US 20110092971A1

(19) **United States**
(12) **Patent Application Publication**
Sartor et al.

(10) **Pub. No.: US 2011/0092971 A1**
(43) **Pub. Date: Apr. 21, 2011**

(54) **ELECTROSURGICAL PENCIL WITH ADVANCED ES CONTROLS**

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(73) Assignee: **Covidien AG**, Neuhausen am Rheinfall (CH)

(21) Appl. No.: **12/980,537**

(22) Filed: **Dec. 29, 2010**

Related U.S. Application Data

(60) Division of application No. 11/337,990, filed on Jan. 24, 2006, now Pat. No. 7,879,033, Continuation-in-part of application No. 11/198,473, filed on Aug. 5, 2005, now Pat. No. 7,503,917, Continuation-in-part of application No. 10/959,824, filed on Oct. 6, 2004, now Pat. No. 7,156,842, Continuation-in-part of application No. PCT/US03/37111, filed on Nov. 20, 2003.

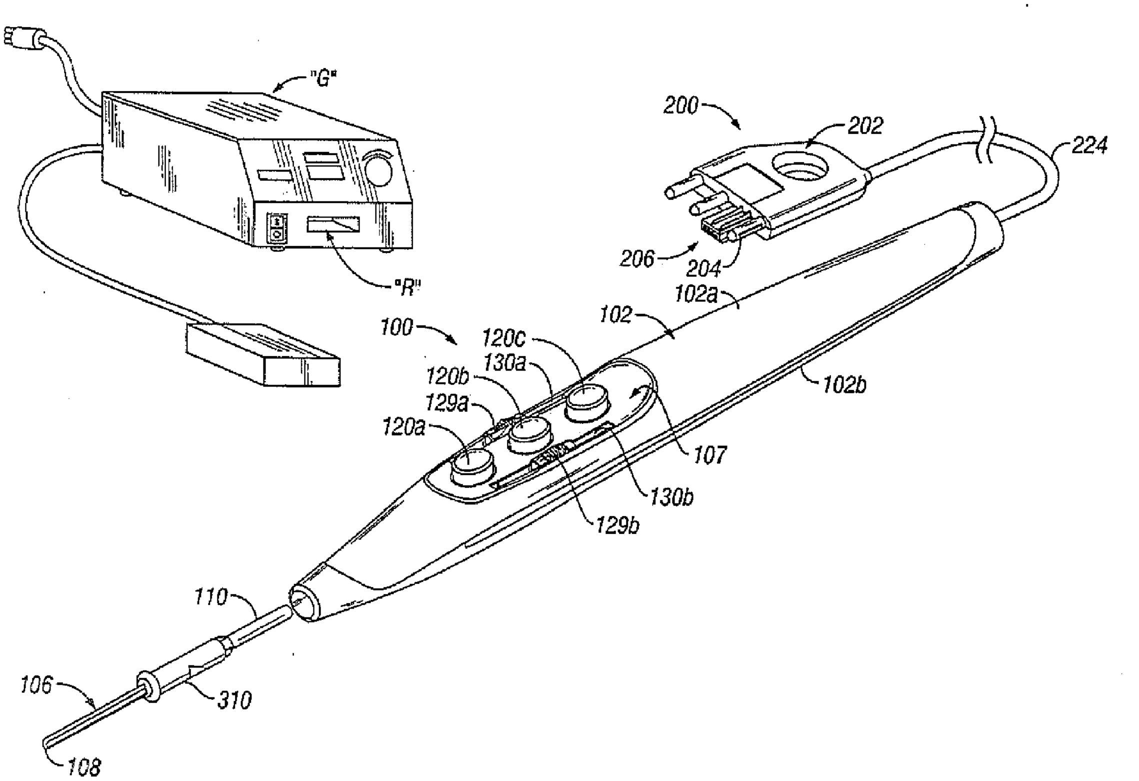
Publication Classification

(51) **Int. Cl.**
A61B 18/14 (2006.01)

(52) **U.S. Cl.** **606/42**; 606/49; 606/45

(57) **ABSTRACT**

An electrosurgical system is provided that includes an electrosurgical generator; and an electrosurgical pencil selectively connectable to the electrosurgical generator. The electrosurgical pencil includes an elongated housing; at least one electrocautery end effector removably supportable within the housing and extending distally from the housing, the electrocautery end effector being connected to the electrosurgical generator; and at least one voltage divider network supported on the housing. The at least one voltage divider network is electrically connected to the electrosurgical generator and controls at least one of the intensity of electrosurgical energy being delivered to the electrosurgical pencil and the mode of electrosurgical energy being delivered to the electrosurgical pencil. The voltage divider network generates a plurality of characteristic voltages which are measurable by the electrosurgical generator and which electrosurgical generator in turn transmits a corresponding waveform duty cycle at a particular intensity to the electrocautery end effector of the electrosurgical pencil.



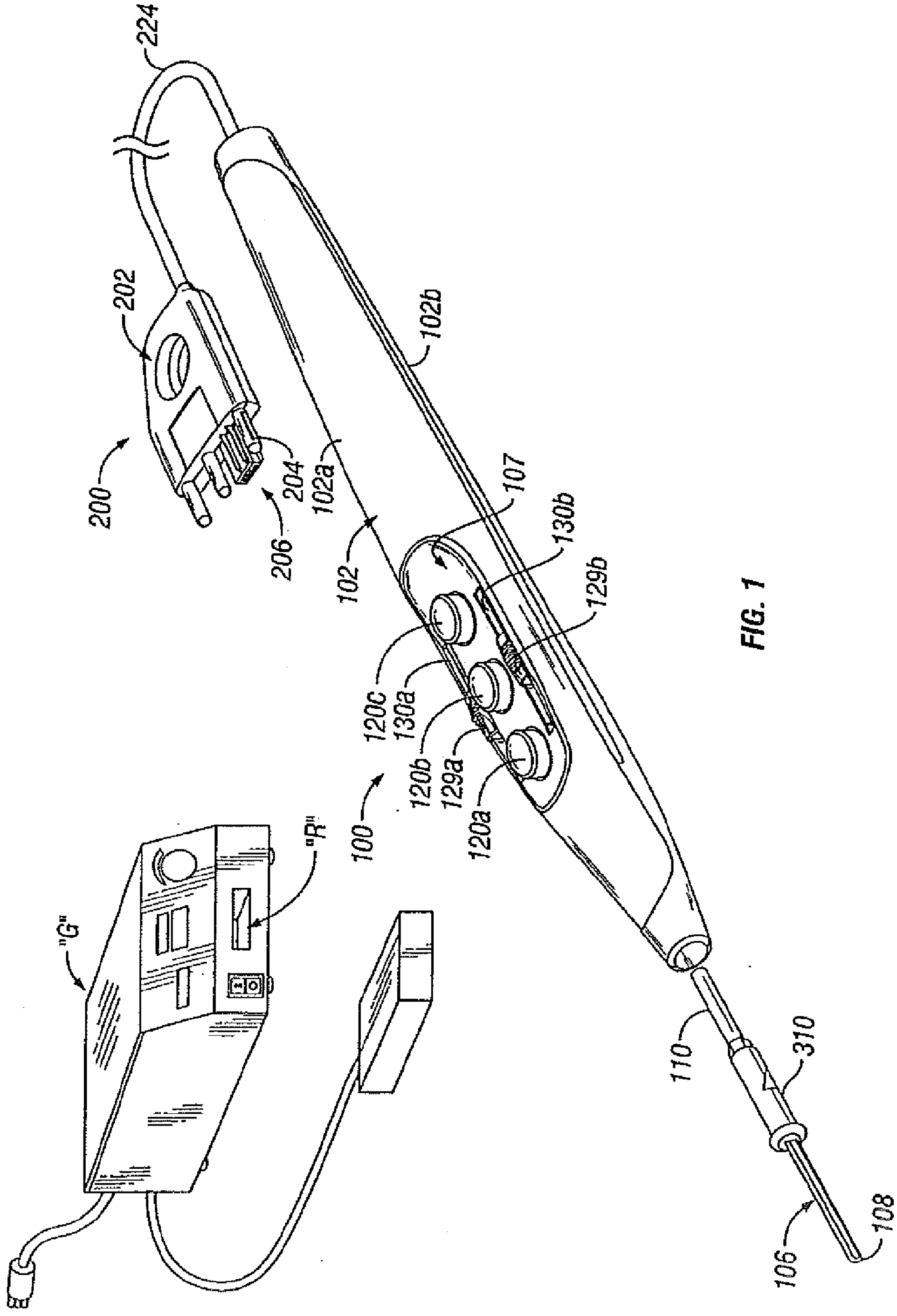

224
202
102b
200
204
206
102a
107
130b
102
129b
120c
130a
120b
129a
120a
100
"R"
"G"
110
310
106
108

FIG. 1

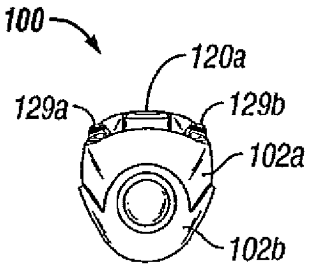


FIG. 2

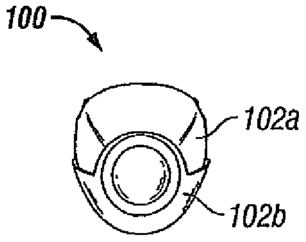


FIG. 3

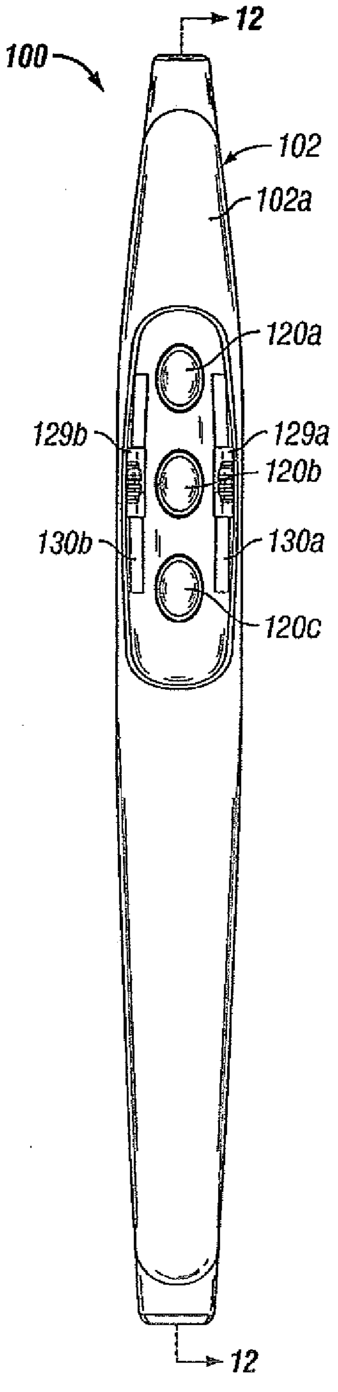


FIG. 4

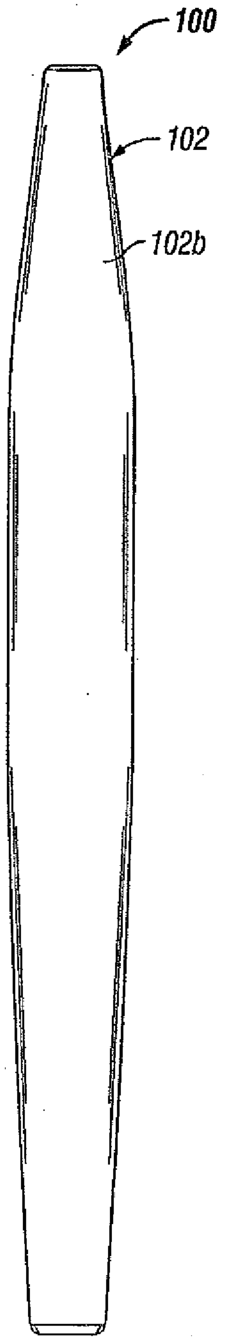


FIG. 5

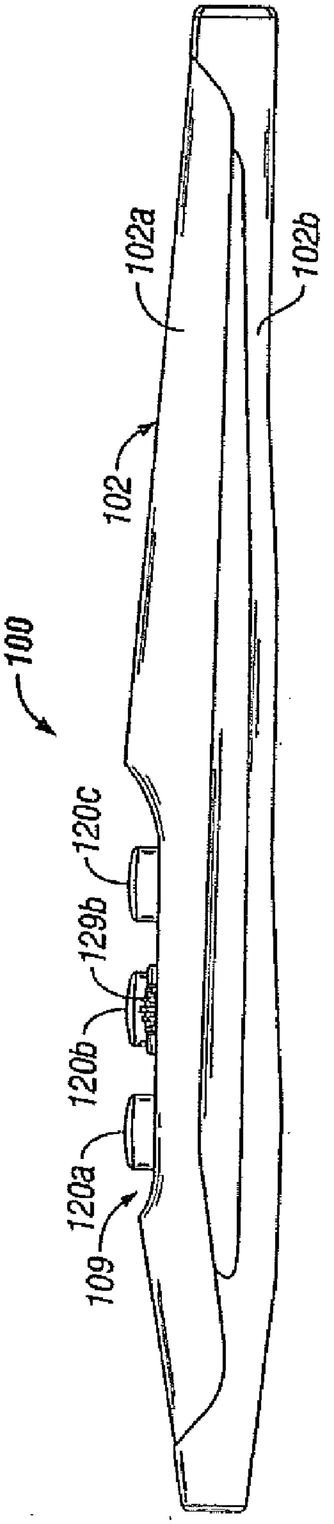

102a
102b
102
100
120c
129b
120b
120a
109

FIG. 6

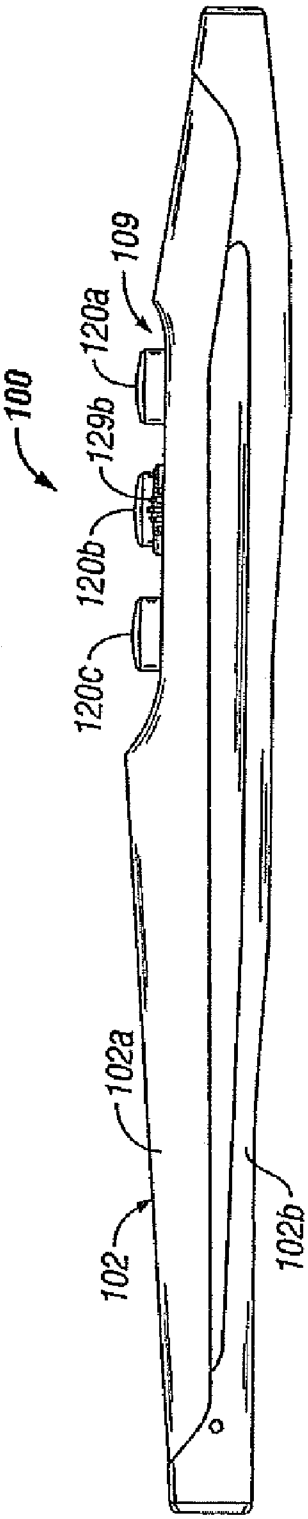

109
120a
100
129b
120b
120c
102a
102
102b

FIG. 7

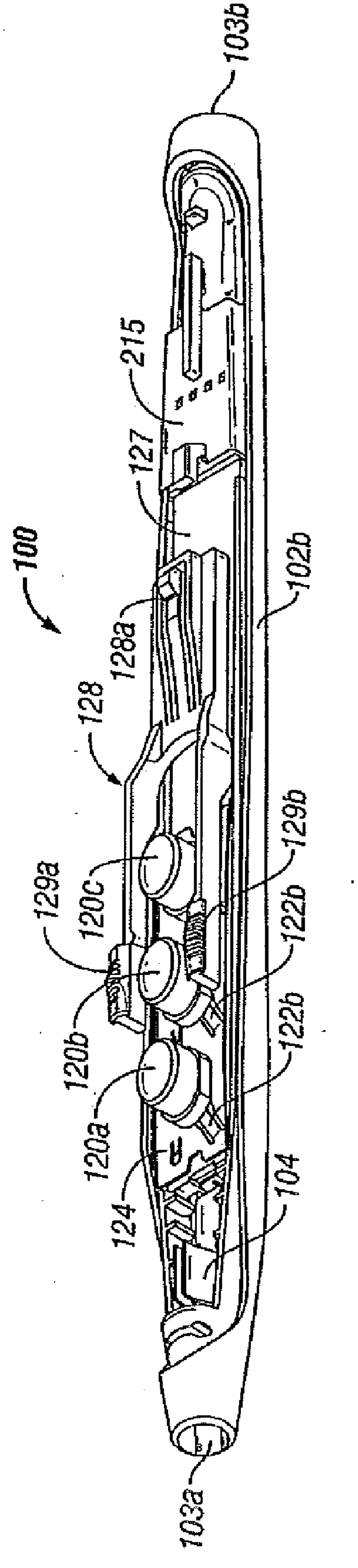

103b
215
127
100
128a
128
102b
129b
129a
120c
122b
122b
120b
120a
124
104
103a

FIG. 8

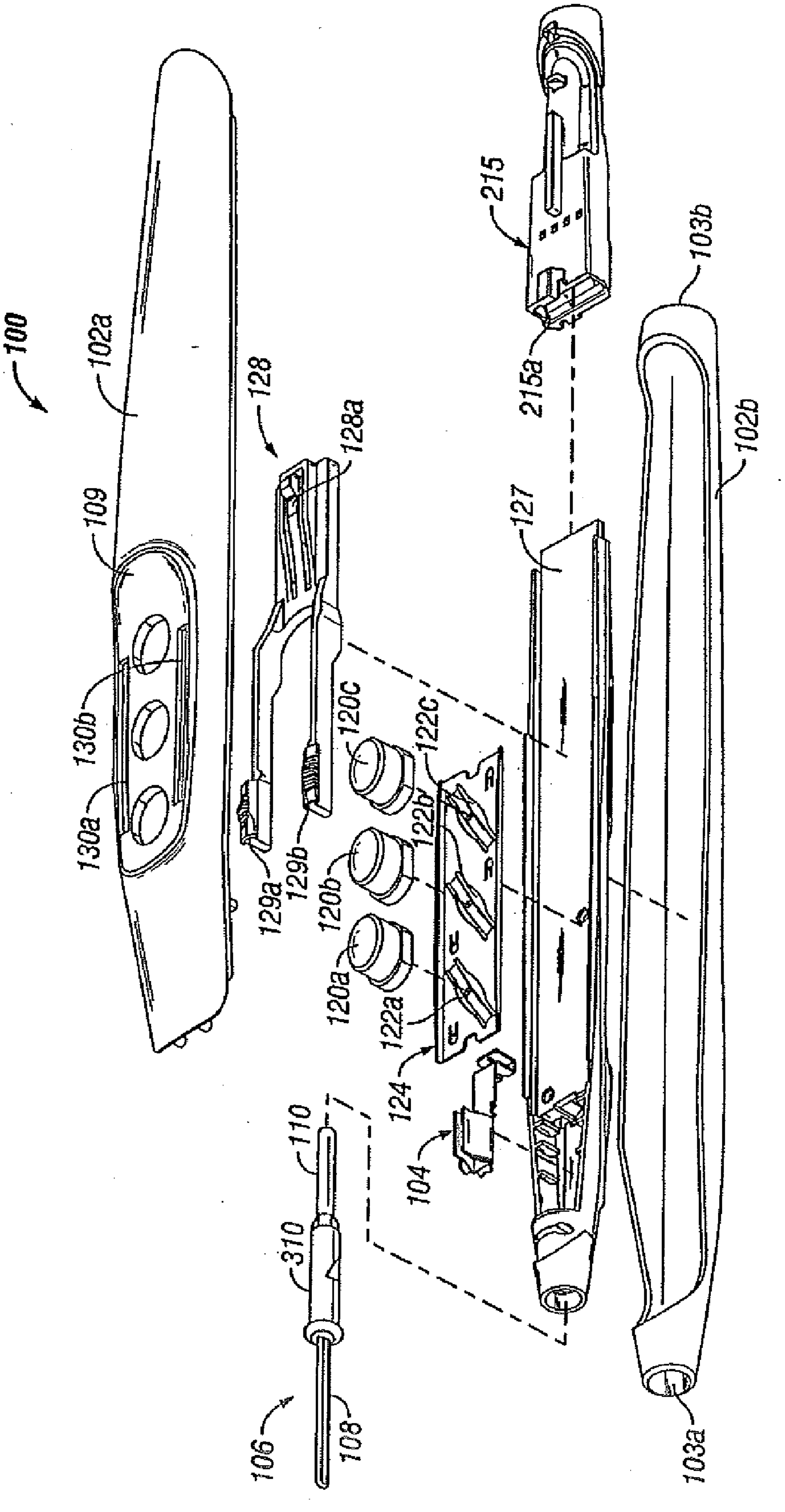

100
102a
109
130b
130a
128
128a
129a
129b
120c
120b
120a
122c
122b
122a
124
104
110
310
106
108
215
215a
127
103b
102b
103a

FIG. 9

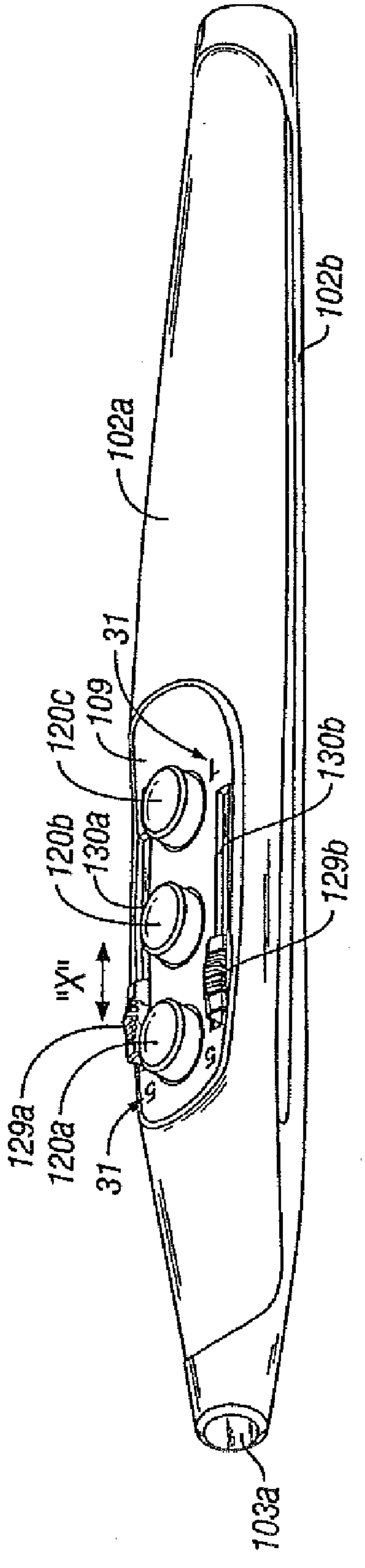

103a
31
120a
129a
"X"
120b
130a
120c
109
31
102a
102b
129b
130b

FIG. 10

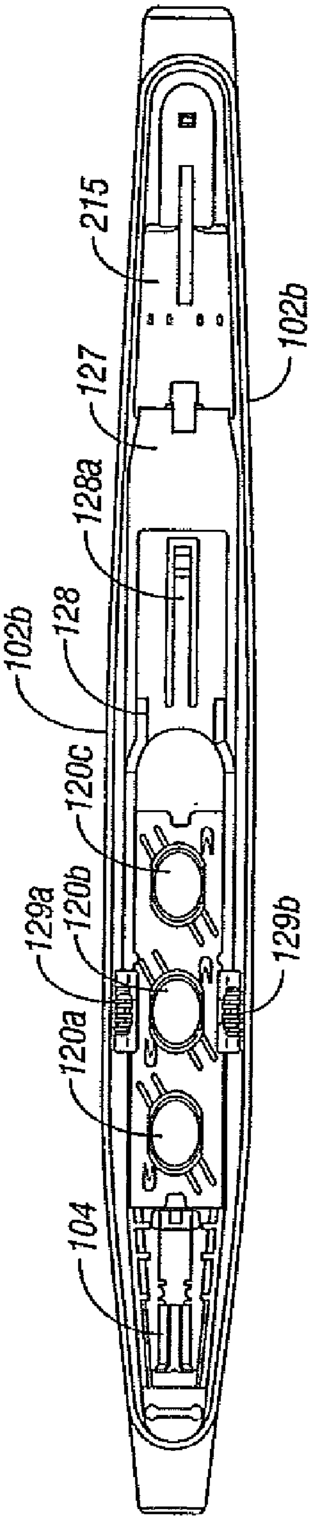

104
120a
129a
120b
120c
102b
128
128a
127
215
102b
129b

FIG. 11

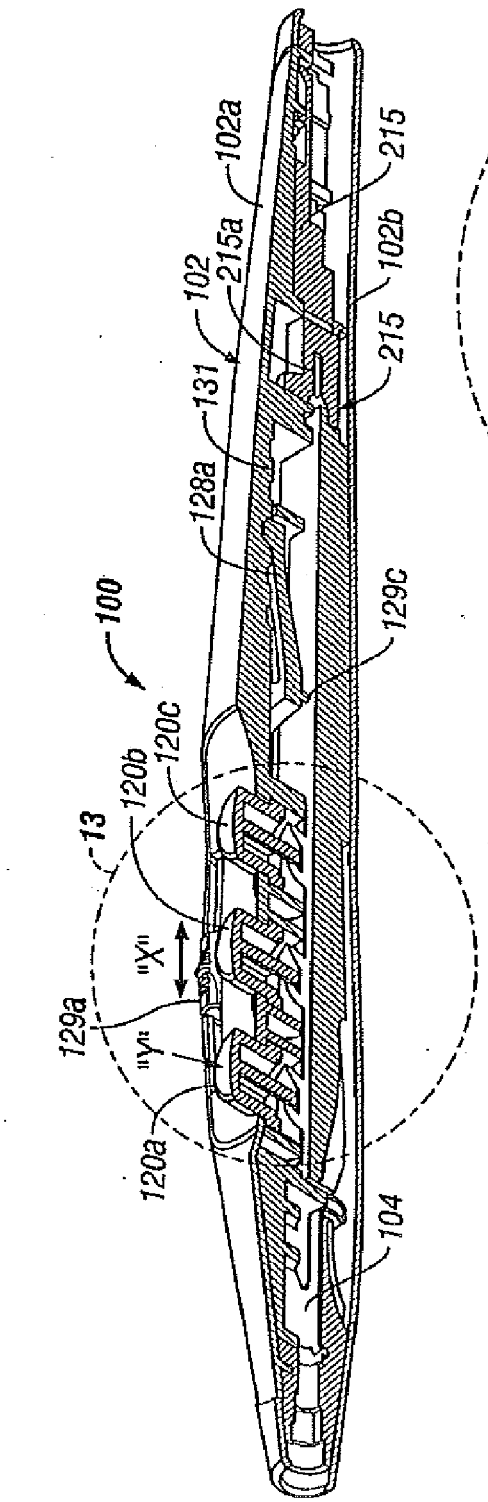

100
102
102a
102b
104
120a
120b
120c
128a
129a
129c
131
13
215
215a
215
"X"
"Y"

