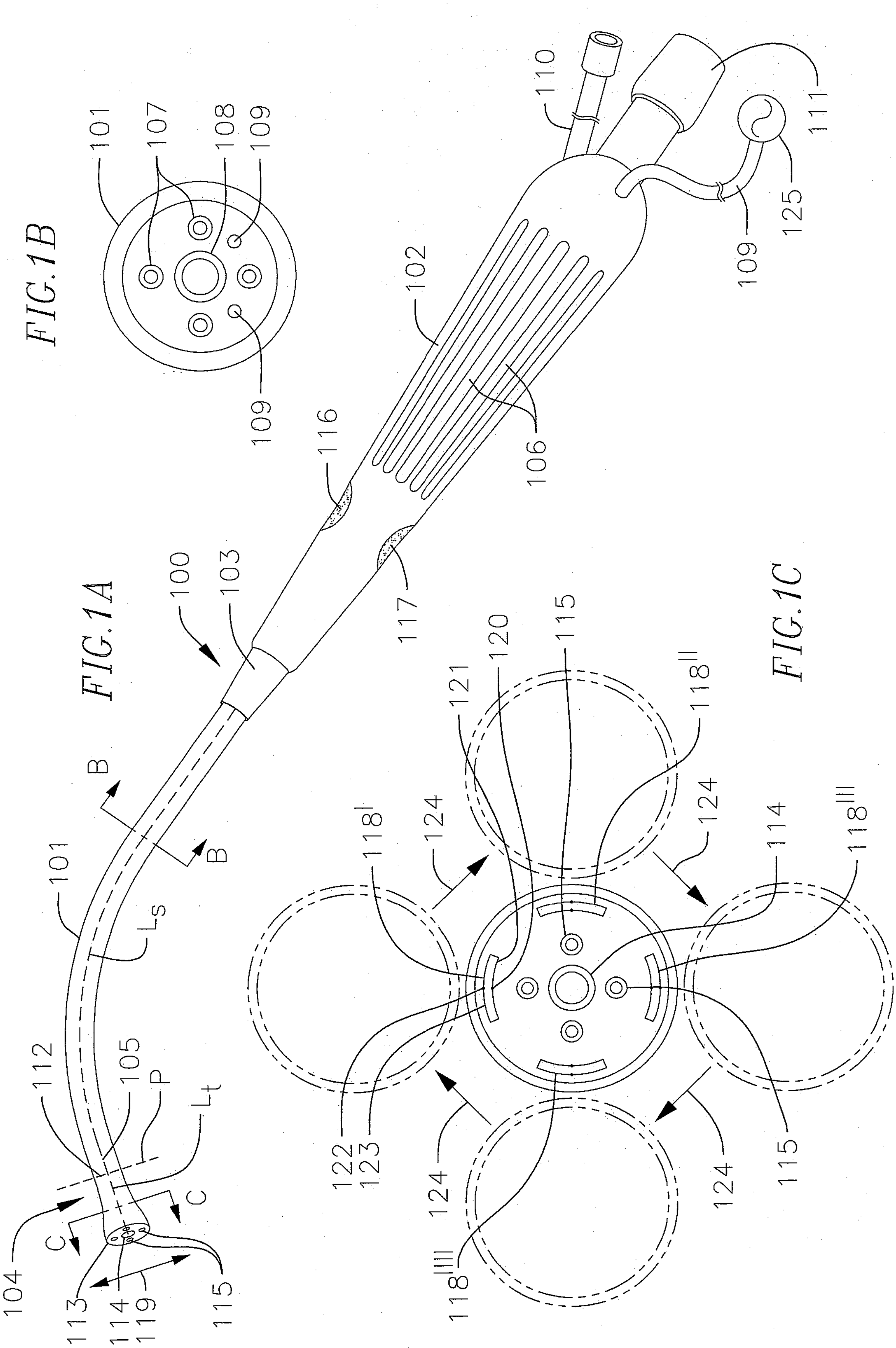


FIG.1A
FIG.1B
FIG.1C

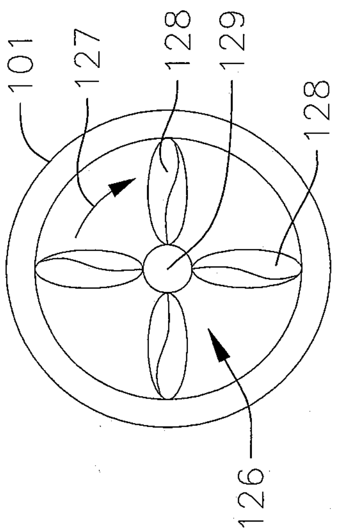


FIG. 2

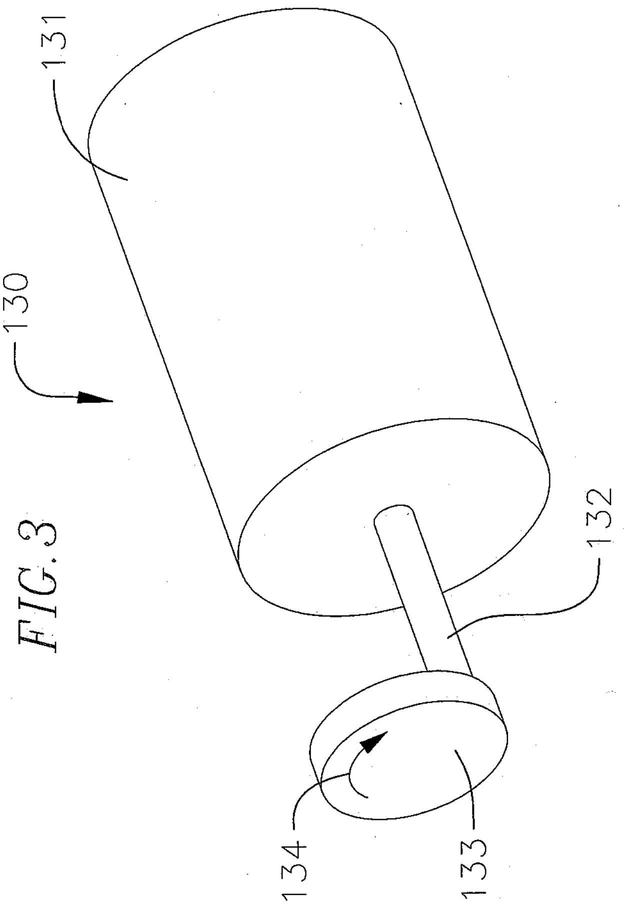


FIG. 3

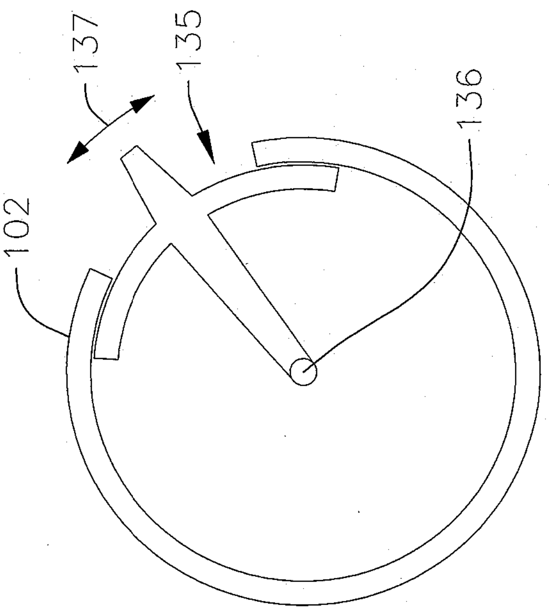


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 16/17014

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61B 18/14, A61B 18/12 (2016.01)
CPC - A61B 2018/00595, A61B 2018/0019, A61B 18/12, A61B 18/14, A61B 2218/002
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
CPC - A61B 2018/00595; IPC(8) - A61B 18/14 (2016.01); USPC - 604/22

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - A61B 2018/0019, A61B 18/12, A61B 18/14, A61B 2218/002, A61B 2018/00922, A61B 2218/007; IPC(8) - A61B 18/12 (2016.01); USPC - 606/41, 606/42, 604/20, 604/35

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase; Google (Web, Patents, Scholar) Search Terms Used: Electrocautery sheath cover tip electrode actuator transducer motor piezoelectric crystal piezoceramic magnetostrictive suction evacuation irrigation fluid delivery tube hose lumen channel insulating conductive oscillate vibration alternating current extend advance retract withdraw