FIG. 12

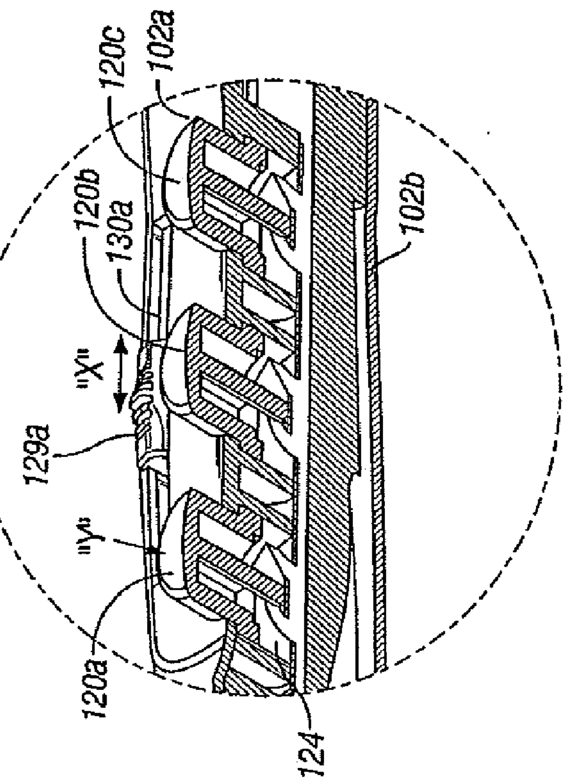

102a
102b
120a
120b
120c
124
129a
130a
"X"
"Y"

FIG. 13

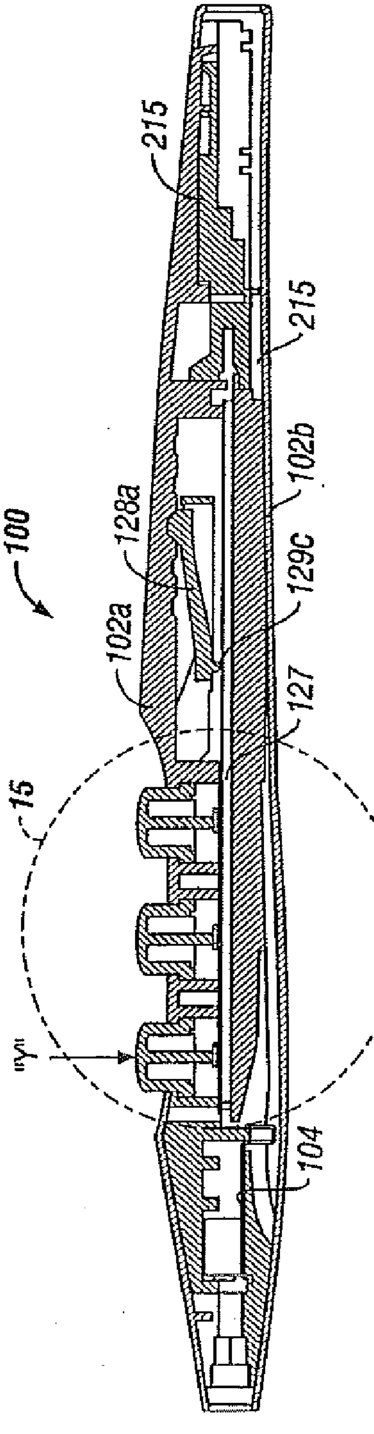

100
15
"Y"
102a
128a
129c
127
102b
215
215
104

FIG. 14

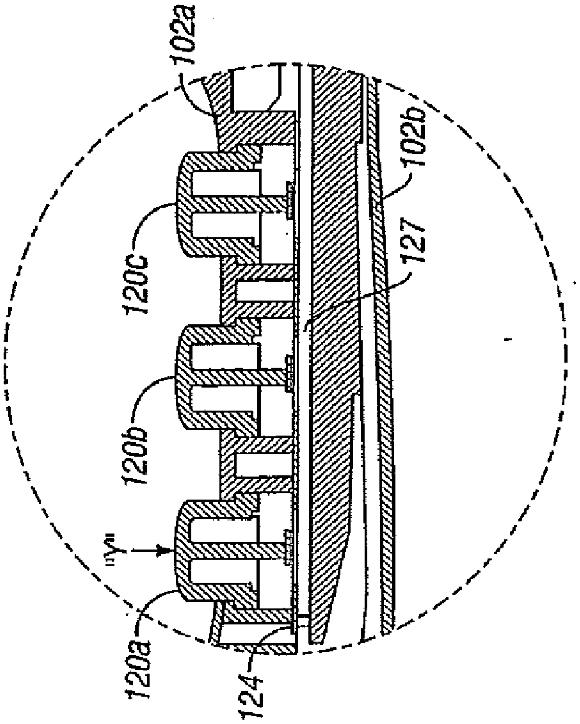

102a
120c
120b
"Y"
120a
124
127
102b

FIG. 15

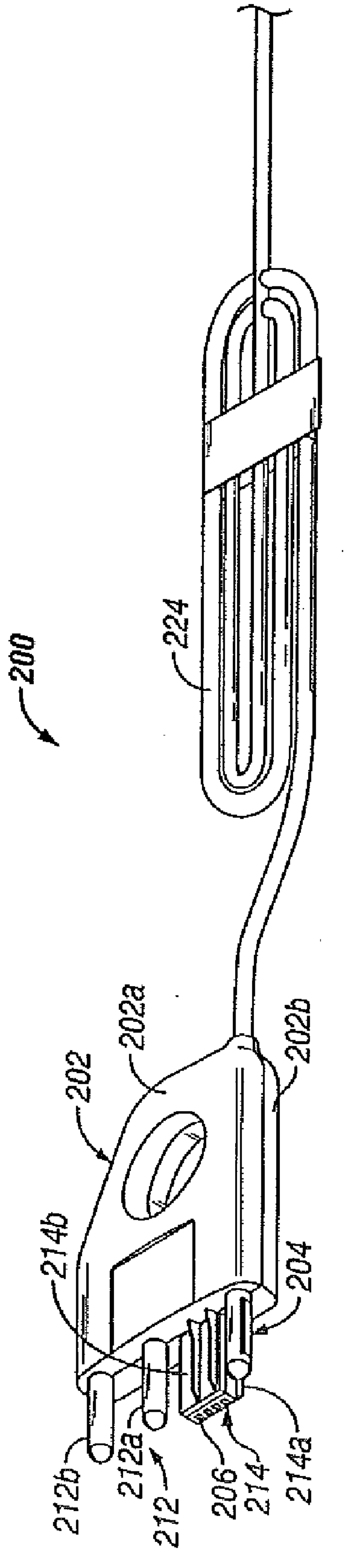


FIG. 16

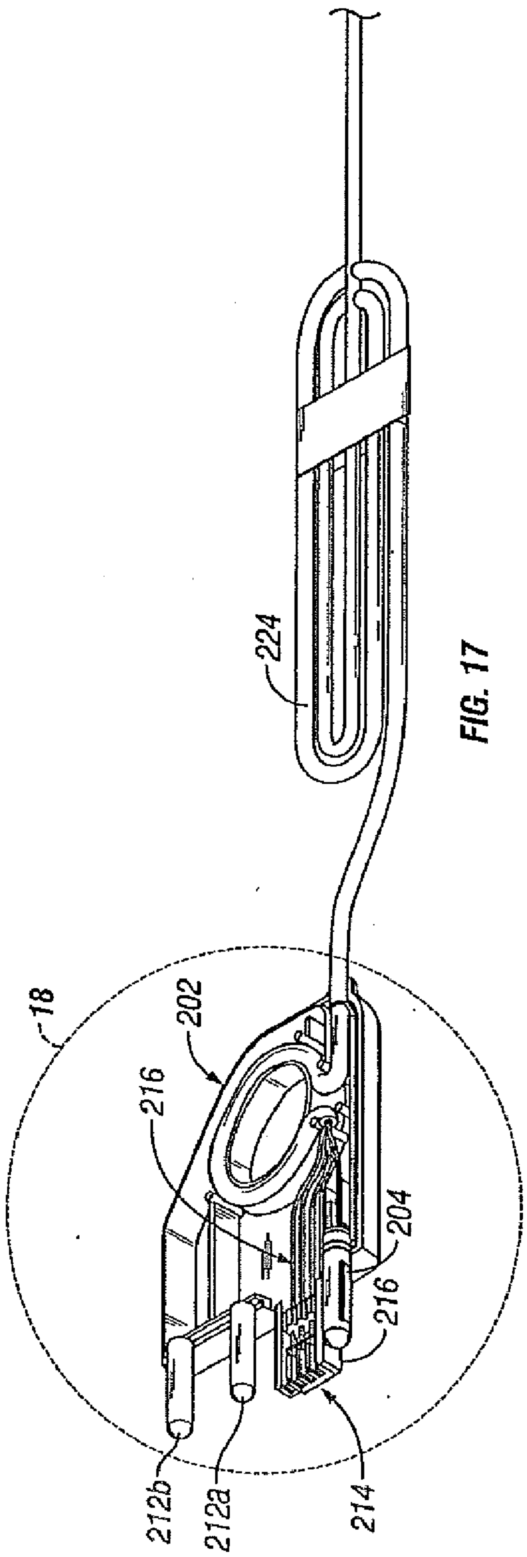

18
202
216
204
216
224
212b
212a
214

FIG. 17

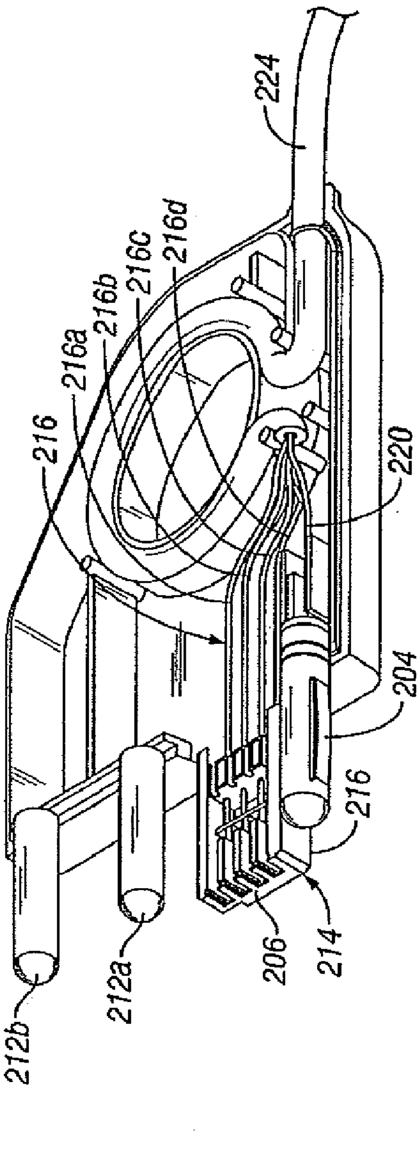

224
216d
216c
216b
216a
216
220
204
216
214
206
212a
212b

FIG. 18

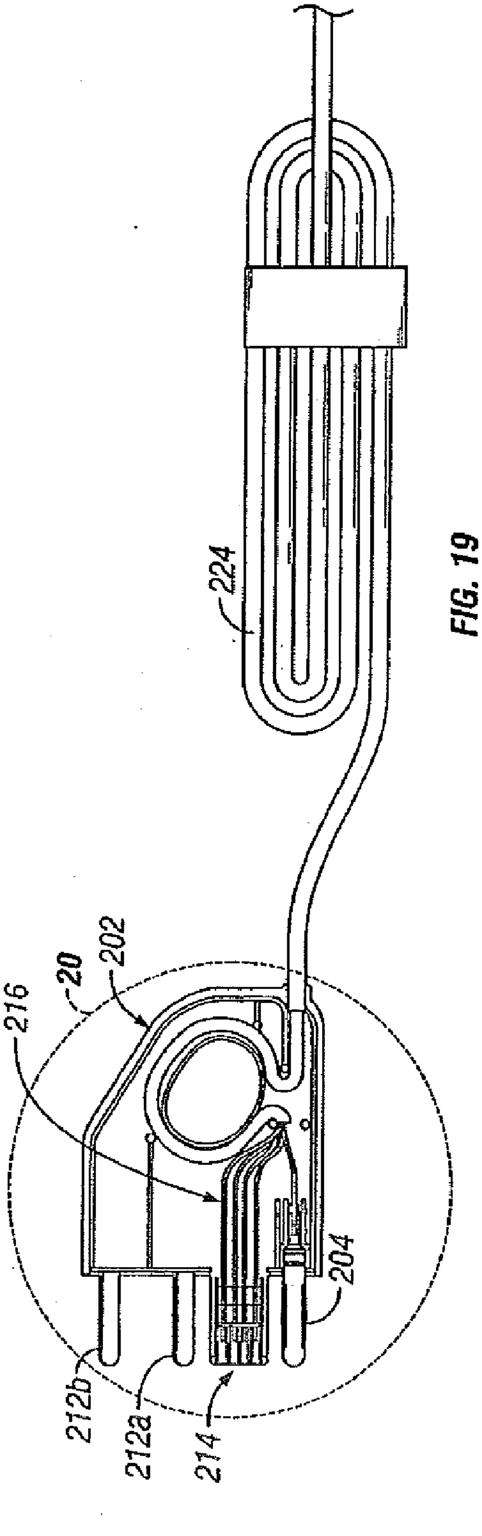

224
216
20
202
204
212b
212a
214

FIG. 19

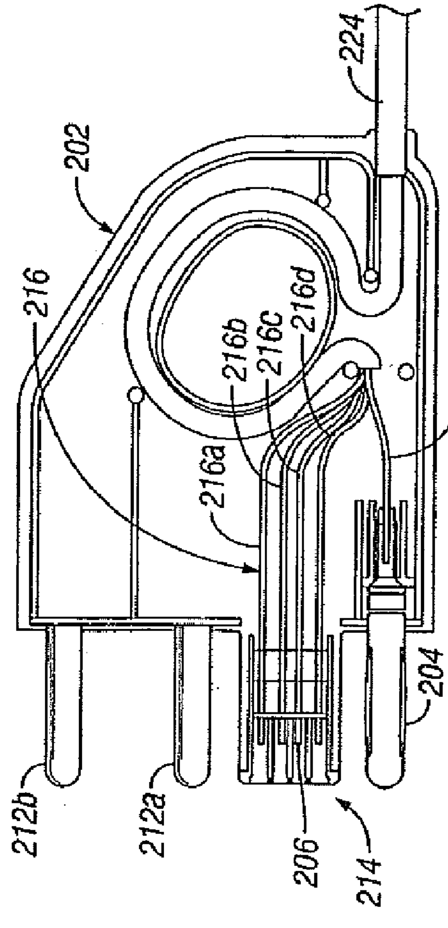

202
224
216
216b
216c
216d
216a
220
204
212b
212a
206
214

FIG. 20

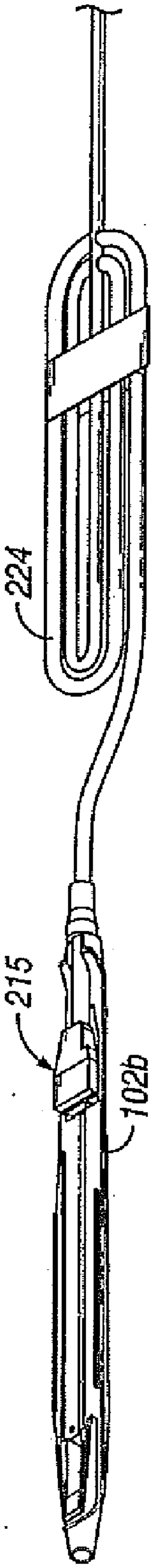


FIG. 21

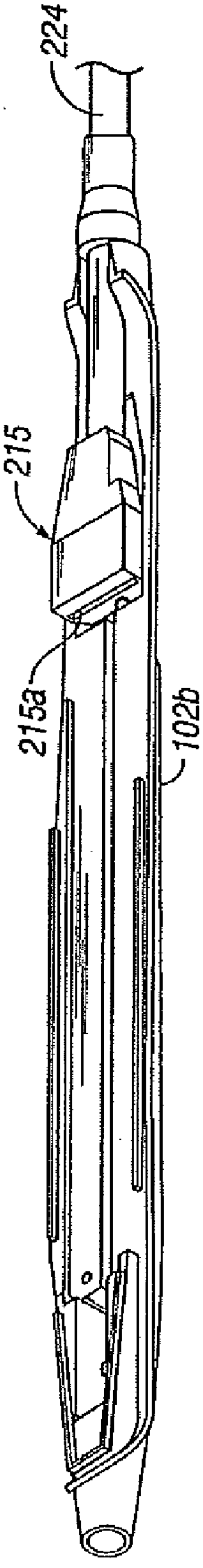


FIG. 22

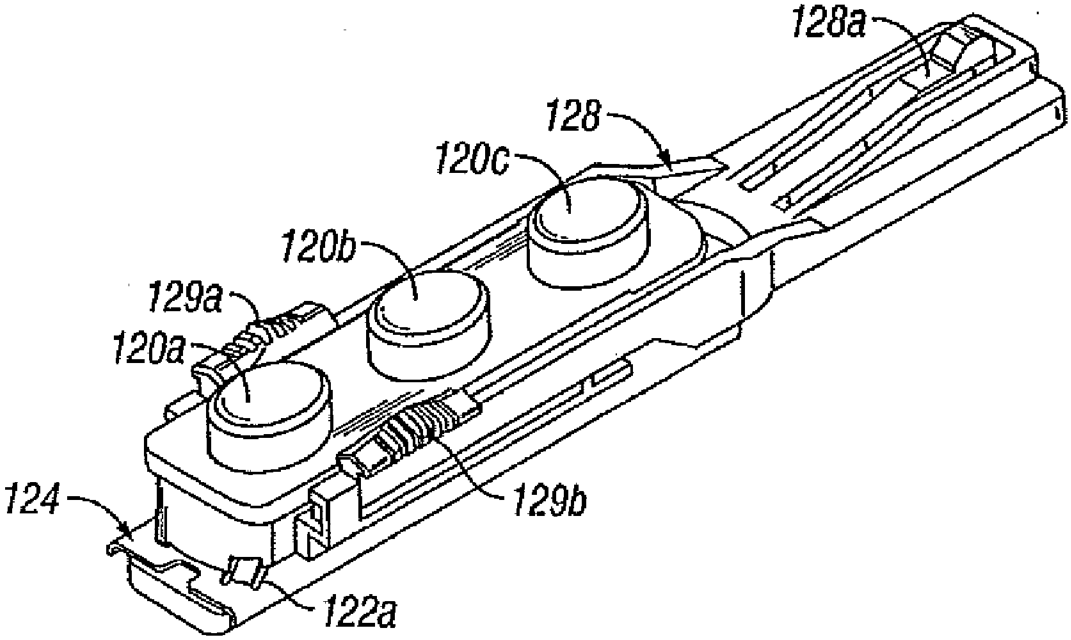


FIG. 23

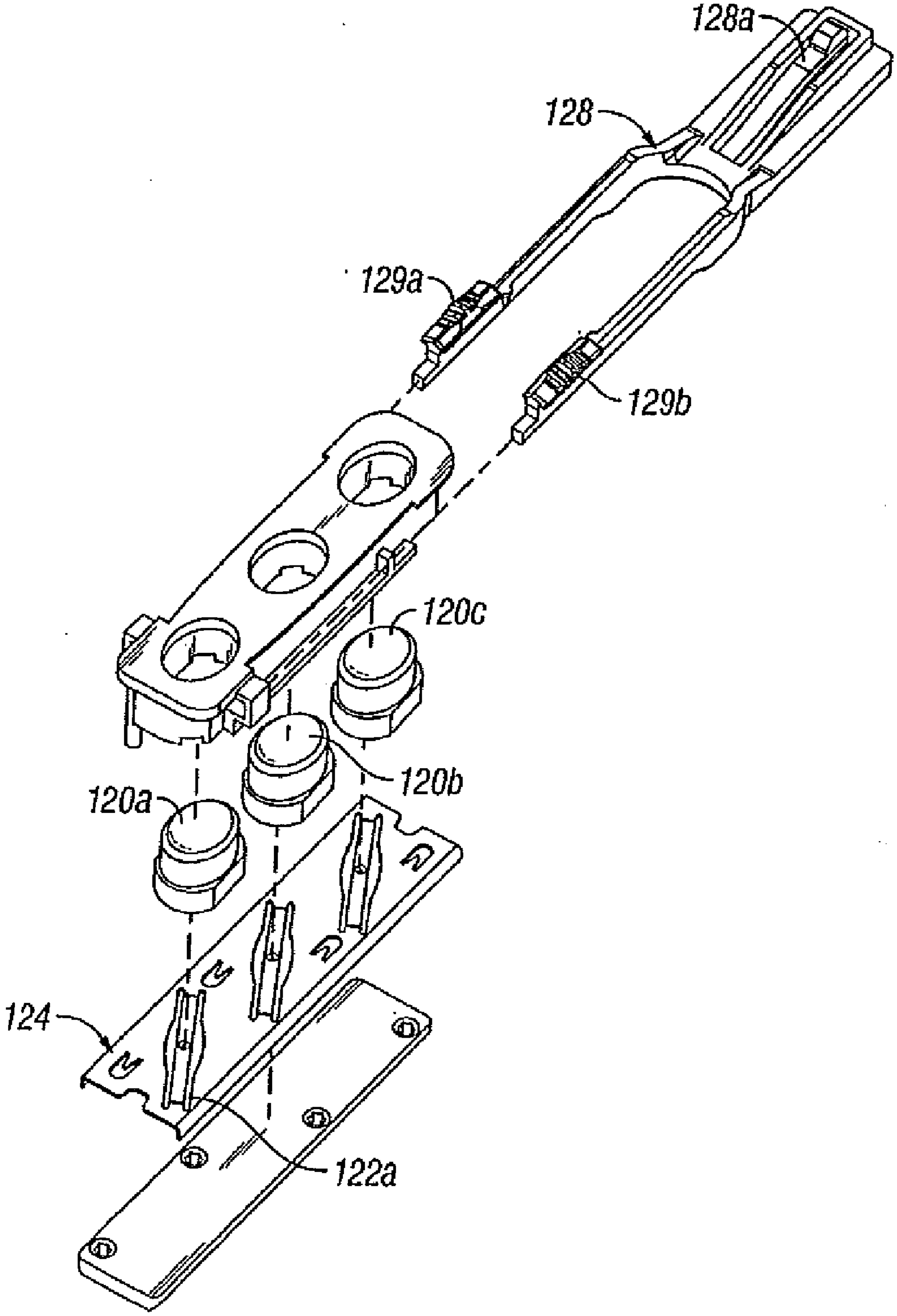


FIG. 24

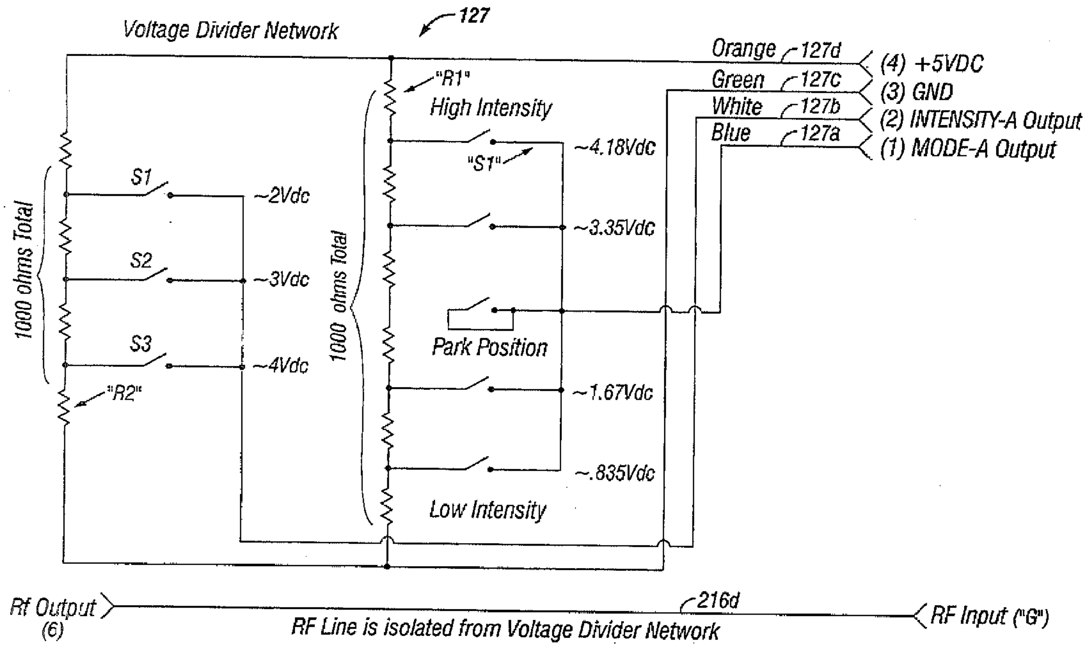

Voltage Divider Network
127
Orange
127d
(4) +5VDC
Green
127c
(3) GND
White
127b
(2) INTENSITY-A Output
Blue
127a
(1) MODE-A Output
"R1"
High Intensity
~4.18Vdc
"S1"
~3.35Vdc
Park Position
~1.67Vdc
~.835Vdc
Low Intensity
1000 ohms Total
1000 ohms Total
S1
~2Vdc
S2
~3Vdc
S3
~4Vdc
"R2"
Rf Output
(6)
216d
RF Line is isolated from Voltage Divider Network
RF Input ("G")