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,254,117 A (Rigby et al.), 19 October 1993 (19.10.1993), entire document, especially Fig. 1, 6 and 9; col 1, ln 16-25; col 5, ln 19 to col 7, ln 13; col 10, ln 53-59; col 12, ln 41 to col 13, ln 10	1, 6-8 and 13-14
X -- Y	US 4,750,902 A (Wuchinich et al.), 14 June 1988 (14.06.1988), entire document, especially Fig. 4A and 5A-5B; col 13, ln 58 to col 15, ln 31; col 17, ln 64 to col 18, ln 17; col 20, ln 50 to col 22, ln 67	1 -- 2-4
Y	US 5,830,214 A (Flom et al.), 03 November 1998 (03.11.1998), entire document, especially Fig. 1 and 6A-7B; col 6, ln 20 to col 9, ln 35	1 and 7-10
Y	US 5,449,357 A (Zinnanti), 12 September 1995 (12.09.1995), entire document, especially Fig. 1 and 6; col 3, ln 6 to col 4, ln 7; col 6, ln 12-30	1 and 7-10
Y	US 4,674,498 A (Stasz), 23 June 1987 (23.06.1987), entire document, especially Fig. 4 and 18; col 1, ln 26-48; col 6, ln 37-44	2-4
A	US 6,451,017 B1 (Moutafis et al.), 17 September 2002 (17.09.2002), entire document	1-4, 6-10 and 13-14
A	US 7,717,913 B2 (Novak et al.), 18 May 2010 (18.05.2010), entire document	1-4, 6-10 and 13-14
A	US 8,133,223 B2 (Docimo et al.), 13 March 2012 (13.03.2012), entire document	1-4, 6-10 and 13-14
A	US 2014/0276813 A1 (Gambrell), 18 September 2014 (18.09.2014), entire document	1-4, 6-10 and 13-14
A	US 2005/0283150 A1 (Moutafis et al.), 22 December 2005 (22.12.2005), entire document	1-4, 6-10 and 13-14

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 May 2016	24 JUN 2016

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 16/17014

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
This application contains the following species of the generic invention which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid

Group I: Claims 1-4, 6-10 and 13-14 directed to the at least one actuator comprising at least on piezoelectric transducer which causes the cauterizing tip to oscillate.

Group II: Claims 1, 5-10 and 13-14 directed to the at least one actuator comprises a micro-motor in the cauterizing tip.

Group III: Claims 1 and 6-14 directed to the at least one actuator comprises at least one turbine in the sheath.

-*-Continued in Supplemental Box-*-

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-4, 6-10 and 13-14

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

-*- Box III - Observations where Unity of Invention is Lacking -*-

Group IV: Claims 1, 6-10, and 13-15 directed to the at least one actuator comprises a plurality of piezoelectric transducers sequentially activated which causes the cauterizing tip to rotate in a circular path.

Group V: Claims 16-18, directed to a method of using an electrocautery device for cauterizing a target area of tissue or organ.

Claims 1, 6-10 and 13-14 are generic to groups I-V.

The inventions listed as Groups I-V do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

SPECIAL TECHNICAL FEATURES

The special technical feature of each species of the independent claim 1 (Groups I-IV) is provided in the group descriptions above. None of these special technical features are common to the other species, nor do they correspond to a special technical feature in the other species.

Group V includes the special technical features of grasping the handle of the electrocautery device with one hand; applying the cauterizing tip to the target area; concurrently activating the cauterizing tip and the suction device for cauterizing and suctioning fluid from the target area; and concurrently actuating the cauterizing tip to move the tip relative to the sheath, and moving the cauterizing tip away from the target area, not required by Groups I-IV.

COMMON TECHNICAL FEATURES

Groups I-V share the technical features of a sheath having a distal end and a proximal end opposite the distal end; a handle coupled to the proximal end of the sheath; a cauterizing tip coupled to the distal end of the sheath; and at least one actuator configured to move the cauterizing tip relative to the sheath.
The apparatus is known in prior art as shown in US 4,750,902 A to Wuchinich et al. (hereinafter 'Wuchinich'), which discloses a cautery device (Fig. 4A), comprising:
a sheath (sheath 22, Fig. 4A; col 13, ln 58-60) having a distal end (front end of sheath 22 attach to working tip 80, Fig. 4A) and a proximal end opposite the distal end (rear end of sheath 22 attached to handpiece 20, Fig. 4A; sheath 22 extends from handpiece 20 to working end of device, col 13, ln 58-60);
a handle coupled to the proximal end of the sheath (handpiece 20, Fig. 4A; sheath is assembled to handpiece at rear end, col 14, ln 7 -9);
a cauterizing tip coupled to the distal end of the sheath (working tip 80, in contact with sheath 22 at distal end, Fig. 4A; current is passed through the tip 80 for cauterization, col 20, ln 50 to col 21, ln 2); and
at least one actuator (resonator assembly 68 including piezoelectric transducer 70, col 14, ln 39-51) configured to move the cauterizing tip relative to the sheath (energy is transferred to the working end 80 of the device, col 14, ln 39-51; col 15, ln 3-10; vibration of tip to dissect and cauterize, col 22, ln 48-67).

As the common features were known in the art at the time of the invention, they cannot be considered special technical features that would otherwise unify the groups.

Therefore, Groups I-V lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.