FIG. 25

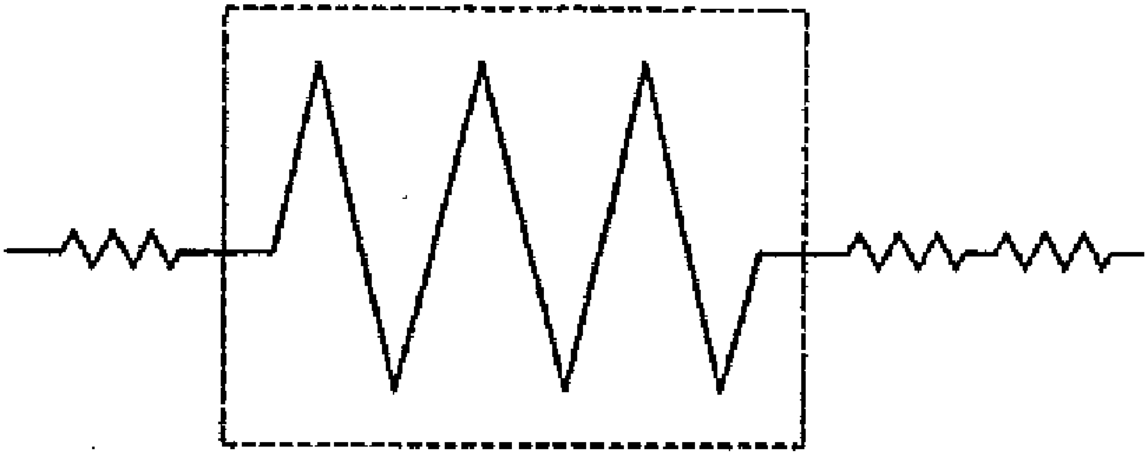


FIG. 25A

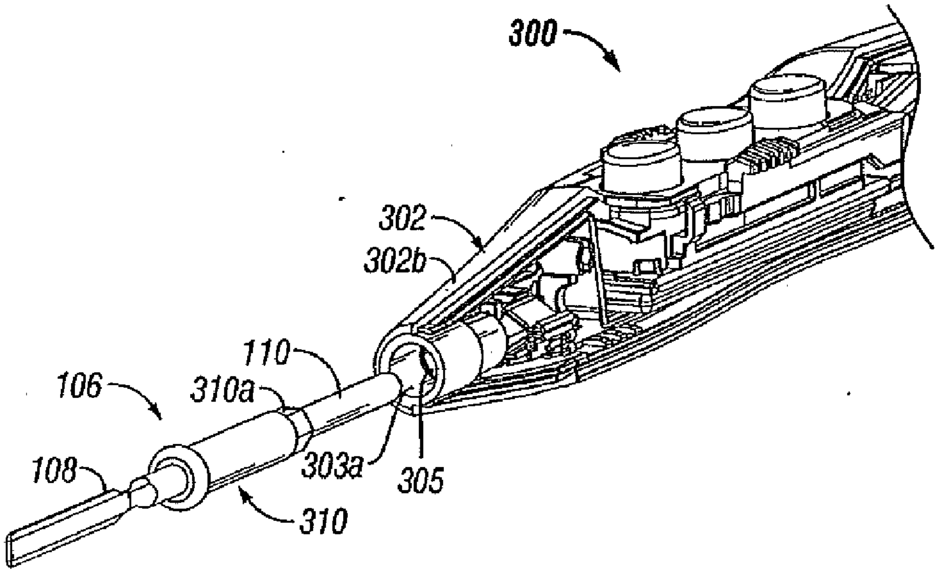

300
302
302b
110
106
310a
108
303a
305
310

FIG. 26

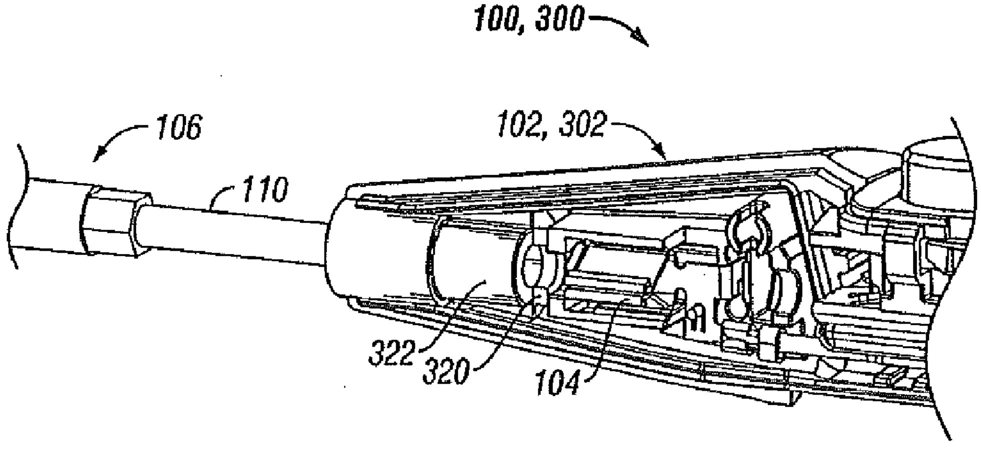

100, 300
106
102, 302
110
322
320
104

FIG. 27

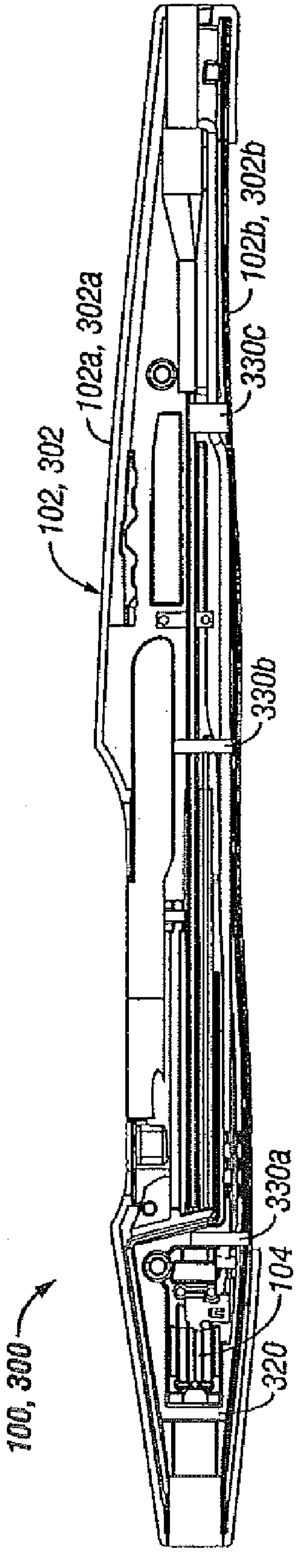


FIG. 28

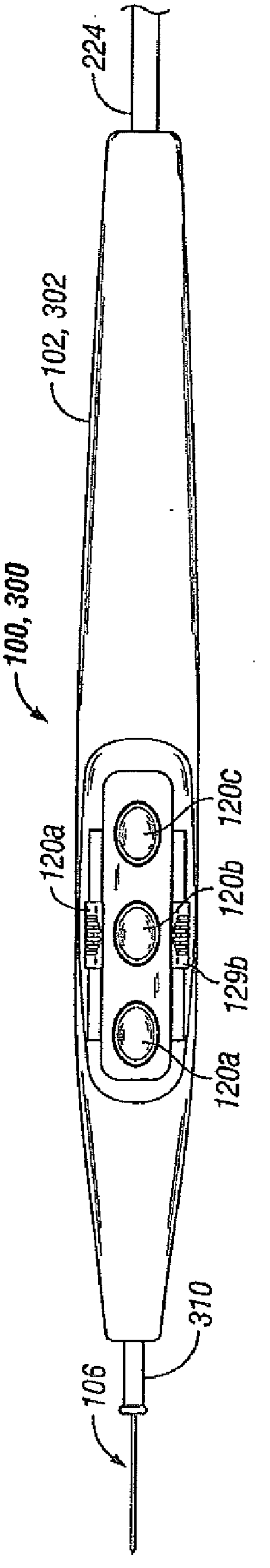

224
102, 302
100, 300
120a
120c
120b
129b
120a
310
106

FIG. 29

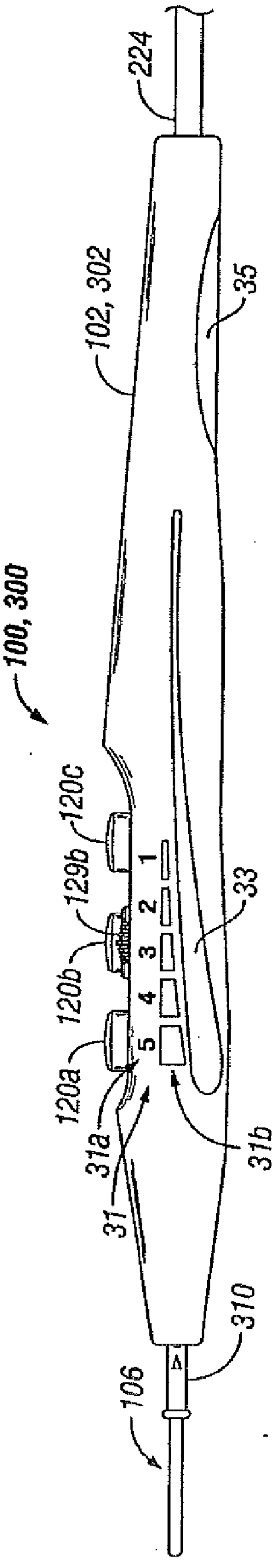

224
102, 302
35
100, 300
120c
129b
120b
120a
1
2
3
4
5
33
31a
31
31b
310
106

FIG. 30

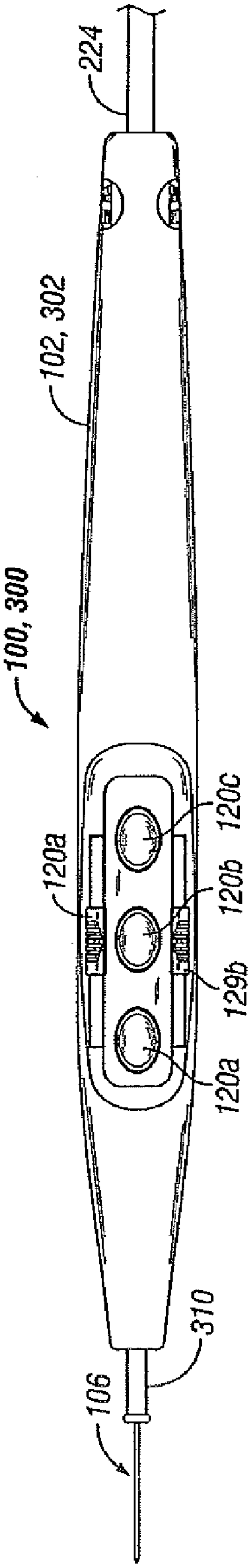

224
102, 302
100, 300
120a
120b
120c
129b
120a
310
106

FIG. 31

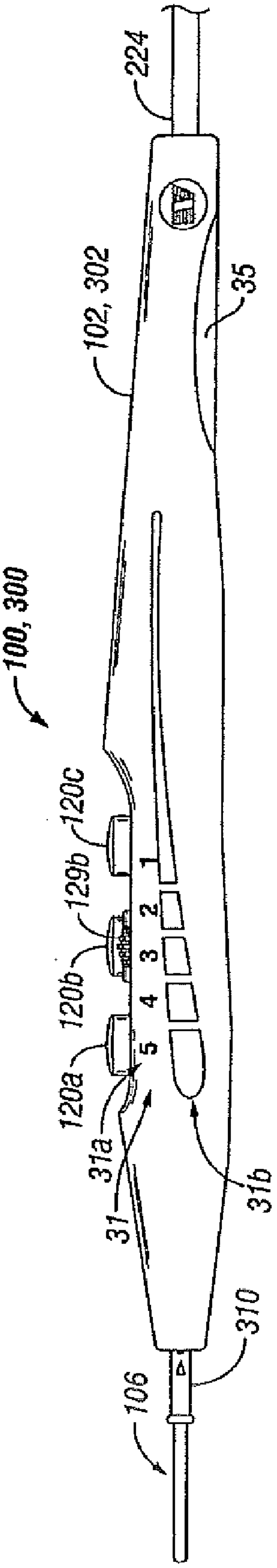

224
102, 302
35
100, 300
120c
129b
120b
120a
31a
31
31b
1
2
3
4
5
310
106

FIG. 32

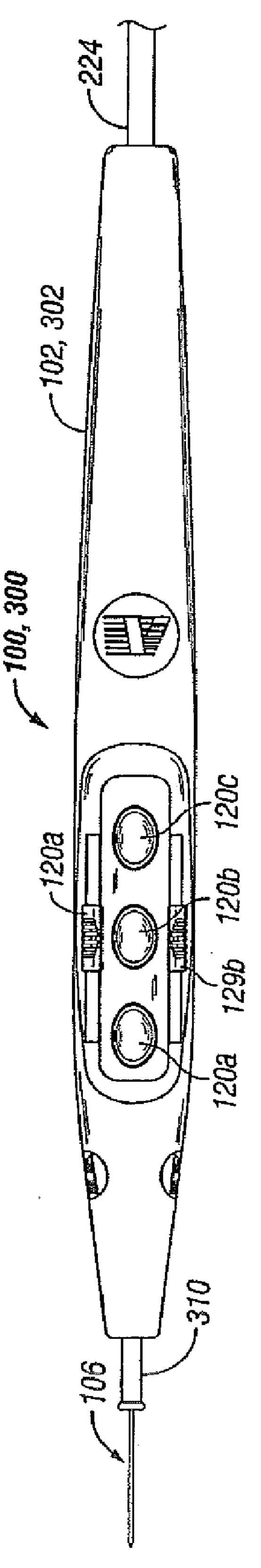

224
102, 302
100, 300
120a
120b
120c
129b
120a
310
106

FIG. 33

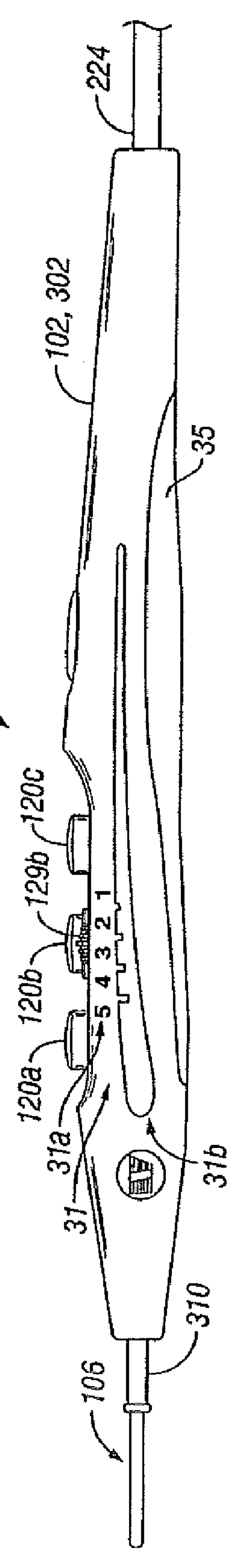

224
102, 302
35
100, 300
120c
129b
120b
120a
1
2
3
4
5
31a
31
31b
310
106

FIG. 34

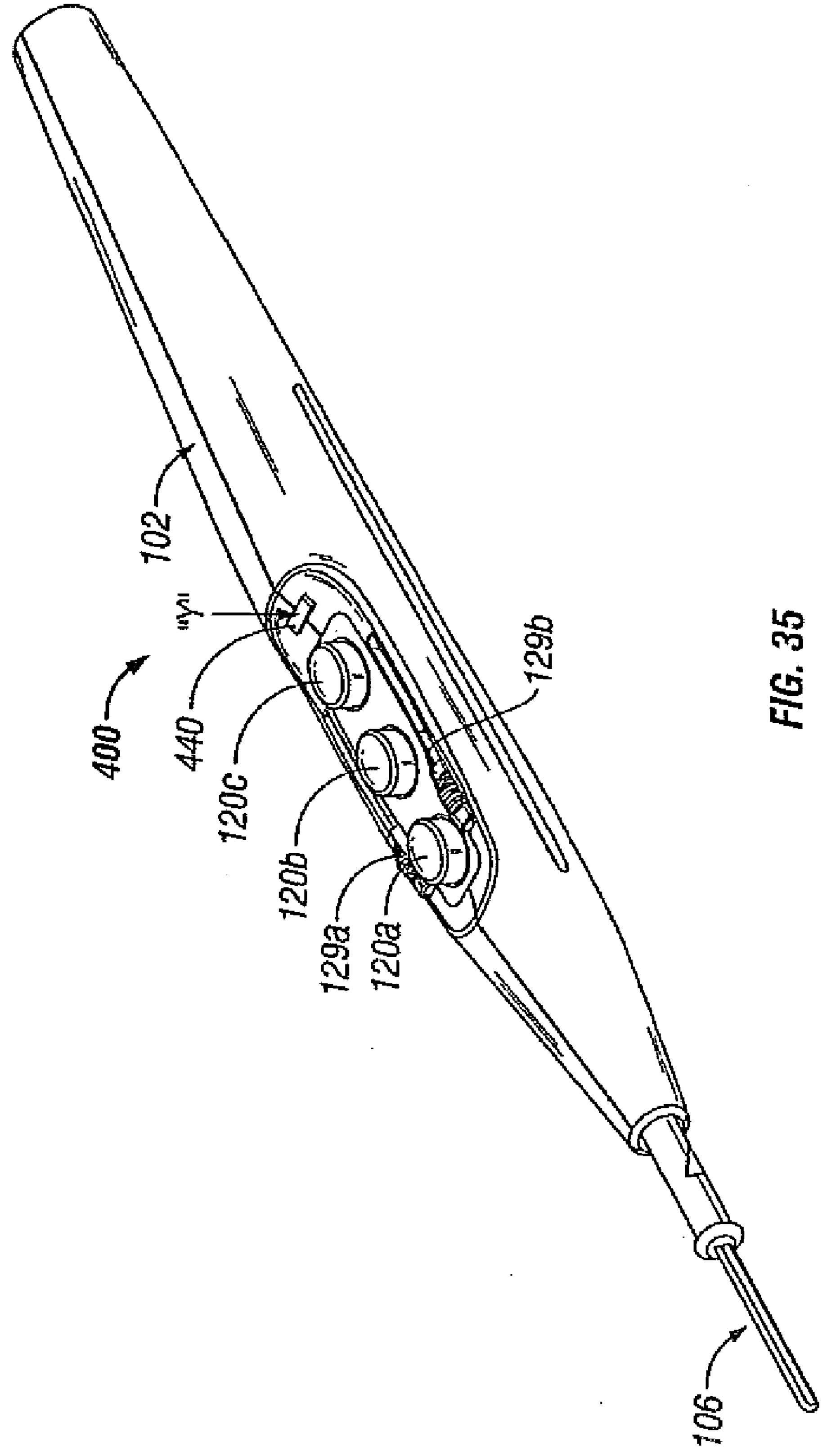


FIG. 35

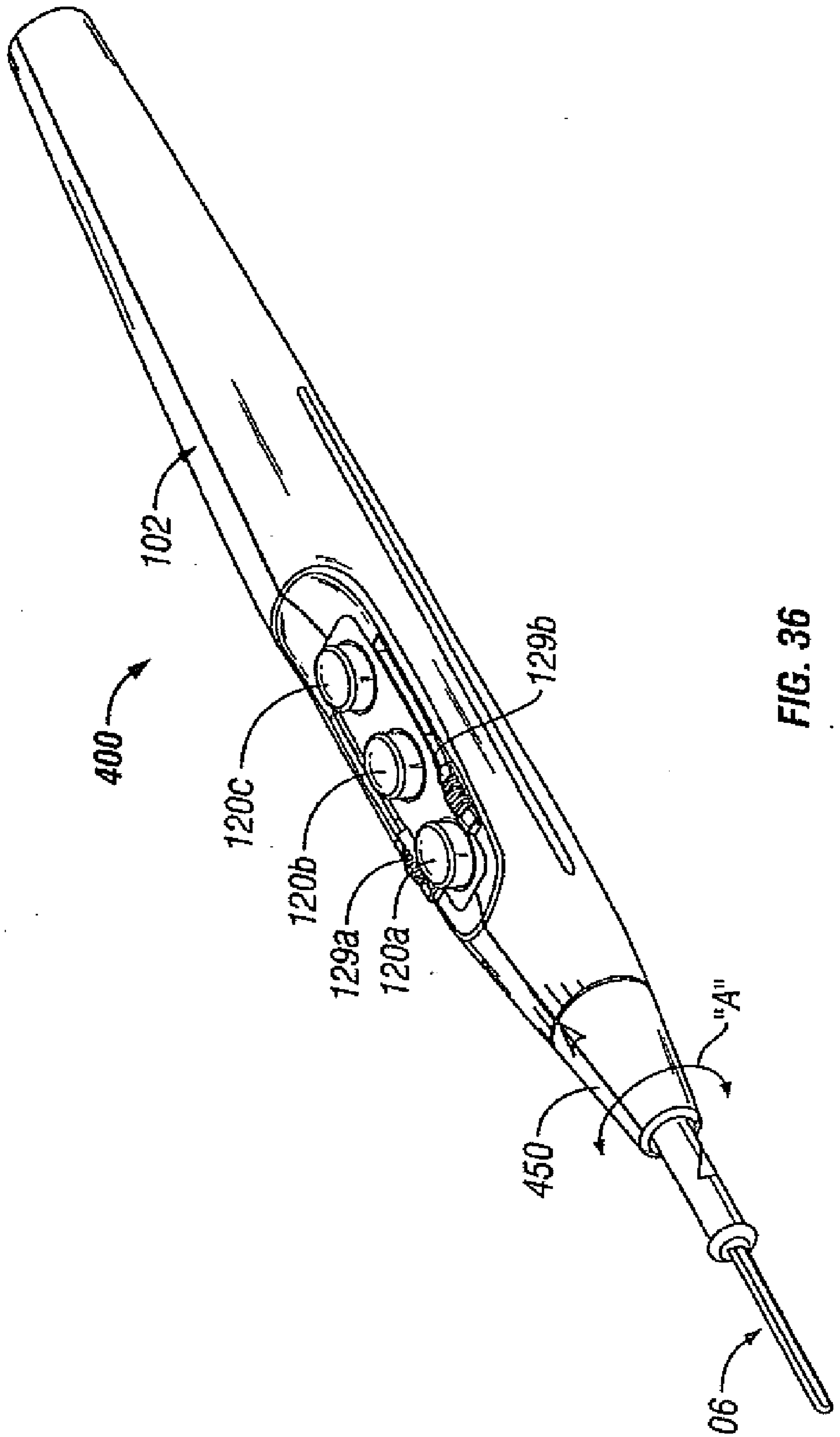


FIG. 36

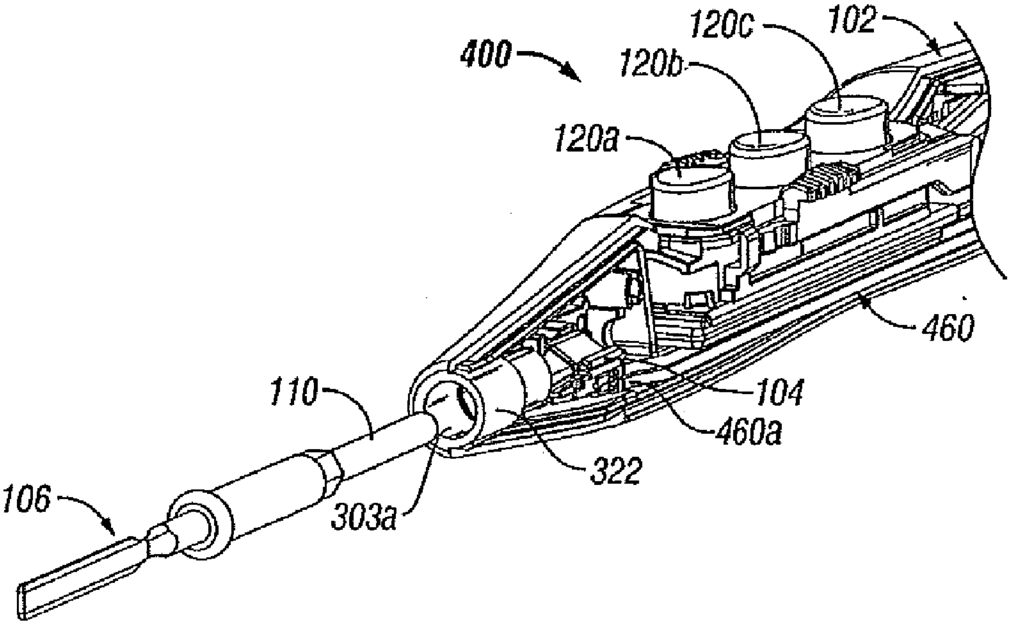


FIG. 37

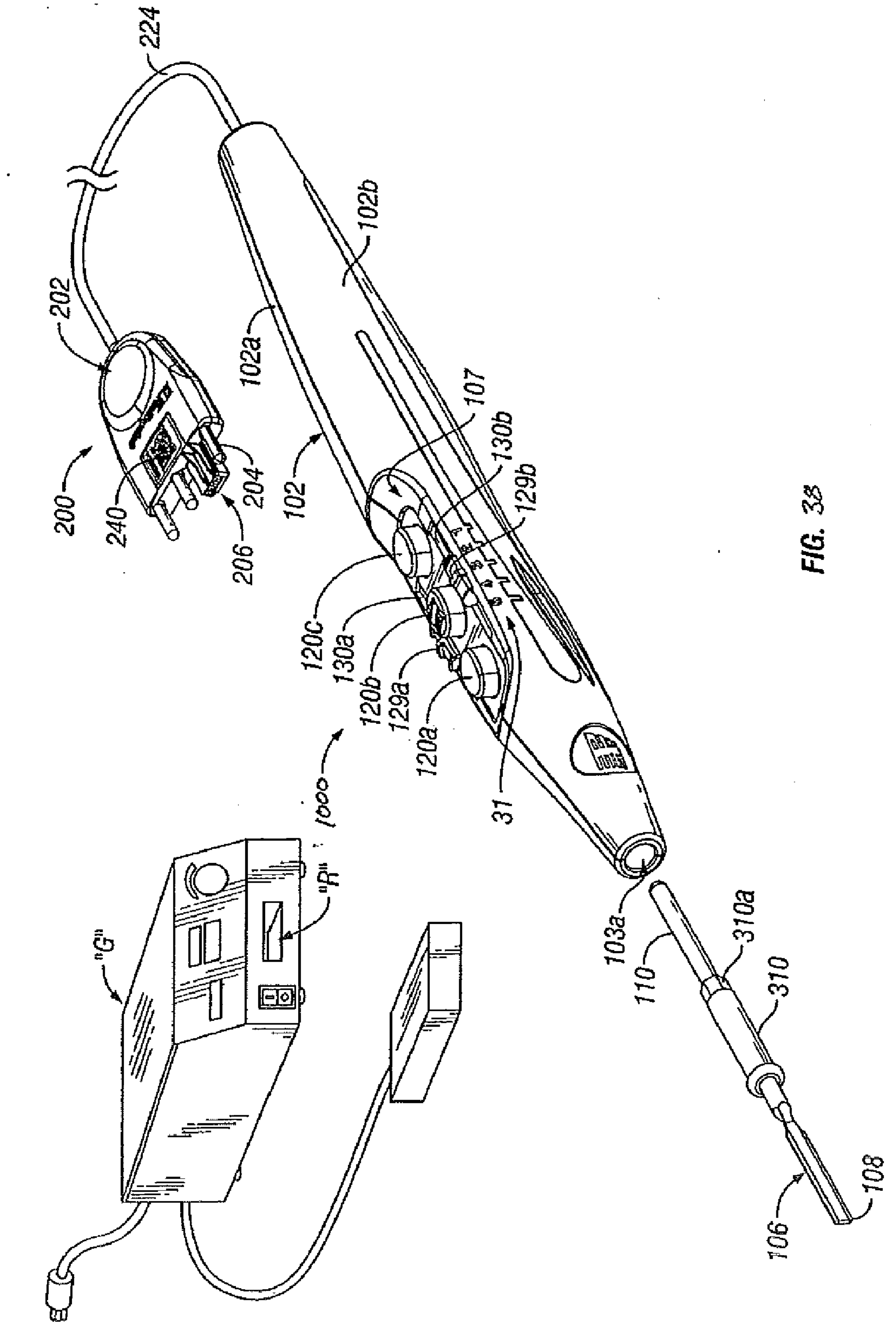

224
202
200
240
206
204
102a
102b
102
107
130b
129b
120c
130a
120b
129a
120a
31
1000
"R"
"G"
103a
110
310a
310
106
108

FIG. 3B

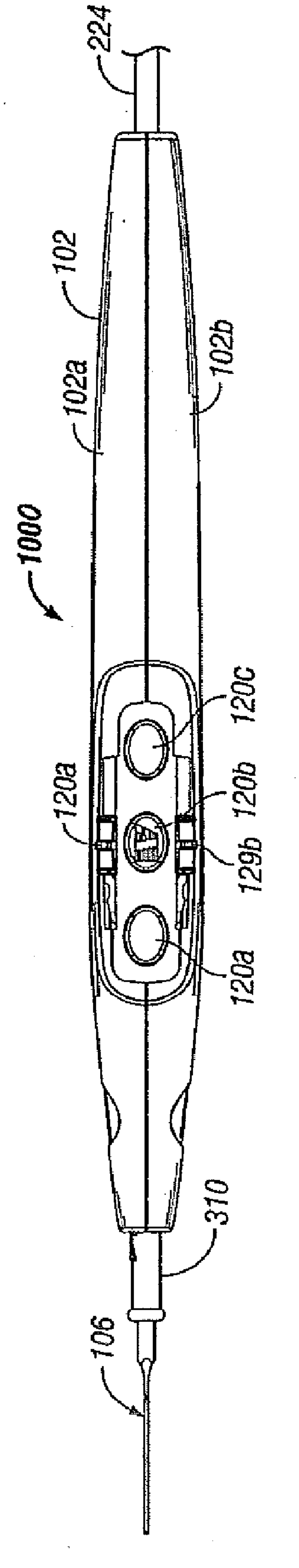

224
102
102a
102b
1000
120a
120c
129b
120b
120a
310
106

FIG. 39

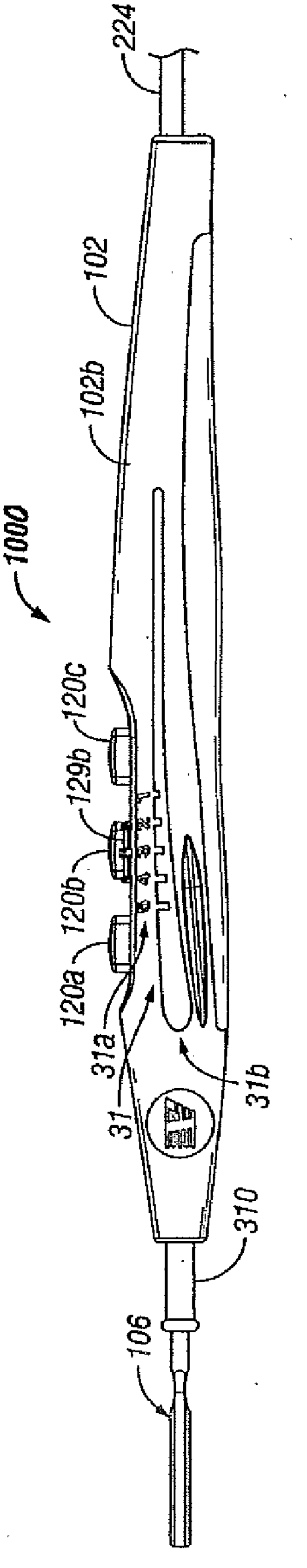
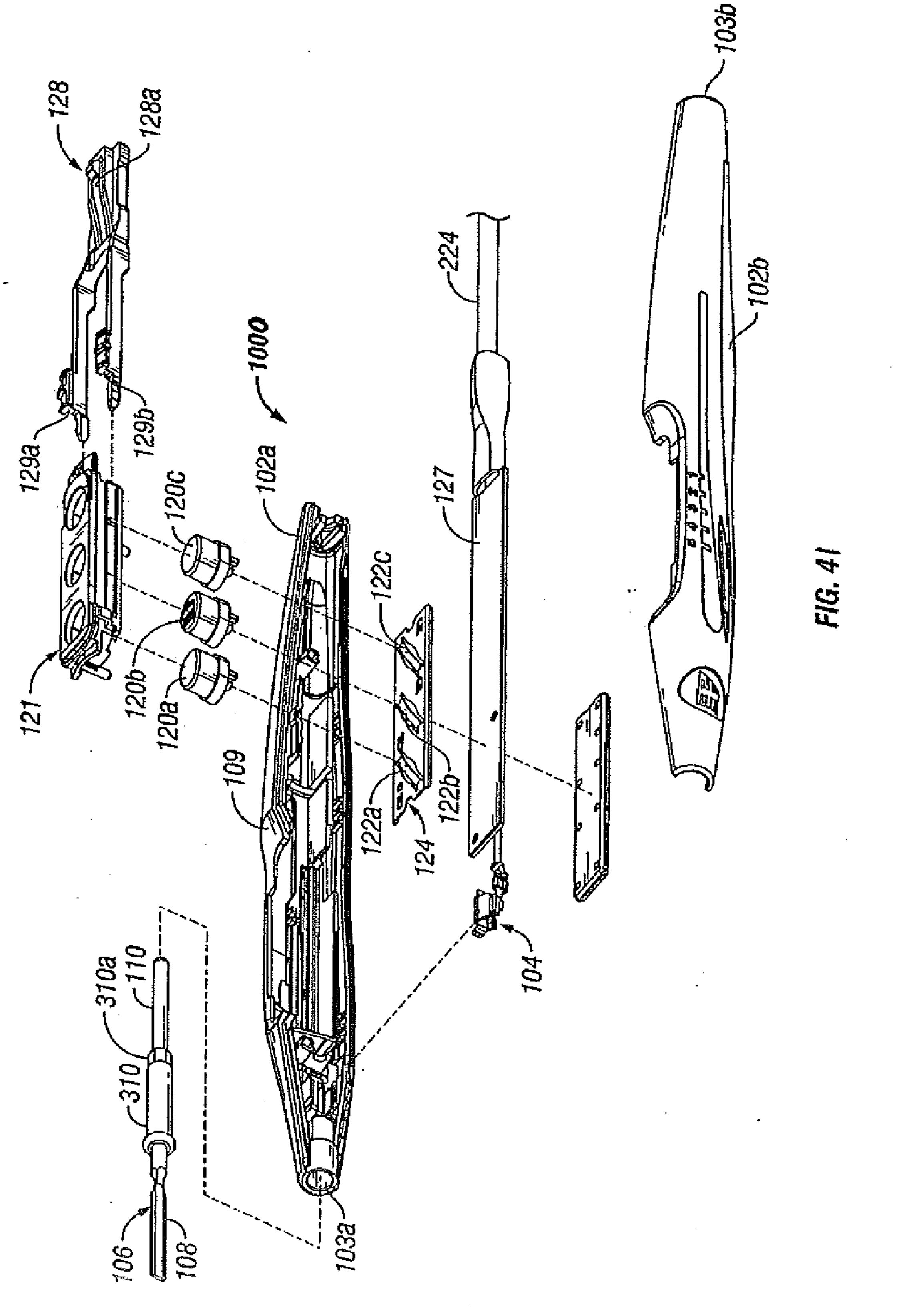

224
102
102b
1000
120c
129b
120b
120a
31a
31
31b
310
106

FIG. 40



128
128a
129a
129b
121
120a
120b
120c
1000
102a
109
122a
122b
122c
124
224
127
104
103b
102b
310a
110
310
106
108
103a

FIG. 4I

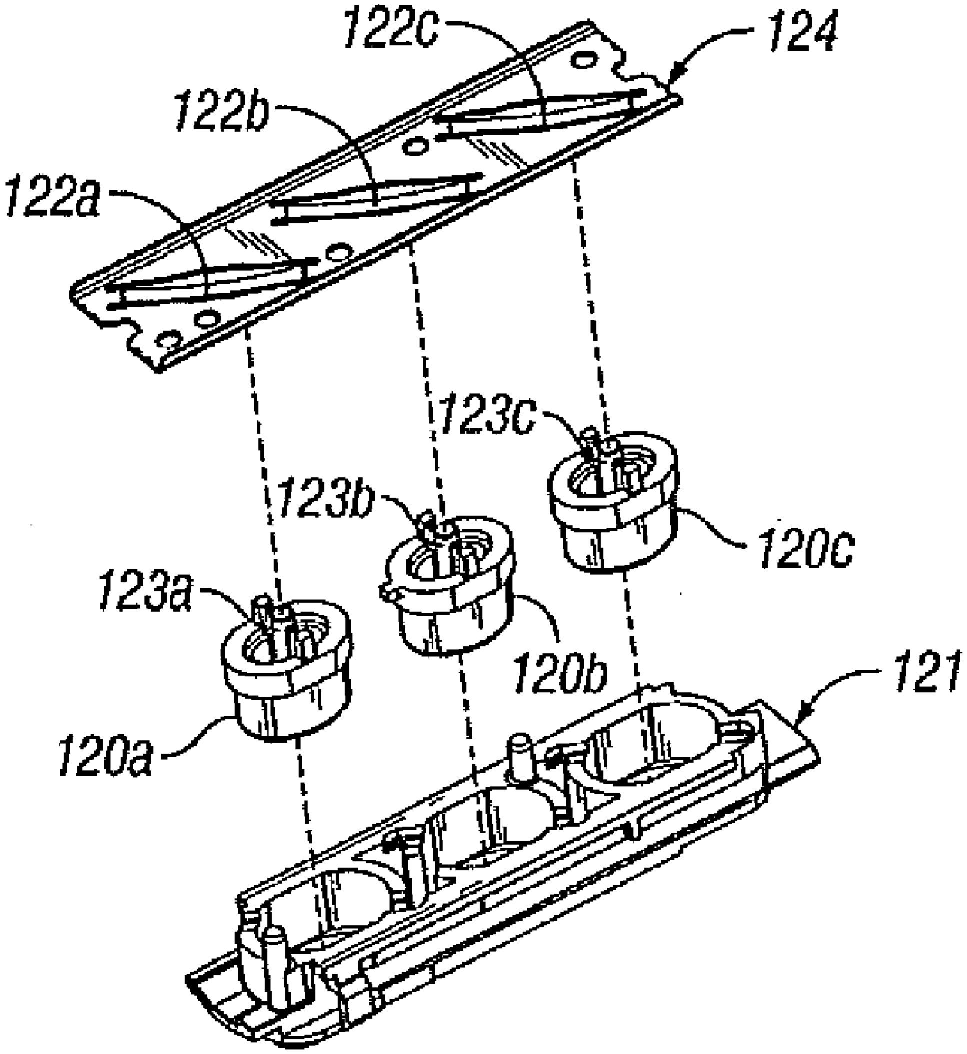


FIG. 42

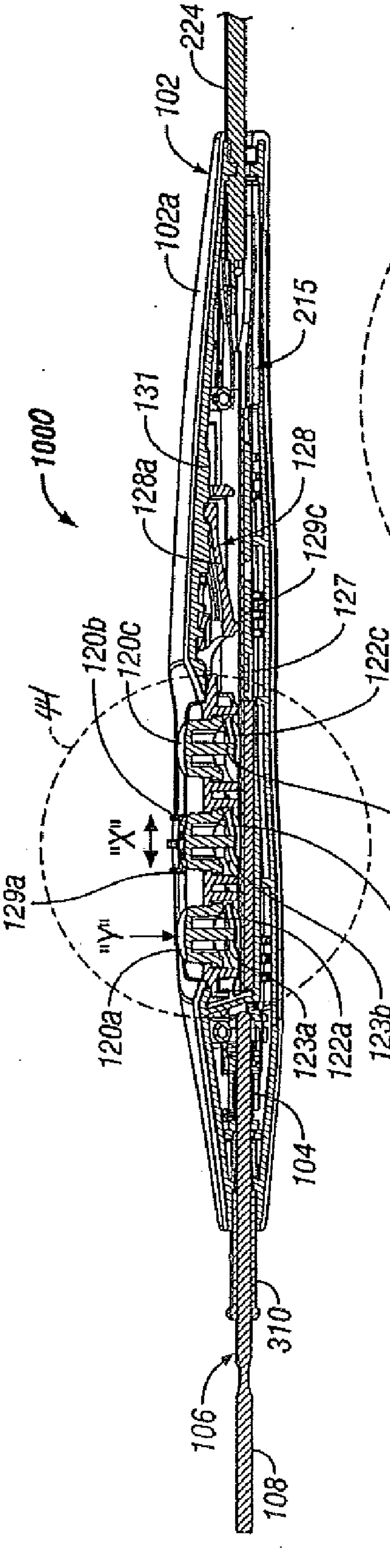

1000
224
102
102a
215
131
128a
128
129c
127
120b
120c
122c
44
"X"
129a
"Y"
120a
123c
123a
122a
123b
122b
104
310
106
108

FIG. 43

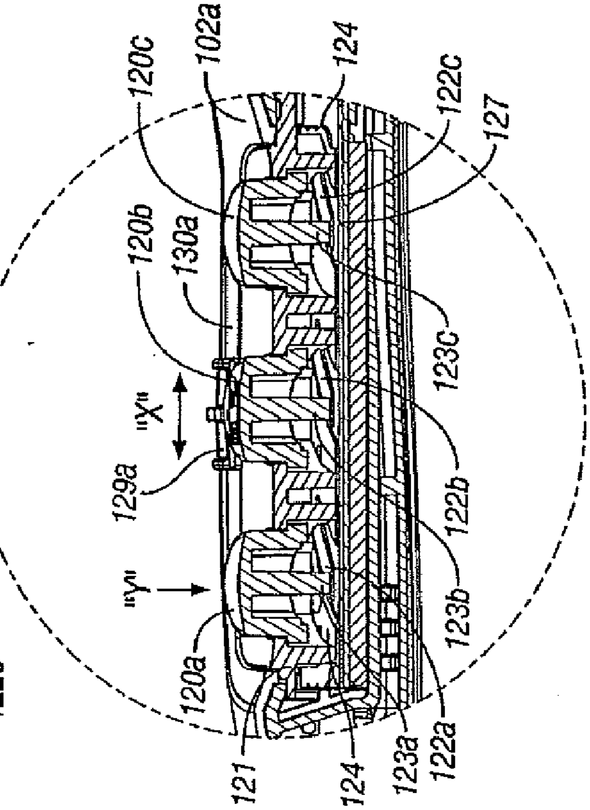

120c
102a
124
122c
127
120b
130a
123c
"X"
129a
122b
"Y"
123b
120a
121
124
123a
122a

FIG. 44

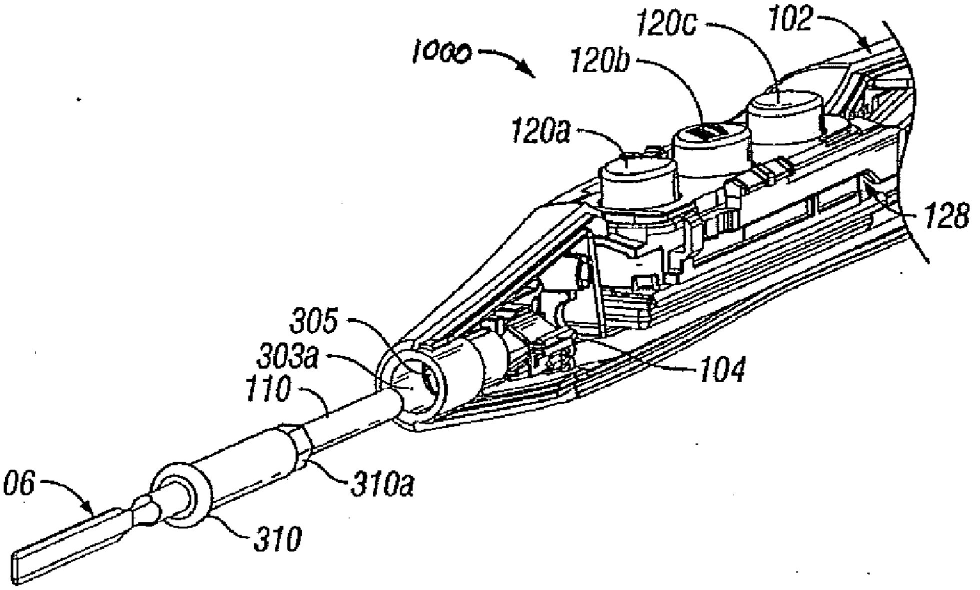

1000
120c
102
120b
120a
128
305
303a
110
104
106
310a
310

FIG. 45

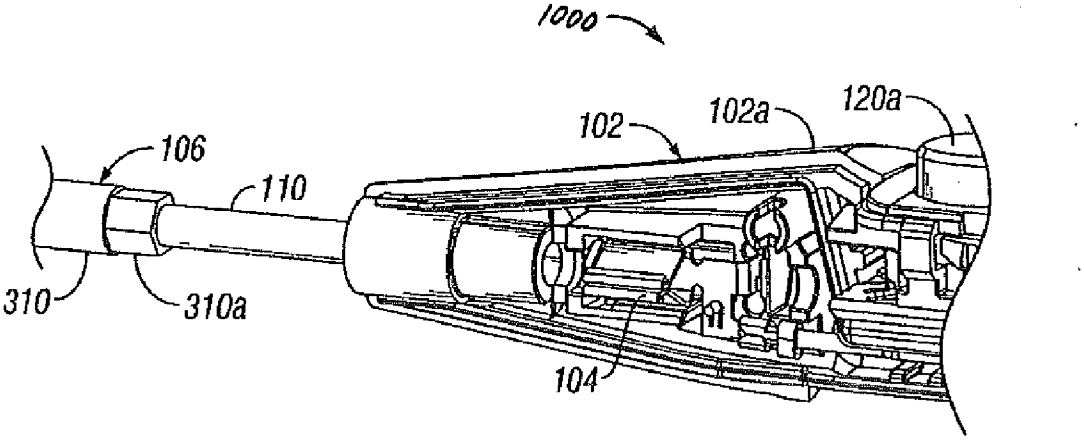

1000
102
102a
120a
106
110
310
310a
104

FIG. 46

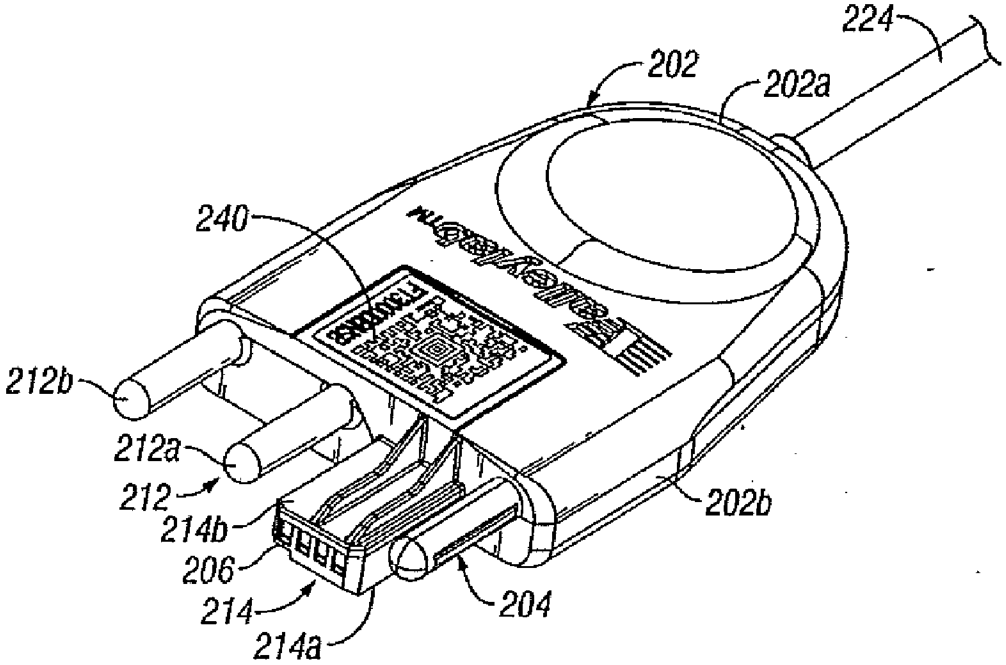

224
202
202a
240
212b
212a
212
214b
206
214
214a
204
202b

FIG. 47

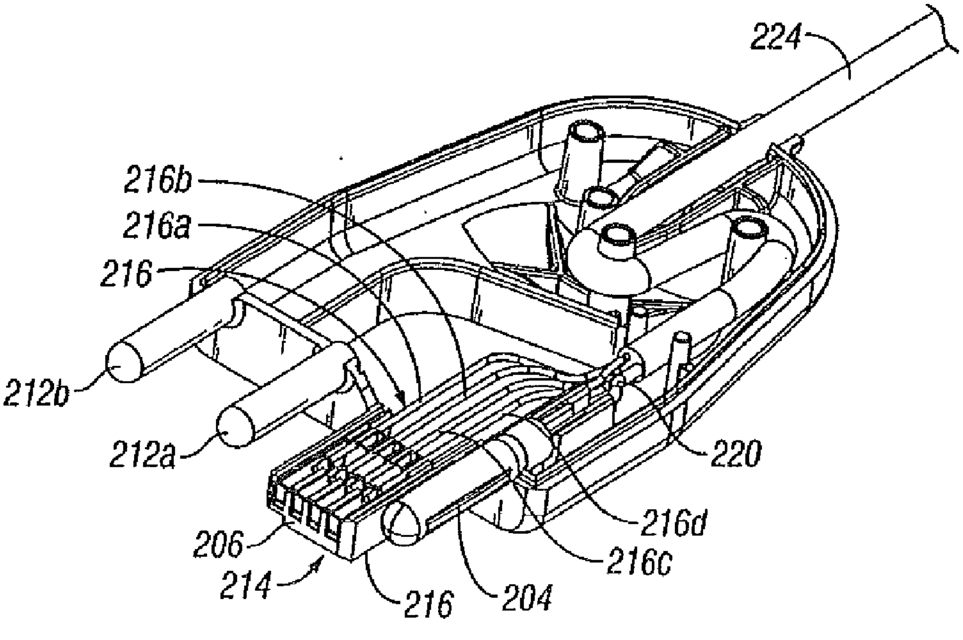

224
216b
216a
216
212b
212a
220
216d
216c
206
214
216
204

FIG. 48

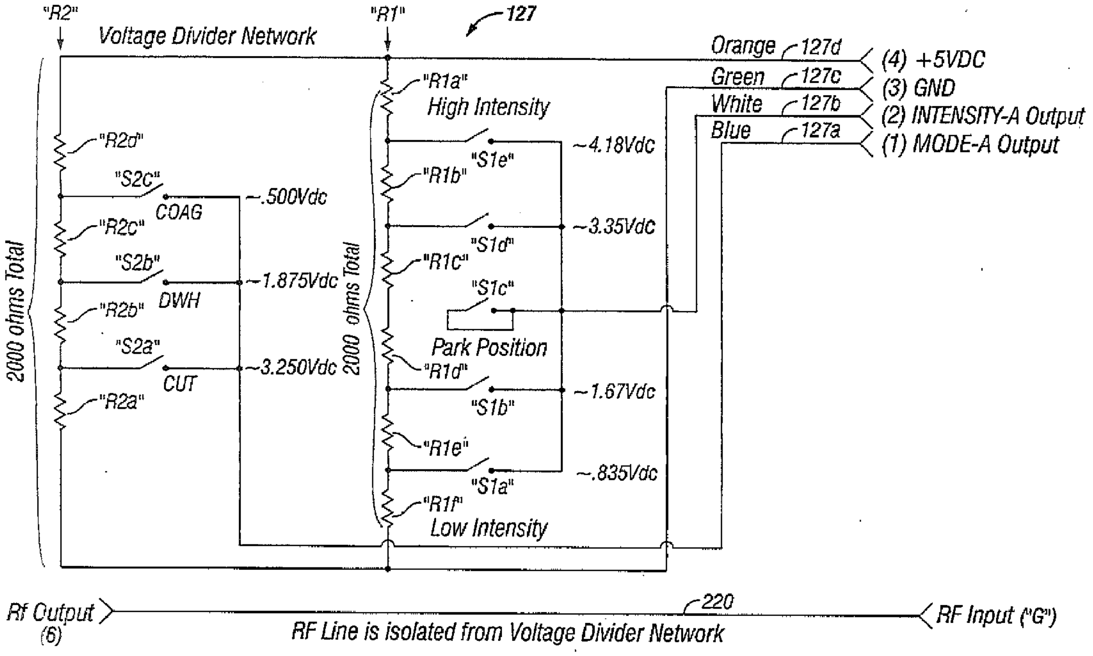

"R2"
Voltage Divider Network
"R1"
127
Orange
127d
(4) +5VDC
Green
127c
(3) GND
White
127b
(2) INTENSITY-A Output
Blue
127a
(1) MODE-A Output
"R1a"
High Intensity
"R2d"
~4.18Vdc
"S1e"
"S2c"
"R1b"
~.500Vdc
COAG
~3.35Vdc
"R2c"
"S1d"
"S2b"
"R1c"
2000 ohms Total
~1.875Vdc
DWH
"S1c"
"R2b"
Park Position
"S2a"
~3.250Vdc
2000 ohms Total
"R1d"
CUT
~1.67Vdc
"R2a"
"S1b"
"R1e"
~.835Vdc
"S1a"
"R1f"
Low Intensity
Rf Output
(6)
220
RF Line is isolated from Voltage Divider Network
RF Input ("G")

FIG. 47

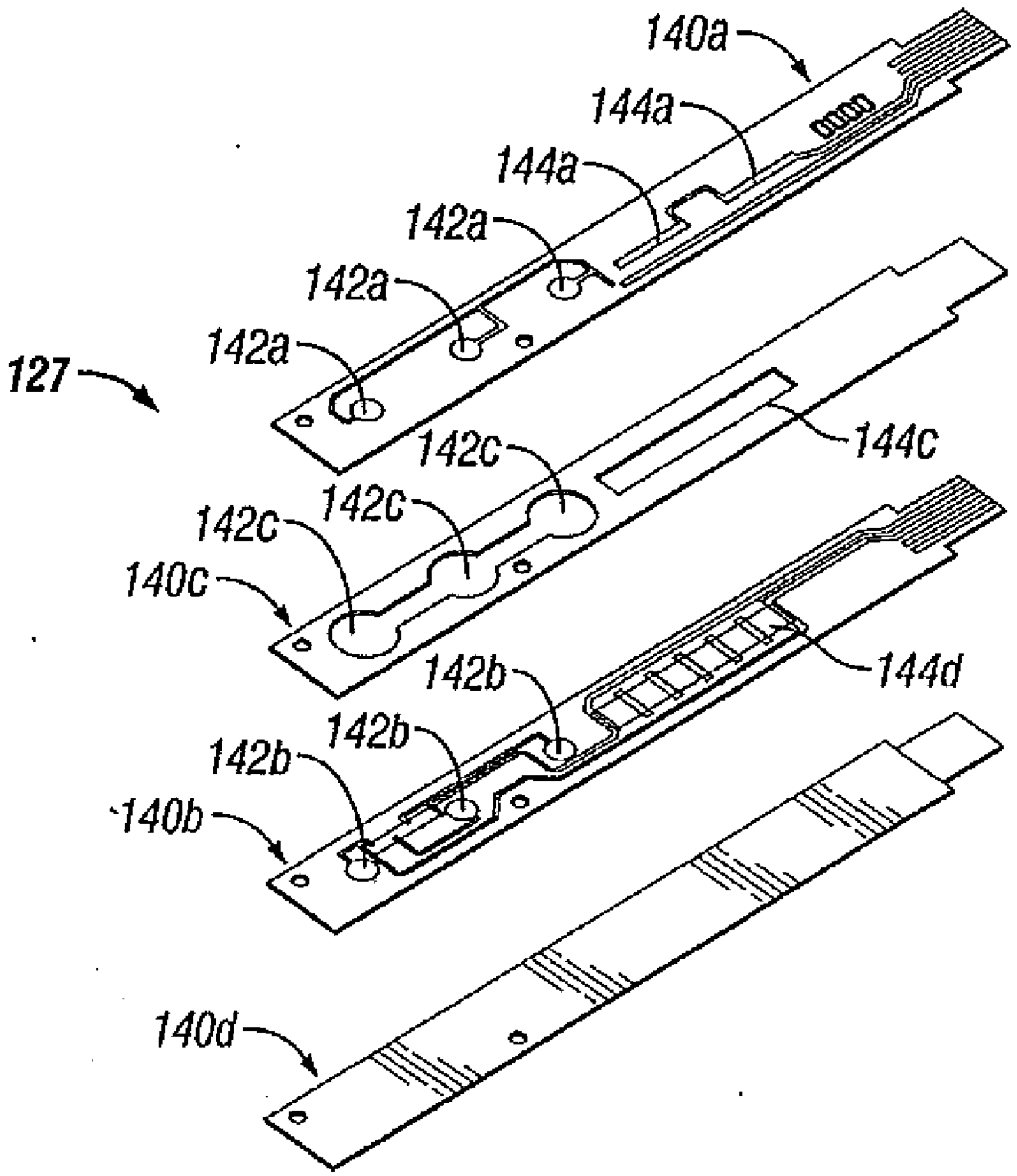

140a
144a
144a
142a
142a
142a
127
144c
142c
142c
142c
140c
144d
142b
142b
142b
140b
140d

FIG. 50

ELECTROSURGICAL PENCIL WITH ADVANCED ES CONTROLS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a Divisional Application claiming the benefit of and priority to U.S. patent application Ser. No. 11/337,990, filed on Jan. 24, 2006, now U.S. Patent Publication No. 2006/0178667, which is a Continuation-in-Part Application of U.S. patent application Ser. No. 11/198,473, filed on Aug. 5, 2005, now U.S. Pat. No. 7,503,917, which is a Continuation-in-Part Application of U.S. patent application Ser. No. 10/959,824, filed Oct. 6, 2004, now U.S. Pat. No. 7,156,842, which is a Continuation-in-Part Application of International Application No. PCT/US03/37111, filed on Nov. 20, 2003, the entire contents of each of which being incorporated herein by reference.

BACKGROUND

[0002] 1. Technical Field

[0003] The present disclosure relates generally to electrosurgical instruments and, more particularly, to an electrosurgical pencil having a plurality of hand-accessible variable controls.

[0004] 2. Background of Related Art

[0005] Electrosurgical instruments have become widely used by surgeons in recent years. Accordingly, a need has developed for equipment and instruments which are easy to handle, are reliable and are safe in an operating environment. By and large, most electrosurgical instruments are hand-held instruments, e.g., an electrosurgical pencil, which transfer radio-frequency (RF) electrical or electrosurgical energy to a tissue site. The electrosurgical energy is returned to the electrosurgical source via a return electrode pad positioned under a patient (i.e., a monopolar system configuration) or a smaller return electrode positionable in bodily contact with or immediately adjacent to the surgical site (i.e., a bipolar system configuration). The waveforms produced by the RF source yield a predetermined electrosurgical effect known generally as electrosurgical cutting and fulguration.

[0006] In particular, electrosurgical fulguration includes the application of electric spark to biological tissue, for example, human flesh or the tissue of internal organs, without significant cutting. The spark is produced by bursts of radio-frequency electrical or electrosurgical energy generated from an appropriate electrosurgical generator. Coagulation is defined as a process of desiccating tissue wherein the tissue cells are ruptured and dehydrated/dried. Electrosurgical cutting/dissecting, on the other hand, includes applying an electrical spark to tissue in order to produce a cutting, dissecting and/or dividing effect. Blending includes the function of cutting/dissecting combined with the production of a hemostasis effect. Meanwhile, sealing/hemostasis is defined as the process of liquefying the collagen in the tissue so that it forms into a fused mass.

[0007] As used herein the term "electrosurgical pencil" is intended to include instruments which have a handpiece which is attached to an active electrode and which is used to cauterize, coagulate and/or cut tissue. Typically, the electrosurgical pencil may be operated by a handswitch or a foot switch. The active electrode is an electrically conducting element which is usually elongated and may be in the form of a thin flat blade with a pointed or rounded distal end. Alternatively, the active electrode may include an elongated narrow cylindrical needle which is solid or hollow with a flat, rounded, pointed or slanted distal end. Typically electrodes of this sort are known in the art as "blade", "loop" or "snare", "needle" or "ball" electrodes.

[0008] As mentioned above, the handpiece of the electrosurgical pencil is connected to a suitable electrosurgical energy source (i.e., generator) which produces the radio-frequency electrical energy necessary for the operation of the electrosurgical pencil. In general, when an operation is performed on a patient with an electrosurgical pencil, electrical energy from the electrosurgical generator is conducted through the active electrode to the tissue at the site of the operation and then through the patient to a return electrode. The return electrode is typically placed at a convenient place on the patient's body and is attached to the generator by a conductive material. Typically, the surgeon activates the controls on the electrosurgical pencil to select the modes/waveforms to achieve a desired surgical effect. Typically, the "modes" relate to the various electrical waveforms, e.g., a cutting waveform has a tendency to cut tissue, a coagulating wave form has a tendency to coagulate tissue, and a blend wave form tends to be somewhere between a cut and coagulate wave from. The power or energy parameters are typically controlled from outside the sterile field which requires an intermediary like a circulating nurse to make such adjustment.

[0009] A typical electrosurgical generator has numerous controls for selecting an electrosurgical output. For example, the surgeon can select various surgical "modes" to treat tissue: cut, blend (blend levels 1-3), low cut, desiccate, fulgurate, spray, etc. The surgeon also has the option of selecting a range of power settings typically ranging from 1-300W. As can be appreciated, this gives the surgeon a great deal of variety when treating tissue. However, so many options also tend to complicate simple surgical procedures and may lead to confusion. Moreover, surgeons typically follow preset control parameters and stay within known modes and power settings. Therefore, there exists a need to allow the surgeon to selectively control and easily select and regulate the various modes and power settings utilizing simple and ergonomically friendly controls associated with the electrosurgical pencil.

[0010] Existing electrosurgical instrument systems allow the surgeon to change between two pre-configured settings (i.e., coagulation and cutting) via two discrete switches disposed on the electrosurgical pencil itself. Other electrosurgical instrument systems allow the surgeon to increment the power applied when the coagulating or cutting switch of the instrument is depressed by adjusting or closing a switch on the electrosurgical generator. The surgeon then needs to visually verify the change in the power being applied by looking at various displays and/or meters on the electrosurgical generator. In other words, all of the adjustments to the electrosurgical instrument and parameters being monitored during the use of the electrosurgical instrument are typically located on the electrosurgical generator. As such, the surgeon must continually visually monitor the electrosurgical generator during the surgical procedure.

[0011] Recently, electrosurgical instrument systems have been increasingly provided with coupling and/or connecting systems (e.g., a plug) for removably connecting the electrosurgical instrument to the electrosurgical generator. Typically, the electrosurgical instrument is provided with a so called "male" connector while the electrosurgical generator is provided with the corresponding "female" connector.

[0012] Since electrosurgery requires controlled application of radio frequency energy to an operative tissue site, it is important that the appropriate electrosurgical generator be correctly and/or properly mated with the electrosurgical instrument for the specific electrosurgical procedure. Due to the variety of operative, electrosurgical procedures, requiring various levels of radio frequency energy delivery from an attached instrument, issues arise with the mismatching of electrosurgical instruments and electrosurgical generators.

[0013] Accordingly, the need exists for electrosurgical instruments which do not require the surgeon to continually monitor the electrosurgical generator during the surgical procedure. In addition, the need exists for electrosurgical instruments which may be configured such that the power output can be adjusted without the surgeon having to turn his/her vision away from the operating site and toward the electrosurgical generator.

[0014] Additionally, a need exists for a connecting system, for electrosurgical generators which allow various surgical instruments to be selectively connected to corresponding electrosurgical generators.

SUMMARY

[0015] The present disclosure relates to electrosurgical pencils having a plurality of hand-accessible variable controls.

[0016] According to an aspect of the present disclosure an electrosurgical pencil is provided including an elongated housing. At least one electrocautery end effector is removably supported within the housing and extends distally from the housing. The electrocautery end effector is connected to a source of electrosurgical energy and a selector is supported on the housing for selecting a range setting of energy to be delivered from the source of electrosurgical energy to the at least one electrocautery end effector. In use, the selector is actuatable to select a range setting corresponding to a particular electrocautery end effector connected to the housing.

[0017] The selector may be at least one of a button depressably supported on the housing or a collet rotatably supported on the housing. The range settings may be selected by at least one of depressing the button and rotating the collet.

[0018] The electrosurgical pencil may further include a plurality of activation switches supported on the housing. Each activation switch may be configured and adapted to selectively complete a control loop extending from the source of electrosurgical energy upon actuation thereof. In use, actuation of at least one of the plurality of activation switches produces tissue division with hemostatic effect at the electrocautery blade.

[0019] The electrosurgical pencil may further include at least one voltage divider network supported on the housing. The at least one voltage divider network is electrically connected to the source of electrosurgical energy and controls at least one of the intensity of electrosurgical energy being delivered to the electrosurgical pencil and the mode of electrosurgical energy being delivered to the electrosurgical pencil.

[0020] The division with hemostatic effect is transmitted in discrete packets of energy. The energy packet has a substantially instantaneous amplification and/or a substantially instantaneous degradation.

[0021] The housing defines an open distal end for selectively receiving a proximal end of the electrocautery blade therein. The open distal end of the housing may have a non-circular inner profile. The electrosurgical pencil may further include a collar operatively supporting the electrocautery blade. The collar has a shaped outer surface complementing the shaped inner profile of the distal open end of the housing. The collar and the inner profile of the distal open end of the housing may have complementary ovular, triangular, rectangular, hexagonal, toothed, multi-faceted profiles.

[0022] The electrosurgical pencil may further include a blade receptacle configured and adapted to selectively engage a proximal end of the electrocautery blade.

[0023] The electrosurgical pencil may further include a stabilizer operatively disposed within the housing for increasing retention forces acting on the proximal end of the electrocautery blade. The stabilizer defines a passage therein configured and adapted to selectively receive a proximal end of the electrocautery blade. The stabilizer may be fabricated from a compliant polymeric material.

[0024] The at least one voltage divider network may be electrically connected to the source of electrosurgical energy for controlling the intensity of electrosurgical energy being delivered to the plurality of activation switches from the source of electrosurgical energy and for controlling the intensity of electrosurgical energy delivered to the plurality of activation switches returning from the electrocautery electrode. The voltage divider network may include at least one return control wire electrically inter-connecting the electrocautery electrode and the source of electrosurgical energy. The return control wire transmits excess electrosurgical energy from the electrocautery electrode to the source of electrosurgical energy.

[0025] The voltage network divider includes a slide potentiometer operatively associated with the housing. The plurality of activation switches define a first resistor network disposed within the housing. The slide potentiometer defines a second resistor network disposed within the housing. The slide potentiometer simultaneously controls the intensity of electrosurgical energy delivered to the plurality of activation switches.

[0026] It is envisioned that at least one activation switch is configured and adapted to control a waveform duty cycle to achieve a desired surgical intent. The electrosurgical pencil may include three mode activation switches supported on the housing. Accordingly, each mode activation switch may generate a characteristic voltage which is measured by the source of electrosurgical energy, the source of electrosurgical energy in turn transmits a corresponding waveform duty cycle to the electrosurgical pencil.

[0027] A first activation switch, when actuated, may generate a first characteristic voltage measured by the source of electrosurgical energy, the source of electrosurgical energy in turn may transmit a waveform duty cycle which produces a cutting effect. A second activation switch, when actuated, may generate a second characteristic voltage measured by the source of electrosurgical energy, the source of electrosurgical energy in turn may transmit a waveform duty cycle which produces a division with hemostatic effect. A third activation switch, when actuated, may generate a third characteristic voltage measured by the source of electrosurgical energy, the source of electrosurgical energy in turn may transmit a waveform duty cycle which produces a coagulating effect.

[0028] The voltage divider network is desirably a potentiometer.

[0029] The electrosurgical pencil further includes a molded hand grip operatively supported on the housing. The hand grip is shaped and dimensioned to reduce fatigue on the hand of the user.

[0030] The electrosurgical pencil further includes indicia provided on the housing indicating to a user the level of energy intensity being delivered to the electrocautery blade. The indicium is typically located along a path of travel of the slide potentiometer.

[0031] In an embodiment it is envisioned that the selector is an optical fiber including a distal end supported in the housing for reading a light intensity from a proximal end of the electrocautery end effector when the electrocautery end effector is connected to the housing.

[0032] It is envisioned that a proximal end of each electrocautery end effector includes a unique color associated therewith, wherein each color produces a different light intensity. Accordingly, when the electrocautery end effector is connected to the housing, the optical fiber transmits the light intensity to the electrosurgical generator. The electrosurgical generator, in turn, adjusts the range settings based on the light intensity transmitted thereto.

[0033] According to another aspect of the present disclosure, an electrosurgical system is provided. The electrosurgical system includes an electrosurgical generator; and an electrosurgical pencil selectively connectable to the electrosurgical generator. The electrosurgical pencil includes an elongated housing; at least one electrocautery end effector removably supportable within the housing and extending distally from the housing, the electrocautery end effector being connected to the electrosurgical generator; and at least one voltage divider network supported on the housing. The at least one voltage divider network is electrically connected to the electrosurgical generator and controls at least one of the intensity of electrosurgical energy being delivered to the electrosurgical pencil and the mode of electrosurgical energy being delivered to the electrosurgical pencil. The voltage divider network generates a plurality of characteristic voltages which are measurable by the electrosurgical generator and which electrosurgical generator in turn transmits a corresponding waveform duty cycle at a particular intensity to the electrocautery end effector of the electrosurgical pencil.

[0034] The voltage divider network may generate a first characteristic voltage which when measured by the electrosurgical generator causes the electrosurgical generator to transmit a waveform duty cycle which produces a cutting effect; a second characteristic voltage which when measured by the electrosurgical generator causes the electrosurgical generator to transmit a waveform duty cycle which produces a division with hemostatic effect; and a third characteristic voltage which when measured by the electrosurgical generator causes the electrosurgical generator to transmit a waveform duty cycle which produces a coagulating effect.

[0035] The voltage divider network may generate a series of characteristic voltages which, when measured by the electrosurgical generator, cause the electrosurgical generator to transmit the particular waveform duty cycle at a corresponding level of intensity.

[0036] The electrosurgical pencil may include a plurality of activation buttons supported on the housing. Each activation button may be operatively associated with the voltage divider network. Each activation button may be actuatable to cause the voltage divider network to generate a respective one of the characteristic voltages for transmission of a corresponding waveform duty cycle.

[0037] The electrosurgical pencil may include an intensity controller supported in the housing. The intensity controller may be operatively associated with the voltage divider network. The intensity controller may be actuatable to cause the voltage divider network to generate a respective one of the series of characteristic voltages for transmission of the waveform duty cycle at a corresponding intensity level. In an embodiment, the intensity controller is slidably supported in the housing of the electrosurgical pencil.

[0038] It is envisioned that the division with hemostatic effect has a waveform with a duty cycle of from about 12% to about 75%; that the coagulation effect has a waveform with a duty cycle of from about 1% to about 12%; and that the cutting effect has a waveform with a duty cycle of from about 75% to about 100%.

[0039] The voltage divider network may be a film-type potentiometer. The voltage divider network may include a pair of layers each supporting a plurality of electrical contacts thereon. It is envisioned that the electrical contacts from an upper layer of the voltage divider network are in juxtaposed electrical relation with respect to the electrical contacts from a lower layer of the voltage divider network. The voltage divider network may include a dividing layer interposed between the upper and lower layers. The dividing layer may include a first series of apertures formed therein which are in vertical registration with the electrical contacts of the upper and lower layers. The dividing layer may include a second aperture formed therein which is in vertical registration between electrical contacts provided on the upper layer and a variable resistance element provided on the lower layer.

[0040] According to a further aspect of the present disclosure, an electrosurgical instrument is provided and includes an elongated housing; at least one electrocautery end effector removably supportable within the housing and extending distally from the housing, the electrocautery end effector being connectable to an electrosurgical generator; and at least one voltage divider network supported on the housing, the at least one voltage divider network being electrically connectable to the electrosurgical generator, the at least one voltage divider network being capable of controlling at least one of the intensity of electrosurgical energy being delivered to the electrosurgical instrument and the mode of electrosurgical energy being delivered to the electrosurgical instrument. The voltage divider network generates a plurality of characteristic voltages which are measurable by the electrosurgical generator and which electrosurgical generator in turn transmits a corresponding waveform duty cycle at a particular intensity to the electrocautery end effector of the electrosurgical instrument.

[0041] The voltage divider network may generate a first characteristic voltage which when measured by the electrosurgical generator causes the electrosurgical generator to transmit a waveform duty cycle which produces a cutting effect; a second characteristic voltage which when measured by the electrosurgical generator causes the electrosurgical generator to transmit a waveform duty cycle which produces a division with hemostatic effect; and a third characteristic voltage which when measured by the electrosurgical generator causes the electrosurgical generator to transmit a waveform duty cycle which produces a coagulating effect.

[0042] The voltage divider network may generate a series of characteristic voltages which when measured by the electrosurgical generator cause the electrosurgical generator to transmit the particular waveform duty cycle at a corresponding level of intensity.

[0043] The electrosurgical instrument may include a plurality of activation buttons supported on the housing, wherein each activation button is operatively associated with the voltage divider network.

[0044] It is envisioned that each activation button is actuatable to cause the voltage divider network to generate a respective one of the characteristic voltages for transmission of a corresponding waveform duty cycle.

[0045] The electrosurgical instrument may include an intensity controller supported in the housing, wherein the intensity controller is operatively associated with the voltage divider network. The intensity controller may be actuatable to cause the voltage divider network to generate a respective one of the series of characteristic voltages for transmission of the waveform duty cycle at a corresponding intensity level. The intensity controller may be slidably supported in the housing of the electrosurgical instrument.

[0046] It is envisioned that the division with hemostatic effect has a waveform with a duty cycle of from about 12% to about 75%; that the coagulation effect has a waveform with a duty cycle of from about 1% to about 12%; and that the cutting effect has a waveform with a duty cycle of from about 75% to about 100%.

BRIEF DESCRIPTION OF THE DRAWINGS

[0047] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention, and together with a general description of the invention given above, and the detailed description of the embodiments given below, serve to explain the principles of the invention.

[0048] FIG. **1** is a perspective view of an electrosurgical system including an electrosurgical pencil in accordance with an embodiment of the present disclosure;

[0049] FIG. **2** is front elevational view of the electrosurgical pencil of FIG. **1**;

[0050] FIG. **3** is a rear elevational view of the electrosurgical pencil of FIGS. **1** and **2**;

[0051] FIG. **4** is a top plan view of the electrosurgical pencil of FIGS. **1-3**;

[0052] FIG. **5** is a bottom plan view of the electrosurgical pencil of FIGS. **1-4**;

[0053] FIG. **6** is a left side elevational view of the electrosurgical pencil of FIGS. **1-5**;

[0054] FIG. **7** is a right side elevational view of the electrosurgical pencil of FIGS. **1-6**;

[0055] FIG. **8** is a front, top perspective view of the electrosurgical pencil of FIGS. **1-7**, with a top-half shell of the housing removed;

[0056] FIG. **9** is an exploded perspective view of the electrosurgical pencil of FIGS. **1-8**;

[0057] FIG. **10** is a perspective view of the electrosurgical pencil of FIGS. **1-9**, illustrating actuation of the intensity controller;

[0058] FIG. **11** is a top plan view of the electrosurgical pencil of FIGS. **1-10**, with the top-half shell of the housing removed;

[0059] FIG. **12** is a longitudinal cross-sectional view, as taken through **12-12** of FIG. **4**;

[0060] FIG. **13** is an enlarged view of the indicated area of detail of FIG. **12**;

[0061] FIG. **14** is a side elevational view of the longitudinal cross-section of the electrosurgical pencil of FIG. **12**;

[0062] FIG. **15** is an enlarged view of the indicated area of detail of FIG. **14**;

[0063] FIG. **16** is a perspective view of a plug assembly for use with the electrosurgical pencil of FIGS. **1-14**;

[0064] FIG. **17** is a perspective view of the plug assembly of FIG. **16**, with a top-half shell section removed therefrom;

[0065] FIG. **18** is an enlarged perspective view of the indicated area of detail of FIG. **17**;

[0066] FIG. **19** is a top plan view of the plug assembly of FIGS. **17** and **18**;

[0067] FIG. **20** is an enlarged view of the indicated area of detail of FIG. **19**;

[0068] FIG. **21** is a top, front perspective view of a bottom-half portion of the electrosurgical pencil of FIGS. **1-14**, illustrating the association of a controller portion of the plug assembly therewith;

[0069] FIG. **22** is an enlarged view of FIG. **21**;

[0070] FIG. **23** is a perspective view of a controller unit of the electrosurgical pencil of FIGS. **1-14**;

[0071] FIG. **24** is an exploded perspective view of the controller unit of FIG. **23**;

[0072] FIG. **25** is a schematic illustration of the voltage divider network of the present disclosure;

[0073] FIG. **25**A is a schematic illustration of the exemplary waveform transmitted by the electrosurgical pencil of the present disclosure when a dividing with hemostatic effect/function is activated;

[0074] FIG. **26** is a partial, longitudinal, cross-sectional, front perspective view of a distal end of an electrosurgical pencil, in accordance with another embodiment of the present disclosure;

[0075] FIG. **27** is a partial, longitudinal, cross-sectional, side elevational view of a distal end of an electrosurgical pencil, in accordance with the embodiment of the FIG. **26** of the present disclosure;

[0076] FIG. **28** is a longitudinal, cross-sectional, side elevational view of a distal end of an electrosurgical pencil, in accordance with another embodiment of the present disclosure;

[0077] FIG. **29** is a top plan view of an electrosurgical pencil according to one embodiment of the present disclosure;

[0078] FIG. **30** is a side elevational view of the electrosurgical pencil of FIG. **29**;

[0079] FIG. **31** is a top plan view of an electrosurgical pencil according to yet another embodiment of the present disclosure;

[0080] FIG. **32** is a side elevational view of the electrosurgical pencil of FIG. **31**;

[0081] FIG. **33** is a top plan view of an electrosurgical pencil according to still another embodiment of the present disclosure;

[0082] FIG. **34** is a side elevational view of the electrosurgical pencil of FIG. **33**;

[0083] FIG. **35** is a perspective view of an electrosurgical pencil according to an alternate embodiment of the present disclosure;

[0084] FIG. **36** is a perspective view of an electrosurgical pencil according to still another embodiment of the present disclosure;

[0085] FIG. **37** is a partial, longitudinal, cross-sectional, front perspective view of a distal end of an electrosurgical pencil, in accordance with another embodiment of the present disclosure;

[0086] FIG. **38** is a perspective view of an electrosurgical system including an electrosurgical pencil according to a further embodiment of the present disclosure;

[0087] FIG. **39** is a top plan view of the electrosurgical pencil of FIG. **38**;

[0088] FIG. **40** is a side elevational view of the electrosurgical pencil of FIGS. **38** and **39**;

[0089] FIG. **41** is an exploded perspective view of the electrosurgical pencil of FIGS. **38-40**;

[0090] FIG. **42** is an exploded perspective view of a controller unit for the electrosurgical pencil of FIGS. **38-41**;

[0091] FIG. **43** is a longitudinal, cross-sectional, side elevational view of the electrosurgical pencil of FIGS. **38-42**;

[0092] FIG. **44** is an enlarged view of the indicated area of detail of FIG. **43**;

[0093] FIG. **45** is a partial, longitudinal, cross-sectional, front perspective view of a distal end of the electrosurgical pencil of FIGS. **38-44**;

[0094] FIG. **46** is a partial, longitudinal, cross-sectional, side elevational view of a distal end of the electrosurgical pencil of FIGS. **38-45**;

[0095] FIG. **47** is a perspective view of a plug assembly of the electrosurgical pencil of FIGS. **38-46**;

[0096] FIG. **48** is an enlarged perspective view of the plug assembly of FIG. **47**, with an upper half-section removed therefrom;

[0097] FIG. **49** is a schematic illustration of a voltage divider network for use with the electrosurgical pencil of FIGS. **38-46**; and

[0098] FIG. **50** is an exploded perspective view of the voltage divider network of the electrosurgical pencil of FIGS. **38-46**.

DETAILED DESCRIPTION

[0099] Preferred embodiments of the presently disclosed electrosurgical pencil will now be described in detail with reference to the drawing figures wherein like reference numerals identify similar or identical elements. As used herein, the term "distal" refers to that portion which is further from the user while the term "proximal" refers to that portion which is closer to the user or surgeon.

[0100] FIG. **1** sets forth a perspective view of an electrosurgical system including an electrosurgical pencil **100** constructed in accordance with one embodiment of the present disclosure. While the following description will be directed towards electrosurgical pencils it is envisioned that the features and concepts (or portions thereof) of the present disclosure can be applied to any electrosurgical type instrument, e.g., forceps, suction coagulators, vessel sealers, wands, etc.

[0101] As seen in FIGS. **1-7**, electrosurgical pencil **100** includes an elongated housing **102** having a top-half shell portion **102***a* and a bottom-half shell portion **102***b*. Desirably, housing **102** is not divided along a longitudinal center line. As seen in FIGS. **8** and **9**, bottom-half shell portion **102***b* includes a distal opening **103***a*, through which a blade **106** extends, and a proximal opening **103***b*, through which connecting wire **224** (see FIG. **1**) extends. Desirably, top-half shell portion **102***a* and bottom-half shell portion **102***b* may be bonded together using methods known by those skilled in the art, e.g., sonic energy, adhesives, snap-fit assemblies, etc.

[0102] Electrosurgical pencil **100** further includes a blade receptacle **104** disposed at a distal end of housing **102**, and a replaceable electrocautery end effector **106** operatively and removably connectable to blade receptacle **104**. Electrocautery end effector **106** may be in the form of a needle, loop, blade and/or wand. A distal end portion **108** of blade **106** extends distally beyond receptacle **104** while a proximal end portion **110** of blade **106** is selectively retained by receptacle **104** within the distal end of housing **102**. It is contemplated that electrocautery blade **106** is fabricated from a conductive type material, such as, for example, stainless steel, or is coated with an electrically conductive material. Blade receptacle **104** is desirable fabricated from an electrically conductive material. Blade receptacle **104** is electrically connected to voltage divider network **127** (FIGS. **8**, **9** and **25**) as explained in more detail below.

[0103] Desirably, as seen in FIG. **1**, electrosurgical pencil **100** may be coupled to a conventional electrosurgical generator "G" via a plug assembly **200** (see FIGS. **16-21**), as will be described in greater detail below.

[0104] For the purposes herein, the terms "switch" or "switches" includes electrical actuators, mechanical actuators, electro-mechanical actuators (rotatable actuators, pivotable actuators, toggle-like actuators, buttons, etc.) or optical actuators.

[0105] With reference to FIGS. **1-7** and **9**, electrosurgical pencil **100** includes at least one activation switch, preferably three activation switches **120***a*-**120***c*, each of which extends through top-half shell portion **102***a* of housing **102**. Each activation switch **120***a*-**120***c* is operatively supported on a respective tactile element **122***a*-**122***c* (here shown as a snap-dome switch) provided on a switch plate **124**. Each activation switch **120***a*-**120***c* controls the transmission of RF electrical energy supplied from generator "G" to electrosurgical blade **106**. More particularly, switch plate **124** is positioned on top of a voltage divider network **127** (hereinafter "VDN **127**") such that tactile elements **122***a*-**122***c* are operatively associated therewith. Desirably, VDN **127** (e.g., here shown as a film-type potentiometer) forms a switch closure. For the purposes herein, the term "voltage divider network" relates to any known form of resistive, capacitive or inductive switch closure (or the like) which determines the output voltage across a voltage source (e.g., one of two impedances) connected in series. A "voltage divider" as used herein relates to a number of resistors connected in series which are provided with taps at certain points to make available a fixed or variable fraction of the applied voltage.

[0106] In use, depending on which activation switch **120***a*-**120***c* is depressed a respective tactile element **122***a*-**122***c* is pressed into contact with VDN **127** and a characteristic signal is transmitted to electrosurgical generator "G" via control wires or electrical wires **216** (see FIGS. **17-20**). Desirably, three control wires **216***a*-**216***c* (one for each activation switch **120***a*-**120***c*, respectively) are provided. Control wires **216***a*-**216***c* are preferably electrically connected to switches **120***a*-**120***c* via a controller terminal **215** (see FIGS. **9**, **11**, **12**, **14**, **21** and **22**) which is operatively connected to VDN **127**. By way of example only, electrosurgical generator "G" may be used in conjunction with the device wherein generator "G" includes a circuit for interpreting and responding to the VDN settings.

[0107] Activation switches **120***a*-**120***c* are configured and adapted to control the mode and/or "waveform duty cycle" to achieve a desired surgical intent. For example, first activation switch **120***a* can be set to deliver a characteristic signal to electrosurgical generator "G" which in turn transmits a duty cycle and/or waveform shape which produces a cutting and/or dissecting effect/function. Meanwhile, second activation switch **120***b* can be set to deliver a characteristic signal to electrosurgical generator "G" which in turn transmits a duty cycle and/or waveform shape which produces a division or dividing with hemostatic effect/function. Finally, third activation switch **120***c* can be set to deliver a characteristic signal to electrosurgical generator "G" which in turn transmits a duty cycle and/or waveform shape which produces a hemostatic effect/function.

[0108] As seen in FIGS. **17-20**, a fourth wire or RF line **216***d* for transmitting RF energy to electrocautery blade **106** is preferably provided and is directly electrically connected to blade receptacle **104** for connection to proximal end **110** of electrocautery blade **106**. Since RF line **216***d* is directly connected to blade receptacle **104**, RF line **216***d* bypasses VDN **127** and is isolated from VDN **127** and control wires **216***a*-**216***c*. By directly connecting RF line **216***d* to blade receptacle **104** and isolating VDN **127** from the RF energy transmission, the electrosurgical current does not flow through VDN **127**. This in turn, increases the longevity and life of VDN **127** and/or switches **120***a*-**120***c*.

[0109] As such, a VDN **127** and/or switches **120***a*-**120***e* may be selected which are less complex and/or which are relatively inexpensive since the switch does not have to transmit current during activation. For example, if return control wire **216***d* is provided, switches **120***a*-**120***c* may be constructed by printing conductive ink on a plastic film. On the other hand, if a return control wire **216***d* is not provided, switches may be of the type made of standard stamped metal which add to the overall complexity and cost of the instrument.

[0110] With reference to FIG. **25**, in accordance with an embodiment of the present disclosure, a voltage divider network (VDN) **127** is shown. VDN **127** includes a first transmission line **127***a* to operate the various modes of electrosurgical pencil **100**; a second transmission line **127***b* to operate the various intensities of electrosurgical pencil **100**; a third transmission line **127***c* to function as a ground for VDN **127**; and a fourth transmission line **127***d* which may transmit up to about +5 volts to VDN **127**.

[0111] As seen in FIG. **25**, RF line **216***d* is isolated from or otherwise completely separate from VDN **127**. In particular, RF line **216***d* extends directly from the RF input or generator "G" to the RF output or to electrocautery blade **106**.

[0112] By way of example only, VDN **127** may include a plurality of resistors "R1" (e.g., six (6) resistors), connected in a first series between first transmission line **127***c* and fourth transmission line **127***d*. The first series of resistors "R1" may combine to total about 1000 ohms of resistance. The first series of resistors "R1" are substantially each separated by a first set of switches "S1". Each switch of the first set of switches "S1" may be electrically connected between adjacent resistors "R1" and first transmission line **127***a* of VDN **127**. In operation, depending on which switch or switches of the first set of switches "S1" is/are closed, a different mode of operation for electrosurgical pencil **100** is activated.

[0113] Additionally, by way of example only, VDN **127** may include a plurality of resistors "R2" (e.g., four (4) resistors), connected in a second series between first transmission line **127***c* and fourth transmission line **127***d*. The second series of resistors "R2" may combine to total about 1000 ohms of resistance. The second series of resistors "R2" are each separated by a second set of switches "S2". Each switch of the second set of switches "S2" may be electrically connected between adjacent resistors "R2" and second transmission line **127***b* of VDN **127**. In operation, depending on which switch or switches of the second set of switches "S2" is/are closed, a different intensity of RE energy is transmitted by electrosurgical pencil **100**.

[0114] The dividing with hemostatic effect/function can be defined as having waveforms with a duty cycle from about 12% to about 75%. The hemostatic/coagulation effect/function can be defined as having waveforms with a duty cycle from about 1% to about 12%. The cutting and/or dissecting effect/function can be defined as having waveforms with a duty cycle from about 75% to about 100%. It is important to note that these percentages are approximated and may be customized to deliver the desired surgical effect for various tissue types and characteristics.

[0115] In accordance with the present disclosure and as seen in FIG. **25**A, the dividing with hemostatic effect/function is transmitted and/or delivered in discrete energy packets. The discrete energy packets include an amplification or ramp-up period and a degradation or ramp-down period which is reduced and/or eliminated. In other words, the discrete energy packets delivered during the transmission of the dividing with hemostatic effect/function include an almost instantaneous amplification of energy and an almost instantaneous degradation of energy. Additionally, the dividing and hemostasis effect/function has a waveform with a duty cycle of approximately 24%. The activation switch **120***b* controlling the dividing and hemostatic effect/function operates as a closed loop control.

[0116] As seen throughout FIGS. **1-15**, electrosurgical pencil **100** further includes an intensity controller **128** slidingly supported on or in housing **102**. Intensity controller **128** includes a pair of nubs **129***a*, **129***b* which are slidingly supported, one each, in respective guide channels **130***a*, **130***b*, formed in top-half shell portion **102***a* of housing **102**. Desirably, guide channels **130***a*, **130***b* are formed on either side of activations switches **120***a*-**120***c*. By providing nubs **129***a*, **129***b* on either side of activation switches **120***a*-**120***c*, intensity controller **128** can be easily manipulated by either hand of the user or the same electrosurgical pencil can be operated by a right-handed or a left-handed user.

[0117] As seen in FIGS. **21** and **14**, intensity controller **128** further includes a nub **129***c* extending from a bottom surface thereof which contacts and presses into or against VDN **127**. In this manner, as intensity controller **128** is displaced in a distal and proximal direction relative to housing **102**, third nub **129***c* moves relative to VDN **127** to vary the intensity setting being transmitted to electrocautery end effector **106**, as will be described in greater detail below.

[0118] Intensity controller **128** may be configured to function as a slide potentiometer, sliding over and along VDN **127**. Intensity controller **128** has a first position wherein nubs **129***a*, **129***b* are at a proximal-most position (e.g., closest to plug assembly **200** and third nub **129***c* being located at a proximal-most position) corresponding to a relative low intensity setting, a second position wherein nubs **129***a*, **129***b* are at a distal-most position (e.g., closest to electrocautery end effector **106** and third nub **129***c* being located at a distal-most position) corresponding to a relative high intensity setting, and a plurality of intermediate positions wherein nubs **129***a*, **129***b* are at positions between the distal-most position and the proximal-most position corresponding to various intermediate intensity settings. As can be appreciated, the intensity settings from the proximal end to the distal end may be reversed, e.g., high to low.

[0119] It is contemplated that nubs **129***a*, **129***b* of intensity controller **128** and corresponding guide channels **130***a*, **130***b* may be provided with a series of cooperating discreet or detented positions defining a series of positions, e.g., five, to allow easy selection of the output intensity from the low intensity setting to the high intensity setting. The series of cooperating discreet or detented positions also provide the surgeon with a degree of tactile feedback. By way of example only, as seen in FIGS. **12** and **14**, a plurality of discreet detents **131** are defined in an inner upper surface of top-half shell portion **102***a* for cooperating with and selectively engaging a resilient finger **128***a* extending upwardly from intensity controller **128**. Accordingly, in use, as intensity controller **128** slides distally and proximally, resilient finger **128***a* selectively engages detents **131** to set the intensity level as well as to provide the user with tactile feedback as to when the intensity controller has been set to the desired intensity setting.

[0120] Intensity controller **128** is configured and adapted to adjust the power parameters (e.g., voltage, power and/or current intensity) and/or the power verses impedance curve shape to affect the perceived output intensity. For example, the greater intensity controller **128** is displaced in a distal direction the greater the level of the power parameters transmitted to electrocautery blade **106**. Conceivably, current intensities can range from about 60 mA to about 240 mA when using an electrosurgical blade and having a typical tissue impedance of about 2K ohms. An intensity level of 60 mA provides very light and/or minimal cutting/dissecting/hemostatic effects. An intensity level of 240 mA provides very aggressive cutting/dissecting/hemostatic effects. Accordingly, the preferred range of current intensity is from about 100 mA to about 200 mA at 2K ohms.

[0121] The intensity settings are preferably preset and selected from a look-up table based on a choice of electrosurgical instruments/attachments, desired surgical effect, surgical specialty and/or surgeon preference. The selection may be made automatically or selected manually by the user. The intensity values may be predetermined or adjusted by the user.

[0122] In operation, and depending on the particular electrosurgical function desired, the surgeon depresses one of activation switches **120***a*-**120***c*, in the direction indicated by arrow "Y" (see FIGS. **12-15**) thereby urging a corresponding tactile element **122***a*-**122***c* against VDN **127** and thereby transmitting a respective characteristic signal to electrosurgical generator "G". For example, the surgeon can depress activation switch **120***a* to perform a cutting and/or dissecting function, activation switch **120***b* to perform a blending function, or activation switch **120***c* to perform a hemostatic function. In turn, generator "G" transmits an appropriate waveform output to electrocautery blade **106** via RF line **216***d*.

[0123] In order to vary the intensity of the power parameters of electrosurgical pencil **100**, the surgeon displaces intensity controller **128**, by manipulating at least one of nubs **129***a*, **129***b*, in the direction indicated by double-headed arrow "X" (see FIGS. **12** and **13**). As mentioned above, the intensity can be varied from approximately 60 mA for a light effect to approximately 240 mA for a more aggressive effect. For example, by positioning nubs **129***a*, **129***b* of intensity controller **128** closer to the proximal-most end of guide channels **130***a*, **130***b* (i.e., closer to plug assembly **200**) a lower intensity level is produced, and by positioning nubs **129***a*, **129***b* of intensity controller **128** closer to the distal-most end of guide channels **130***a*, **130***b* (i.e., closer to electrocautery end effector **106**) a larger intensity level is produced. It is envisioned that when nubs **129***a*, **129***b* of intensity controller **128** are positioned at the proximal-most end of guide channels **130***a*, **130***b*, VDN **127** is set to a null and/or open position. Electrosurgical pencil **100** may be shipped with intensity controller **128** set to the null and/or open position.

[0124] Intensity controller **128** controls the intensity level of the electrosurgical energy activated by all three activation switches **120***a*-**120***c*, simultaneously. In other words, as nubs **129***a*, **129***b* of intensity controller **128** are positioned relative to guide channels **130***a*, **130***b*, the intensity level of the electrosurgical energy transmitted to each activation switch **120***a*-**120***c* is set to the same value of intensity controller **128**.

[0125] As a safety precaution, it is envisioned that when electrosurgical pencil **100** is changed from one mode to another, intensity controller **128** may be configured such that it must be reset (i.e., nubs **129***a*, **129***b*, re-positioned to the proximal-most end of guide channels **130***a*, **130***b* thus setting VDN **127** to the null and/or open position). After being reset, intensity controller **128** may be adjusted as needed to the desired and/or necessary intensity level for the mode selected.

[0126] It is envisioned and contemplated that VDN **127** may also include an algorithm which stores the last intensity level setting for each mode. In this manner, intensity controller **128** does not have to be reset to the last operative value when the particular mode is re-selected.

[0127] The combination of placing VDN **127** and RF line **216***d* in electrosurgical pencil **100** essentially places the entire resistor network of the electrosurgical system (e.g., electrosurgical pencil **100** and the source of electrosurgical energy "G") within electrosurgical pencil **100**. Conventional electrosurgical systems typically include a current limiting resistor disposed within the electrosurgical pencil, for activating the electrosurgical pencil, and a second resistor network disposed in the source of electrosurgical energy, for controlling the intensity of the electrosurgical energy transmitted. In accordance with the present disclosure, both the first and the second resistor networks are disposed within electrosurgical pencil **100**, namely, the first resistor network as evidenced by activation switches **120***a*-**120***e*, and the second resistor network as evidenced by intensity controller **128**.

[0128] As described above, intensity controller **128** can be configured and adapted to provide a degree of tactile feedback by the inter-engagement of resilient finger **128***a* of intensity controller **128** in detents **131** formed in top-half shell portion **102***a*. Alternatively, audible feedback can be produced from intensity controller **128** (e.g., a "click"), from electrosurgical energy source "G" (e.g., a "tone") and/or from an auxiliary sound-producing device such as a buzzer (not shown).

[0129] As seen throughout FIGS. **1-15**, nubs **129***a*, **129***b* of intensity controller **128** and activation switches **120***a*-**120***c* are positioned in a depression **109** formed in top-half shell portion **102***a* of housing **102**. Desirably, activation switches **120***a*-**120***c* are positioned at a location where the fingers of the surgeon would normally rest when electrosurgical pencil **100** is held in the hand of the surgeon while nubs **129***a*, **129***b* of intensity controller **128** are placed at locations which would not be confused with activation switches **120***a*-**120***c*. Alternatively, nubs **129***a*, **129***b* of intensity controller **128** are positioned at locations where the fingers of the surgeon would normally rest when electrosurgical pencil **100** is held in the hand of the surgeon while activation switches **120***a*-**120***e* are placed at locations which would not be confused with nubs **129***a*, **129***b* of intensity controller **128**. In addition, depression **109** formed in top-half shell portion **102***a* of housing **102** advantageously minimizes inadvertent activation (e.g., depressing, sliding and/or manipulating) of activation switches **120***a*-**120***c* and intensity controller **128** while in the surgical field and/or during the surgical procedure.

[0130] As best seen in FIG. **10**, housing **102** can include a series of indicia **31** provided thereon which are visible to the user. Indicia **31** may be a series of numbers (e.g., numbers 1-5) which reflect the level of intensity that is to be transmitted. Desirably, indicia **31** are provided alongside guide channels **130***a*, **130***b*. Indicia **31** are preferably provided on housing **102** and spaced therealong to correspond substantially with detents **131** of the tactile feedback. Accordingly, as intensity controller **128** is moved distally and proximally, nubs **129***a*, **129***b* are moved along guide channels **130***a*, **130***b* and come into registration with particular indicia **31** which correspond to the location of detents **131** of the tactile feedback. For example, indicia **31** may include numeric characters, as shown in FIG. **10**, alphabetic character, alphanumeric characters, graduated symbols, graduated shapes, and the like.

[0131] As seen in FIGS. **1-15**, housing **102** of electrosurgical pencil **100** is molded/contoured to improve the handling of electrosurgical pencil **100** by the surgeon. Desirably, the contouring reduces the pressure and gripping force required to use and/or operate electrosurgical pencil **100** thereby potentially reducing the fatigue experienced by the surgeon and to prevent movement of electrosurgical pencil **100** during proximal and distal adjustments of nubs **129***a* and **129***b*.

[0132] Turning now to FIGS. **16-22**, a detailed discussion of plug assembly **200** is provided. As seen in FIGS. **16-22**, plug assembly **200** includes a housing portion **202**, a controller terminal **215**, and a connecting wire **224** electrically interconnecting housing portion **202** and control terminal **215**.

[0133] As seen in FIGS. **16-20**, housing portion **202** includes a first half-section **202***a* and a second half-section **202***b* operatively engageable with one another, e.g., via a snap-fit engagement. Half-sections **202***a*, **202***b* are configured and adapted to retain a common power pin **204** and a plurality of electrical contacts **206** therebetween, as will be described in greater detail below.

[0134] Desirably, power pin **204** of plug assembly **200** extends distally from housing portion **202** at a location preferably between first half-section **202***a* and second half-section **202***b*. Power pin **204** may be positioned to be off center, i.e., closer to one side edge of housing portion **202** than the other. Plug assembly **200** further includes at least one, desirably, a pair of position pins **212** also extending from housing portion **202**. Position pins **212** may be positioned between half-sections **202***a* and **202***b* of housing portion **202** and are oriented in the same direction as power pin **204**. Desirably, a first position pin **212***a* is positioned in close proximity to a center of housing portion **202** and a second position pin **212***b* is positioned to be off center and in close proximity to an opposite side edge of housing portion **202** as compared to power pin **204**. Pins **212***a*, **212***b* and **204** may be located on housing portion **202** at locations which correspond to pin receiving positions (not shown) of a connector receptacle "R" of electrosurgical generator "G" (see FIG. **1**).

[0135] Plug assembly **200** further includes a prong **214** extending from housing portion **202**. In particular, prong **214** includes a body portion **214***a* (see FIGS. **17** and **18**) extending from second half-section **202***b* of housing portion **202** and a cover portion **214***b* extending from first half-section **202***a* of housing portion **202**. In this manner, when half-sections **202***a*, **202***b* are joined to one another, cover portion **214***h* of prong **214** encloses body portion **214***a*. Prong **214** may be positioned between power pin **204** and first position pin **212***a*. Prong **214** is configured and adapted to retain electrical contacts **206** therein such that a portion of each contact **206** is exposed along a front or distal edge thereof. While four contacts **206** are shown, it is envisioned that any number of contacts **206** can be provided, including and not limited to two, six and eight. Prong **214** may be located on housing portion **202** at a location which corresponds to a prong receiving position (not shown) of connector receptacle "R" of electrosurgical generator "G" (see FIG. **1**).

[0136] Since prong **214** extends from second half-section **202***b* of housing portion **202**, housing portion **202** of plug assembly **200** will not enter connector receptacle "R" of electrosurgical generator "G" unless housing portion **202** is in a proper orientation. In other words, prong **214** functions as a polarization member. This ensures that power pin **204** is properly received in connector receptacle "R" of electrosurgical generator "G".

[0137] With continued reference to FIGS. **17-20**, connecting wire **224** includes a power supplying wire **220** electrically connected to power pin **204**, control wires **216***a*-**216***c* electrically connected to a respective contact **206**, and RF line **216***d* electrically connected to a respective contact **206**.

[0138] Turning now to FIGS. **8**, **9**, **11**, **12**, **15**, **21** and **22**, control terminal **215** is supported in housing **202** near a proximal end thereof. Control terminal **215** includes a slot **215***a* formed therein for electrically receiving and connecting with VDN **127**.

[0139] Turning now to FIG. **26**, an electrosurgical pencil, according to another embodiment of the present disclosure, is shown generally as **300**. Electrosurgical pencil **300** is substantially similar to electrosurgical pencil **100** and will only be discussed in detail to the extent necessary to identify differences in construction and operation.

[0140] Electrosurgical pencil **300** includes a housing **302** defining an open distal end **303***a* for selectively receiving proximal end **110** of electrocautery blade **106** therein. Open distal end **303***a* defines a non-circular inner profile **305**, such as, for example, ovular, triangular, rectangular, hexagonal (as seen in FIG. **26**), toothed, multi-faceted and the like.

[0141] Desirably, electrocautery blade **106** is supported in a collar **310**. Collar **310** is desirably positioned between distal end **108** and proximal end **110** of electrocautery blade **106**. Collar **310** has a shaped outer surface **310***a* configured and dimensioned to complement the inner profile **305** of open distal end **303***a*. In one embodiment, the open distal end **303***a* of housing **302** defines a hexagonal inner profile **305** and collar **310** defines a hexagonal outer surface **310***a*.

[0142] The shaped inner profile **305** of open distal end **303***a* of housing **302** may be formed using plastic injection molding, insert molding and/or broaching techniques. Desirably, open distal end **303***a* of housing **302** is completely formed in the bottom-half shell section **302***b*. By completely forming open distal end **303***a* in the bottom-half shell section **302***b* of housing **302**, the tolerances, dimensions and shape of opening **303***a* and inner profile **305** are more consistent as compared to a housing whose top-half shell portion and bottom-half shell portion extend through the open distal end. Additionally, an open distal end **303***a* formed solely in bottom-half shell portion **302***b* is more centered, has less variability and increases the precision of fitting with mating geometry (i.e., shaped outer surface **310***a* of collar **310**) as compared to a housing whose top-half shell portion and bottom-half shell portion extend through the open distal end.

[0143] Turning now to FIG. **27**, an electrosurgical pencil substantially similar to electrosurgical pencils **100** and **300** is shown and will be discussed in detail to the extent necessary to identify difference in construction and operation therein. As seen in FIG. **27**, electrosurgical pencil **100**, **300** may include a stabilizer **320** disposed within its respective housing **102**, **302** in order to take up any free-play in the connection of electrocautery blade **106** to housing **102**, **302**. Additionally, stabilizer **320** functions to improve the retention forces acting on proximal end **110** of electrocautery blade **106** which hold electrocautery blade **106** in position in housing **102**, **302**. Desirably, stabilizer **320** is positioned proximal of an electrocautery blade mount **322** provided near the distal end of housing **102**, **302**, and distal of blade receptacle **104**.

[0144] Stabilizer **320** includes an opening or passage **321** formed therein through which proximal end **110** of electrocautery blade **106** passes when electrocautery blade **106** is connected to pencils **100** or **300**. In use, with regard to electrosurgical pencil **300**, as electrocautery blade **106** is connected to housing **302** of electrosurgical pencil **300**, proximal end **110** is inserted into open distal end **303***a* of bottom-half shell portion **302***b*, through blade mount **322**, through passage **321** of stabilizer **320**, and into operative engagement with blade receptacle **104**. Stabilizer **320** and, in particular, passage **321** of stabilizer **320** is configured and dimensioned to create an interference-type fit with proximal end **110** of electrocautery blade **106**. As mentioned above, stabilizer **320** functions to at least take up any free-play in proximal end **110** of electrocautery blade **106** and to improve the retention forces associated with holding electrocautery blade **106** in place in housing **302** of electrosurgical pencil **300**.

[0145] As seen in FIG. **27**, passage **321** of stabilizer **320** is substantially circular. Desirably, passage **321** of stabilizer **320** has a dimension (i.e., a radius or diameter) which is less that a dimension (i.e., a radius or diameter) of proximal end **110** of electrocautery blade **106**. While passage **321** of stabilizer **320** is shown as being circular, it is envisioned and within the scope of the present disclosure for passage **321** of stabilizer **320** to have any possible shape, such as, for example, and not limited to, a slit, star-shaped, cruciform-shaped, etc.

[0146] Stabilizer **320** is fabricated from a compliant polymeric material. Desirably, stabilizer **320** is fabricated from an insulative material. Stabilizer **320** is desirably fabricated from a material commercially available from Versaflex, Incorporated, Kansas City, Kans., and sold under the tradename Versaflex® 1245x-1.

[0147] Turning now to FIG. **28**, an electrosurgical pencil substantially similar to electrosurgical pencils **100** and **300** is shown and will be discussed in detail to the extent necessary to identify difference in construction and operation therein. As seen in FIG. **28**, electrosurgical pencil **100**, **300** may include at least one, preferably, a plurality of runners **330** disposed within housing **120**, **302** of electrosurgical pencil **100**, **300** (three runners **330***a*-**330***c* shown in FIG. **28**). Desirably, a first runner **330***a* is positioned near a distal end of electrosurgical pencil **100**, **300**; a second runner **330***b* is positioned near an intermediate portion of electrosurgical pencil **100**, **300**; and a third runner **330***c* is positioned near a proximal end of electrosurgical pencil **100**, **300**.

[0148] Turning now to FIGS. **29** and **30**, an embodiment of electrosurgical pencils **100** or **300** is shown. As seen in FIGS. **29** and **30**, in particular in FIG. **30**, desirably, indicia **31** is provided on housing **102**, **302** of electrosurgical pencil **100** and/or **300** along at least one side thereof. Indicia **31** include a first or alphanumeric portion **31***a*, and a second, graphic or symbolic portion **31***b*. In the interest of economy, only one side of electrosurgical pencil **100**, **300** is shown, the opposite side of electrosurgical pencil **100**, **300** being a mirror image of the first side.

[0149] Desirably, as seen in FIG. **30**, first indicium **31***a* includes numerals increasing from a proximal end of indicia **31** to a distal end of indicia **31**. Also as seen in FIG. **30**, second indicia **31***b* includes a series of symbols and/or shapes which increase in size from a proximal end of indicia **31** to a distal end of indicia **31**. As described previously, as nubs **129***a*, **129***b* are moved in a distal direction, the intensity of the energy delivered to electrocautery blade **106** increases as evidenced by the increasing numbers of first indicia **31***a* and/or the increasing size of second indicia **31***b*. It follows that as nubs **129***a*, **129***b* are moved in a proximal direction, the intensity of the energy delivered to electrocautery blade **106** decreases as evidenced by the decreasing numbers of first indicia **31***a* and/or the decreasing size of indicia **31***b*.

[0150] As seen in FIG. **30**, electrosurgical pencil **100**, **300** further includes a further graphic or a grip enhancing feature **33** provided on each side thereof. Grip enhancing feature **33** includes an elongate tapering "swoosh" shape (i.e., a profile substantially similar to a cross-sectional profile of an aircraft wing) formed along the side of housing **102**, **302**. Desirably, grip enhancing feature **33** is a rubberized material, a texturized surface, or the like. In this manner, when electrosurgical pencil **100**, **300** is held in the hand of the surgeon, the fingers of the surgeon contact and/or touch grip enhancing feature **33**, thereby increasing the maneuverability and operation of electrosurgical pencil **100**, **300**.

[0151] Electrosurgical pencil **100**, **300** may also include a soft-touch element **35** provided on housing **102**, **302**. As seen in FIG. **30**, soft-touch element **35** is desirably provided near a proximal end of housing **102**, **302**, along a bottom surface thereof. In this manner, when electrosurgical pencil **100**, **300** is held in the hand of the surgeon, the soft-touch element **35** comes to rest on the surgeons' hand thereby increasing the comfort and operation of electrosurgical pencil **100**, **300**.

[0152] Turning now to FIGS. **31** and **32**, indicia **31** includes a first or alphanumeric portion **31***a*, and a second, graphic or symbolic portion **31***b*. In the interest of economy, only one side of electrosurgical pencil **100**, **300** is shown, the opposite side of electrosurgical pencil **100**, **300** being a mirror image of the first side. Desirably, second portion **31***b* of indicia **31** is in the shape of an elongate tapering "swoosh". It is envisioned that a relatively enlarged end of second portion **31***b* of indicia **31** is located proximate the largest alphanumeric value of first portion **31***a* of indicia **31**, and a relatively thinner end of second portion **31***b* of indicia **31** extends beyond the smallest alphanumeric value of first portion **31***a* of indicia **31**. It is contemplated that second portion **31***b* of indicia **31** is segmented or otherwise divided into discrete portions wherein each portion corresponds with an alphanumeric value of first portion **31***a* of indicia **31**.

[0153] Turning now to FIGS. **33** and **34**, indicia **31** include a first or alphanumeric portion **31***a*, and a second or symbolic portion **31***b*. In the interest of economy, only one side of electrosurgical pencil **100**, **300** is shown, the opposite side of electrosurgical pencil **100**, **300** being a mirror image of the first side. Desirably, second portion **31***b* of indicia **31** is in the shape of an elongate tapering "swoosh". It is envisioned that a relatively enlarged end of second portion **31***b* of indicia **31** is located distal of the largest alphanumeric value of first portion **31***a* of indicia **31**, and a relatively thinner end of second portion **31***b* of indicia **31** extends beyond the smallest alphanumeric value of first portion **31***a* of indicia **31**. It is contemplated that second portion **31***b* of indicia **31** includes notches and the like formed therein to demark segments of second portion **31***b* of indicia **31**, wherein each segment corresponds with an alphanumeric value of first portion **31***a* of indicia **31**.

[0154] As seen in FIG. **34**, electrosurgical pencil **100** or **300** includes soft-touch element **35** extending along a bottom surface thereof. In this manner, when electrosurgical pencil **100**, **300** is held in the hand of the surgeon, the soft-touch element **35** comes to rest on the surgeons' hand thereby increasing the comfort and operation of electrosurgical pencil **100**, **300**.

[0155] Desirably, second portion **31***b* of indicia **31** is fabricated from a soft-touch material or other material capable of enhancing the grip of electrosurgical instrument **100** or **300**.

[0156] Turning now to FIGS. **35**-**37**, electrosurgical pencils according to alternate embodiments of the present disclosure are shown generally as **400**. Electrosurgical pencils **400** are similar to electrosurgical pencils **100** or **300** and thus will only be discussed in detail to the extent necessary to identify differences in construction and operation.

[0157] As seen in FIG. **35**, electrosurgical pencil **400** includes a range setting selector in the form of a button **440** supported on housing **102**. While button selector **440** is shown positioned proximally of activation switches **120***a*-**120***c*, it is envisioned and within the scope of the present disclosure to place button selector **440** at any convenient, accessible and non-disruptive location on housing **102**.

[0158] In one embodiment, button selector **440** may be electrically connected to VDN **127** (see FIGS. **9** and **11**), or, in an alternate embodiment, button selector **440** may be electrically connected to a separate respective VDN (not shown).

[0159] In use, button selector **440** is depressed, as needed, to change the range settings of the energy delivered to electrocautery end effector **106**. In other words, depending on the particular shape and/or configuration of electrocautery end effector **106** (e.g., blade, loop, ball, etc.) button selector **440** is depressed in the direction of arrow "Y" in order to cycle through the range setting until the appropriate range setting for the particular electrocautery end effector **106** is selected.

[0160] By placing button selector **440** on housing **102** the appropriate range setting for the particular electrocautery end effector **106** may be selected entirely from within the sterile or operative field. Accordingly, during an operative procedure, when the surgeon desires and/or needs to change one electrocautery end effector **106** to an electrocautery end effector of a different shape, the surgeon toggles or cycles through the range settings by pressing button selector **440** until the appropriate range setting is achieved for the corresponding electrocautery end effector **106**.

[0161] As seen in FIG. **36**, electrosurgical pencil **400** may include a selector in the form of a collet **450** operatively supported at a distal end of housing **102**. Desirably, the proximal end of electrocautery end effector **106** may be introduced through collet selector **450** to blade receptacle **104** (see FIGS. **8** and **9**). Collet selector **450** is rotatably supported on the distal end of housing **102**.

[0162] In one embodiment, collet selector **450** may be electrically connected to VDN **127** (see FIGS. **9** and **11**), or, in an alternate embodiment, collet selector **450** may be electrically connected to a separate respective VDN (not shown).

[0163] In use, collet selector **450** is rotated, as needed, to change the range settings of the energy delivered to electrocautery end effector **106**. In other words, depending on the particular shape and/or configuration of electrocautery end effector **106** (e.g., blade, loop, ball, etc.) collet selector **450** is rotated in the direction of double-headed arrow "A" in order to select the appropriate range setting for the particular electrocautery end effector **106**. Accordingly, during an operative procedure, when the surgeon desires and/or needs to change the electrocautery end effector **106** to an end effector having a different shape, the surgeon rotates collet selector **450** until the appropriate range setting is achieved for the corresponding electrocautery end effector **106**.

[0164] In an embodiment, as seen in FIG. **37**, the range setting selector electrosurgical pencil **400** may include an optical fiber **460** or the like having a distal end **460***a* in operative association with blade mount **320** disposed in housing **102** and a proximal end (not shown) in operative association with electrosurgical generator "G". In the present embodiment, the proximal end **110** of each individual electrocautery end effector **106** would have a unique color associated therewith (e.g., yellow, red, blue, green, white, black, etc.) and in turn a unique light intensity when proximal end **110** of electrocautery end effector **106** is inserted in blade mount **320**.

[0165] Accordingly, when the electrocautery end effector **106** is inserted into opening **303***a* of blade mount **320** and into blade receptacle **104**, optical fiber **460** transmits the color and/or the intensity of the light produced by the proximal end **110** of the electrocautery end effector **106** back to the electrosurgical generator "G". The electrosurgical generator "G" will then read the color being transmitted thereto and adjust the range settings to correspond with the range settings desired and/or necessary for particular electrocautery end effector **106** which is connected to the electrosurgical pencil **400**. In this embodiment, optical fiber **460** enables automatic selection of the range setting upon insertion of electrocautery end effector **106** into opening **303***a* of blade mount **320** and/or into blade receptacle **104**.

[0166] While an optical fiber **460** has been shown and described to automatically select the range settings of the electrosurgical generator "G" upon connection of a particular electrocautery end effector **106** to housing **102**, it is envisioned and within the scope of the present disclosure that any system may be provided to achieve automatic establishment of range settings based-upon the insertion of a unique electrocautery end effector. For example, such systems may include machine readable indicia provided on the surface of the electrocautery end effector which is read by a corresponding reader provided in the housing, or a mechanical keying element provided on the surface of the electrocautery end effector which selectively engages complementary receiving elements provided within the housing.

[0167] It is further envisioned that any of the electrosurgical pencils disclosed herein can be provided with a lock-out mechanism/system (not shown) wherein when one of the activation switches is depressed, the other remaining activation switches can either not be depressed or can not cause transmission of electrosurgical energy to electrocautery blade **106**.

[0168] It is also envisioned that the electrosurgical pencil **100** may include a smart recognition technology which communicates with the generator to identify the electrosurgical pencil and communicate various surgical parameters which relate to treating tissue with electrosurgical pencil **100**. For example, the electrosurgical pencil **100** may be equipped with a bar code or Aztec code which is readable by the generator and which presets the generator to default parameters associated with treating tissue with electrosurgical pencils. The bar code or Aztec code may also include programmable data which is readable by the generator and which programs the generator to specific electrical parameters prior to use.

[0169] Other smart recognition technology is also envisioned which enable the generator to determine the type of instrument being utilized or to insure proper attachment of the instrument to the generator as a safety mechanism. One such safety connector is identified in U.S. patent application Ser. No. 10/718,114, filed Nov. 20, 2003, the entire contents of which being incorporated by reference herein. For example, in addition to the smart recognition technology described above, such a safety connector can include a plug or male portion operatively associated with the electrosurgical pencil and a complementary socket or female portion operatively associated with the electrosurgical generator. Socket portion is "backward compatible" to receive connector portions of electrosurgical pencils disclosed therein and to receive connector portions of prior art electrosurgical instruments.

[0170] Turning now to FIGS. **38-50**, an electrosurgical system including an electrosurgical pencil according to a further embodiment of the present disclosure is shown generally as **1000**. Electrosurgical pencil **1000** is substantially similar to electrosurgical pencil **100** and will only be described in detail herein to the extent necessary to identify differences in construction and/or operation.

[0171] As seen in FIGS. **38-50**, electrosurgical pencil **1000** includes an elongated housing **102** having a right-half shell section **102***a* and a left-half shell section **102***b*. As seen in FIG. **38**, when right and left-half shell sections **102***a*, **102***b* are connected to one another, a distal opening **103***a* is defined therebetween, through which an electrode **106** extends, and a proximal opening **103***b* (see FIG. **41**) is defined therebetween, through which connecting cable **224** (see FIG. **38**) extends. Right and left-half shell sections **102***a*, **102***b* are welded to one another along a portion of a length of a top edge thereof and along an entire length of a bottom edge thereof. Connecting cable **224** is held in place between right and left-half shell sections **102***a*, **102***b* by a friction-fit engagement in a non-hermetically sealed manner.

[0172] As seen in FIGS. **41**, **43**, **45** and **46**, electrosurgical pencil **1000** further includes an electrode receptacle **104** disposed at a distal end of housing **102**, and a replaceable electrode **106** operatively and removably connectable to electrode receptacle **104**.

[0173] Electrode **106** is in the form of a blade. When coupled to electrode receptacle **104**, a distal end portion **108** of electrode **106** extends distally beyond electrode receptacle **104** while a proximal end portion **110** of electrode **106** is selectively retained by electrode receptacle **104** within the distal end of housing **102**. Electrode **106** is fabricated from a stainless steel rod having a silicone elastomer coating. Electrode receptacle **104** electrically interconnects electrode **106** to electrosurgical generator "G".

[0174] With continued reference to FIGS. **38-50**, electrosurgical pencil **1000** includes three activation buttons **120***a*-**120***c*, each of which is reciprocally supported in a carrier **121** (see FIG. **41**) of a controller unit which is supported in housing **102**. Each activation button **120***a*-**120***c* includes a portion which extends through an upper surface of housing **102**.

[0175] As seen in FIG. **41**, each activation button **120***a*-**120***c* is operatively supported on a respective tactile element **122***a*-**122***c* formed in a switch plate **124**. Each tactile element **122***a*-**122***c* is in the form of an arcuate bridge projecting upwardly from a top surface of switch plate **124** to contact a respective button **120***a*-**120***c*. Each tactile element **122***a*-**122***c* has a first, un-biased condition in which the tactile element **122***a*-**122***c* projects upwardly from the top surface of switch plate **124** and a second, biased condition in which the tactile element **122***a*-**122***c* is deflected downwardly, by a respective activation button **120***a*-**120***c*, against a voltage divider network **127**, to close a switch.

[0176] As seen in FIGS. **42-44**, each activation button **120***a*-**120***c* includes a stem **123***a*-**123***c*, respectively, which stem **123***a*-**123***c* is in operative engagement with a respective tactile element **122***a*-**122***c*.

[0177] Each activation switch **120***a*-**120***e* controls the transmission of RF electrical energy supplied from generator "G" to electrode **106**. Switch plate **124** is positioned over the top of a voltage divider network **127** (hereinafter "VDN **127**") such that tactile elements **122***a*-**122***e* are in operative association therewith. VDN **127** is a film-type potentiometer which forms the basis of a switch closure assembly.

[0178] As seen in FIG. **42**, VDN **127** includes a pair of layers **140***a*, **140***b* of resilient material each supporting a plurality of electrical contacts **142***a*, **142***b* thereon. Electrical contacts **142***a* from an upper layer **140***a* of VDN **127** are in juxtaposed electrical relation with respect to electrical contacts **142***b* from a lower layer **140***b* of VDN **127**. The electrical contacts **142***a*, **142***b* of the upper and the lower layers **140***a*, **140***b* of VDN **127** are in juxtaposed relation with respective tactile elements **122***a*-**122***c*.

[0179] Upper and lower layers **140***a*, **140***b* of VDN **127** are separated by a dividing layer **140***c*. Dividing layer **140***c* includes a first series of apertures **142***c* formed therein which are in vertical registration with electrical contacts **142***a*, **142***b*. Dividing layer **140***c* includes a second aperture **144***e* formed therein which is in vertical registration between electrical contacts **144***a* provided on upper layer **140***a* and a variable resistance element **144***d* provided on lower layer **140***b*. Upper layer **140***a*, lower layer **140***b*, and dividing layer **140***c* are supported on a support layer **140***d*.

[0180] In operation, and depending on the particular electrosurgical function desired, the surgeon depresses one of activation buttons **120***a*-**120***c*, in the direction indicated by arrow "Y" (see FIGS. **43** and **44**) thereby urging and/or deflecting a corresponding tactile element **122***a*-**122***c* against VDN **127** and thereby causing the respective electrical contact **142***a* of upper layer **140***a* to electrically engage the respective electrical contact **142***b* of the lower layer **140***b*. In so doing, a respective characteristic voltage is generated and measured by electrosurgical generator "G". In turn, depending on the characteristic voltage generated, generator "G" selects and transmits an appropriate waveform output to electrocautery blade **106** via RF line **220** (see FIGS. **48** and **49**).

[0181] Activation buttons **120***a*-**120***c* are operable to control the mode and/or "waveform duty cycle" to achieve a desired surgical intent. First activation button **120***a* is set to generate a first characteristic voltage in VDN **127** which is measured by electrosurgical generator "G" which generator "G" in turn transmits a unique duty cycle and/or waveform shape which produces a cutting and/or dissecting effect/function. Second activation button **120***b* is set to generate a second characteristic voltage in VDN **127** which is measured by electrosurgical generator "G" which generator "G" in turn transmits a unique duty cycle and/or waveform shape which produces a division with hemostatic effect/function. Third activation button **120***c* is set to generate a third characteristic voltage in VDN **127** which is measured by electrosurgical generator "G" which generator "G" in turn transmits a unique duty cycle and/or waveform shape which produces a hemostatic/coagulation effect/function.

[0182] The division with hemostatic effect/function is defined as having waveforms with a duty cycle from about 12% to about 75%. The hemostatic/coagulation effect/function is defined as having waveforms with a duty cycle from about 1% to about 12%. The cutting and/or dissecting effect/function is defined as having waveforms with a duty cycle from about 75% to about 100%.

[0183] The division with hemostatic effect/function is transmitted and/or delivered in discrete energy packets. The discrete energy packets include an amplification or ramp-up period and a degradation or ramp-down period which is reduced and/or eliminated. The discrete energy packets delivered during the transmission of the dividing with hemostatic effect/function include an almost instantaneous amplification of energy and an almost instantaneous degradation of energy.

[0184] The division with hemostatic effect/function has a higher duty cycle than the cutting and/or dissecting effect/function. The division with hemostatic effect/function includes four (4) pulses per rep rate as compared to one (1) pulse per rep rate for a fulgurate or spray effect/function. The division with hemostatic effect/function differs from the blending effect/function in that the division with hemostatic effect/function has a very low stored energy on the output as compared to the blending effect/function. Accordingly, the division with hemostatic effect/function has a higher crest factor as compared to the blending effect/function and a more continuous output as compared to coagulating effect/function.

[0185] As seen in FIGS. **38**-**41** and **43**-**45**, electrosurgical pencil **1000** includes an intensity controller **128** slidingly supported in housing **102**. Intensity controller **128** includes a pair of nubs **129***a*, **129***b* which are slidingly supported, one each, in respective guide channels **130***a*, **130***b* (see FIG. **38**). Guide channels **130***a*, **130***b* are defined between respective right and left-half shell sections **102***a*, **102***b* and carrier **121** when right and left-half sections **102***a*, **102***b* are joined together around carrier **121** and ultrasonically welded to one another. Guide channels **130***a*, **130***b* are formed on either side of activations buttons **120***a*-**120***c* allowing the surgeon to operate electrosurgical pencil **100** with either the right or the left hand.

[0186] As seen in FIG. **43**, intensity controller **128** includes a nub **129***c* extending from a bottom surface thereof which contacts and presses into or against VDN **127**. As seen in FIG. **50**, VDN **127** includes electrical contacts **144***a* provided on upper layer **140***a* and lower layer **140***b*. In this manner, as intensity controller **128** is displaced in a distal and proximal direction relative to housing **102**, third nub **129***c* moves along VDN **127**, thereby pressing electrical contact **144***a* from upper layer **140***a* of VDN **127** against resistance element **144***b* of lower layer **140***b* of VDN **127**. In so doing, a resistance value of resistance element **144***b* is changed thereby changing the value of the voltage measured by electrosurgical generator "G". The electrosurgical generator "G" in turn varies the intensity of the waveform being transmitted to electrode **106**.

[0187] Intensity controller **128** in combination with VDN **127** functions as a slide potentiometer. Intensity controller **128** has an initial position wherein nubs **129***a*, **129***b* are at a proximal-most position which corresponds to a relatively low intensity setting, a final position wherein nubs **129***a*, **129***b* are at a distal-most position which corresponds to a relatively high intensity setting, and a plurality of intermediate positions wherein nubs **129***a*, **129***b* are at positions between the distal-most position and the proximal-most position corresponding to various intermediate intensity settings.

[0188] Slidable manipulation or movement of intensity controller **128** adjusts the power parameters (e.g., voltage, power and/or current intensity) and/or the power verses impedance curve shape to affect the output intensity of the waveform. The greater intensity controller **128** is displaced in a distal direction the greater the level of the power parameters for the waveforms are transmitted to electrode **106**. Current intensities range from about 60 mA to about 240 mA and have a typical tissue impedance of about 2K ohms. A waveform with an intensity level of 60 mA provides very light and/or minimal cutting/dividing/coagulating effects. An intensity level of 240 mA provides very aggressive cutting/dividing/coagulating effects.

[0189] In order to vary the intensity of the power parameters of electrosurgical pencil **100**, the surgeon displaces intensity controller **128**, by manipulating at least one of nubs **129***a*, **129***b*, in either of the directions indicated by double-headed arrow "X" (see FIGS. **43** and **44**, supra).

[0190] Intensity controller **128** is operable to provide a degree of tactile feedback by the inter-engagement of resilient finger **128***a* of intensity controller **128** in detents **131** formed along an inner surface of right-half shell section **102***a*.

[0191] As seen in FIGS. **38**-**42**, housing **102** includes a series of indicia **31** provided thereon which are visible to the user and which reflect the relative level of intensity that is to be transmitted. Indicia **31** are provided alongside guide channels **130***a*, **130***b* and are spaced therealong to correspond substantially with detents **131** which provide the tactile feedback to intensity controller **128**.

[0192] As seen below in FIGS. **48** and **49**, an RF line **220** for transmitting RF energy to electrode **106** is provided and is directly electrically connected to electrode receptacle **104** for connection to proximal end **110** of electrode **106**. Since RF line **220** is directly connected to electrode receptacle **104**, RF line **220** bypasses VDN **127** and thus isolates VDN **127** and control wires **216***a*-**216***d*.

[0193] With reference to FIG. **49**, VDN **127** includes a first transmission line **127***a* for identifying the various modes of electrosurgical pencil **1000**; a second transmission line **127***b* for identifying the various intensities of electrosurgical pencil **1000**; a third transmission line **127***c* to function as a ground for VDN **127**; and a fourth transmission line **127***d* which transmits up to about +5 volts to VDN **127**.

[0194] VDN **127** includes a first variable resistor "R1" having a maximum resistance of 2000 ohms. First resistor

"R1" is a variable resistor which is represented in FIG. **49** as six (6) individual resistors "R1a-R1f" connected between third transmission line **127***c* and fourth transmission line **127***d*. Each resistor "R1a-R1f" of the first set of resistors has a resistance of 333 ohms. First resistor "R1" is selectively actuatable by intensity controller **128** at a plurality of locations along the length thereof. The locations along the length of the first resistor "R1" correspond to the detents **131** formed along the inner surface of right-half shell section **102***a*. (see FIG. **43**) These locations along the length of resistor "R1" are represented as a first set of switches "S1a-S1e". In operation, as intensity controller **128** is moved along first resistor "R1" the value of the resistance of first resistor "R1" is changed. The change of the resistance value of first resistor "R1" is represented in FIG. **49** as the closing of a switch "S1a-S1e". The change in resistance of first resistor "R1" causes a change in voltage which is measured by electrosurgical generator "G" which, in turn, transmits an RF energy at a unique intensity to electrosurgical pencil **1000**.

[0195] When intensity controller **128** is moved to a third of middle position along first resistor "R1", corresponding to switch "S1c", a "park position" is established in which no resistance is present. Accordingly, electrosurgical generator "G" measures a maximum voltage value of zero volts.

[0196] VDN **127** further includes a second variable resistor "R2" having a maximum resistance of 2000 ohms. Second resistor "R2" is represented in FIG. **49** as four (4) individual resistors "R2a-R2d" connected between third transmission line **127***c*, and fourth transmission line **127***d*. Resistor "R2a" has a resistance of 200 ohms, resistor "R2b" has a resistance of 550 ohms, resistor "R2c" has a resistance of 550 ohms, and resistor "R2d" has a resistance of 700 ohms.

[0197] Second resistor "R2" is selectively actuatable by any one of activation buttons **120***a*-**120***c*. The location where second resistor "R2" is actuated by an activation button **120***a*-**120***c* is represented as a second set of switches "S2a-S2c". In operation, depending on which switch "S2a-S2c" of the second set of switches "S2" is closed, by actuation of a particular activation button **120***a*-**120***c*, the value of the resistance of second resistor "R2" is changed. The change of the resistance value of second resistor "R2" causes a change in voltage which is measured by electrosurgical generator "G" which, in turn, activates and transmits a different mode of operation to electrosurgical pencil **1000**.

[0198] In operation, if more than one activation button **120***a*-**120***c* is actuated simultaneously (i.e., a "multi-key activation" scenario), electrosurgical generator "G" will measure a unique voltage which does not correspond to any preset known voltage stored therein and thus does not activate or transmit any mode of operation to electrosurgical pencil **1000**.

[0199] In use, depending on which activation button **120***a*-**120***c* is depressed a respective tactile element **122***a*-**122***c* is pressed, via a respective stem **123***a*-**123***c*, into contact with VDN **127**. The depressed activation button **120***a*-**120***c* electrically engages juxtaposed electrical contacts of VDN **127** thereby changing the value of the second resistor. Depending on the value of the resistance of the second resistor "R2" a characteristic voltage is generated and measured by electrosurgical generator "G" via first transmission line **127***a* and first control wire **216***a* (see FIGS. **48** and **49**).

[0200] In order to vary the intensity of the power parameters of electrosurgical pencil **100**, the surgeon displaces intensity controller **128** as described above, thereby changing the value of the first resistor "R1". Depending on the value of the resistance of first resistor "R1" a characteristic voltage is generated and measured by electrosurgical generator "G" via second transmission line **127***b* and second control wire **216***b* (see FIGS. **48** and **49**).

[0201] Turning back to FIG. **38**, electrosurgical pencil **100** is coupled to electrosurgical generator "G" via a plug assembly **200**. As seen in FIGS. **38** and **47**-**49**, plug assembly **200** includes a housing portion **202**, and a connecting cable **224** electrically interconnecting housing portion **202** to device **1000**.

[0202] Housing portion **202** includes a first half-section **202***a* and a second half-section **202***b* operatively engageable with one another. A power pin **204** of plug assembly **200** extends distally from housing portion **202**. Power pin **204** is positioned off center of housing portion **202**. Plug assembly **200** further includes a pair of position pins **212** also extending from housing portion **202**. A first position pin **212***a* is positioned in close proximity to a center of housing portion **202** and a second position pin **212***b* is positioned to be off center of and in close proximity to an opposite side edge of housing portion **202** as compared to power pin **204**.

[0203] Plug assembly **200** further includes a prong **214** extending from housing portion **202**. Prong **214** is positioned between power pin **204** and first position pin **212***a*. Prong **214** is configured and adapted to retain electrical contacts **206** therein such that a portion of each contact **206** is exposed along a front or distal edge thereof.

[0204] Since prong **214** extends from between power pin **204** and first position pin **212***a* housing portion **202** of plug assembly **200** will not enter connector receptacle "R" of electrosurgical generator "G" unless housing portion **202** is in a proper orientation.

[0205] Connecting cable **224** includes an RF line **220** electrically connected to power pin **204**, and control wires **216***a*-**216***d* electrically connected to a respective contact **206**. Each control wire **216***a*-**216***d* is attached individually and separately to a respective contact **206** of prong **214**.

[0206] Electrosurgical pencil **1000** includes smart recognition technology provided on plug **200** which communicates with the generator "G" to identify the electrosurgical pencil and communicate various surgical parameters which relate to treating tissue with electrosurgical pencil **100**. As seen in FIGS. **38** and **47**, the smart recognition technology includes an Aztec code **240** (see FIG. **47** above) which is optically readable by the generator "G" and which identifies electrosurgical pencil **1000** and which presets the generator "G" to default parameters associated with treating tissue with this particular electrosurgical pencil **1000**.

[0207] As seen in FIG. **45**, open distal end **103***a* of electrosurgical pencil **100** defines a non-circular inner profile **305**. Meanwhile, electrode **106** is supported in a collar **310** having a shaped outer surface **310***a* configured and dimensioned to complement the inner profile **305** of open distal end **103***a*. Open distal end **103***a* of housing **102** defines a hexagonal inner profile **305** and collar **310** defines a hexagonal shaped outer surface **310***a*.

[0208] It is also envisioned that the current controls may be based on current density or designed to deliver a specific current for a defined surface area (amp/cm^2).

[0209] Although the subject apparatus has been described with respect to preferred embodiments, it will be readily apparent, to those having ordinary skill in the art to which it appertains, that changes and modifications may be made thereto without departing from the spirit or scope of the subject apparatus.

What is claimed is:

1. An electrosurgical system, comprising:
  - an electrosurgical generator; and
  - an electrosurgical pencil selectively connectable to the electrosurgical generator, the electrosurgical pencil including:
    - an elongated housing;
    - at least one electrocautery end effector removably supportable within the housing and extending distally from the housing, the electrocautery end effector being connected to the electrosurgical generator; and
    - at least one voltage divider network supported on the housing, the at least one voltage divider network being electrically connected to the electrosurgical generator and controlling at least one of the intensity of electrosurgical energy being delivered to the electrosurgical pencil and the mode of electrosurgical energy being delivered to the electrosurgical pencil;
    - wherein the voltage divider network generates a plurality of characteristic voltages which are measurable by the electrosurgical generator and which electrosurgical generator in turn transmits a corresponding waveform duty cycle at a particular intensity to the electrocautery end effector of the electrosurgical pencil.

2. The electrosurgical system according to claim **1**, wherein the voltage divider network generates:
  - a first characteristic voltage which when measured by the electrosurgical generator causes the electrosurgical generator to transmit a waveform duty cycle which produces a cutting effect;
  - a second characteristic voltage which when measured by the electrosurgical generator causes the electrosurgical generator to transmit a waveform duty cycle which produces a division with hemostatic effect; and
  - a third characteristic voltage which when measured by the electrosurgical generator causes the electrosurgical generator to transmit a waveform duty cycle which produces a coagulating effect.

3. The electrosurgical system according to claim **2**, wherein the voltage divider network generates a series of characteristic voltages which when measured by the electrosurgical generator cause the electrosurgical generator to transmit the particular waveform duty cycle at a corresponding level of intensity.

4. The electrosurgical system according to claim **3**, wherein the electrosurgical pencil includes a plurality of activation buttons supported on the housing, wherein each activation button is operatively associated with the voltage divider network.

5. The electrosurgical system according to claim **4**, wherein each activation button is actuatable to cause the voltage divider network to generate a respective one of the characteristic voltages for transmission of a corresponding waveform duty cycle.

6. The electrosurgical system according to claim **5**, wherein the electrosurgical pencil includes an intensity controller supported in the housing, wherein the intensity controller is operatively associated with the voltage divider network.

7. The electrosurgical system according to claim **6**, wherein the intensity controller is actuatable to cause the voltage divider network to generate a respective one of the series of characteristic voltages for transmission of the waveform duty cycle at a corresponding intensity level.

8. The electrosurgical system according to claim **7**, wherein the intensity controller is slidably supported in the housing of the electrosurgical pencil.

9. The electrosurgical system according to claim **8**, wherein the division with hemostatic effect has a waveform with a duty cycle of from about 12% to about 75%; the coagulation effect has a waveform with a duty cycle of from about 1% to about 12%; and the cutting effect has a waveform with a duty cycle of from about 75% to about 100%.

10. The electrosurgical system according to claim **1**, wherein the voltage divider network is a film-type potentiometer.

11. The electrosurgical system according to claim **1**, wherein the voltage divider network includes a pair of layers each supporting a plurality of electrical contacts thereon, wherein the electrical contacts from an upper layer of the voltage divider network are in juxtaposed electrical relation with respect to the electrical contacts from a lower layer of the voltage divider network.

12. The electrosurgical system according to claim **11**, wherein the voltage divider network includes a dividing layer interposed between the upper and lower layers, wherein the dividing layer includes a first series of apertures formed therein which are in vertical registration with the electrical contacts of the upper and lower layers.

13. The electrosurgical system according to claim **12**, wherein the dividing layer includes a second aperture formed therein which is in vertical registration between electrical contacts provided on the upper layer and a variable resistance element provided on the lower layer.

14. An electrosurgical instrument, comprising:
  - an elongated housing;
  - at least one electrocautery end effector removably supportable within the housing and extending distally from the housing, the electrocautery end effector being connectable to an electrosurgical generator; and
  - at least one voltage divider network supported on the housing, the at least one voltage divider network being electrically connectable to the electrosurgical generator, the at least one voltage divider network being capable of controlling at least one of the intensity of electrosurgical energy being delivered to the electrosurgical pencil and the mode of electrosurgical energy being delivered to the electrosurgical instrument;
  - wherein the voltage divider network generates a plurality of characteristic voltages which are measurable by the electrosurgical generator and which electrosurgical generator in turn transmits a corresponding waveform duty cycle at a particular intensity to the electrocautery end effector of the electrosurgical instrument.

15. The electrosurgical instrument according to claim **14**, wherein the voltage divider network generates:
  - a first characteristic voltage which when measured by the electrosurgical generator causes the electrosurgical generator to transmit a waveform duty cycle which produces a cutting effect;
  - a second characteristic voltage which when measured by the electrosurgical generator causes the electrosurgical generator to transmit a waveform duty cycle which produces a division with hemostatic effect; and

- a third characteristic voltage which when measured by the electrosurgical generator causes the electrosurgical generator to transmit a waveform duty cycle which produces a coagulating effect.

16. The electrosurgical instrument according to claim **15**, wherein the voltage divider network generates a series of characteristic voltages which when measured by the electrosurgical generator cause the electrosurgical generator to transmit the particular waveform duty cycle at a corresponding level of intensity.

17. The electrosurgical instrument according to claim **16**, wherein the electrosurgical instrument includes a plurality of activation buttons supported on the housing, wherein each activation button is operatively associated with the voltage divider network.

18. The electrosurgical instrument according to claim **17**, wherein each activation button is actuatable to cause the voltage divider network to generate a respective one of the characteristic voltages for transmission of a corresponding waveform duty cycle.

19. The electrosurgical instrument according to claim **18**, wherein the electrosurgical instrument includes an intensity controller supported in the housing, wherein the intensity controller is operatively associated with the voltage divider network.

20. The electrosurgical instrument according to claim **19**, wherein the intensity controller is actuatable to cause the voltage divider network to generate a respective one of the series of characteristic voltages for transmission of the waveform duty cycle at a corresponding intensity level.

21. The electrosurgical instrument according to claim **20**, wherein the intensity controller is slidably supported in the housing of the electrosurgical instrument.

22. The electrosurgical instrument according to claim **21**, wherein the division with hemostatic effect has a waveform with a duty cycle of from about 12% to about 75%; the coagulation effect has a waveform with a duty cycle of from about 1% to about 12%; and the cutting effect has a waveform with a duty cycle of from about 75% to about 100%.

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