United States Patent Application Publication	20250261988
Kind Code	A1
Publication Date	August 21, 2025
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Electrosurgical Instrument

Abstract

An example electrosurgical instrument includes a housing extending from a proximal end to a distal end, an electrosurgical electrode extending from the distal end of the housing, and a user activation device disposed between the proximal end of the housing and the distal end of the housing. The user activation device is operable to control a supply of electrosurgical energy to the electrosurgical electrode. The user activation device includes a collar that extends around at least a half of a circumference of the housing. The collar is movable between a home position relative to the housing and a first activation position relative to the housing. The user activation device also includes a switch that is configured to control the supply of electrosurgical energy to the electrosurgical electrode responsive to the collar moving from the home position to the first activation position.

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Family ID:	**1000008576222**
Appl. No.:	**18/854872**
Filed (or PCT Filed):	**April 11, 2023**
PCT No.:	**PCT/IB2023/000195**

Related U.S. Application Data

us-provisional-application US 63329738 20220411
us-provisional-application US 63428310 20221128

Publication Classification

Int. Cl.: **A61B18/14** (20060101); **A61B17/00** (20060101); **A61B18/00** (20060101)

U.S. Cl.:

CPC **A61B18/148** (20130101); A61B2017/0042 (20130101); A61B2017/00526 (20130101); A61B2018/00607 (20130101); A61B2018/00708 (20130101); A61B2018/00922 (20130101); A61B2018/00946 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application claims the benefit of priority to U.S. Provisional Application No. 63/329,738, filed Apr. 11, 2022, and U.S. Provisional Application No. 63/428,310, filed Nov. 28, 2022, the contents of which applications are hereby incorporated by reference in their entirety.

BACKGROUND
[0002] Electrosurgery involves applying a radio frequency (RF) electric current (also referred to as electrosurgical energy) to biological tissue to cut, coagulate, or modify the biological tissue during an electrosurgical procedure. Specifically, an electrosurgical generator generates and provides the electric current to an active electrode, which applies the electric current (and, thus, electrical power) to the tissue. The electric current passes through the tissue and returns to the generator via a return electrode (also referred to as a “dispersive electrode”). As the electric current passes through the tissue, an impedance of the tissue converts a portion of the electric current into thermal energy (e.g., via the principles of resistive heating), which increases a temperature of the tissue and induces modifications to the tissue (e.g., cutting, coagulating, ablating, and/or sealing the tissue).

Description

BRIEF DESCRIPTION OF THE FIGURES
[0003] The novel features believed characteristic of the illustrative embodiments are set forth in the appended claims. The illustrative embodiments, however, as well as a preferred mode of use, further objectives and descriptions thereof, will best be understood by reference to the following detailed description of an illustrative implementation of the present disclosure when read in conjunction with the accompanying figures, wherein:
[0004] FIG. **1** depicts a simplified block diagram of an electrosurgical system, according to an example.
[0005] FIG. **2**A depicts an electrosurgical instrument of FIG. **1** with a collar in a home position, according to an example.
[0006] FIG. **2**B depicts the electrosurgical instrument of FIG. **2**A with the collar in a first activation position, according to an example.
[0007] FIG. **2**C depicts the electrosurgical instrument of FIG. **2**A with the collar in the second activation position, according to the example.
[0008] FIG. **3**A depicts an electrosurgical instrument of FIG. **1** with a collar in a home position, according to another example.
[0009] FIG. **3**B depicts the electrosurgical instrument of FIG. **3**A with the collar in a first activation position, according to an example.
[0010] FIG. **3**C depicts the electrosurgical instrument of FIG. **3**A with the collar in the second activation position, according to the example.
[0011] FIG. **4**A depicts an electrosurgical instrument of FIG. **1** with a collar in a home position,

according to another example.
[0012] FIG. **4**B depicts the electrosurgical instrument of FIG. **4**A with the collar in a first activation position, according to an example.
[0013] FIG. **4**C depicts the electrosurgical instrument of FIG. **4**A with the collar in the second activation position, according to the example.
[0014] FIG. **5**A depicts an electrosurgical instrument of FIG. **1** with a collar in a home position, according to another example.
[0015] FIG. **5**B depicts the electrosurgical instrument of FIG. **5**A with the collar in a first activation position, according to an example.
[0016] FIG. **5**C depicts the electrosurgical instrument of FIG. **5**A with the collar in the second activation position, according to the example.
[0017] FIG. **6**A depicts a perspective view of a first example implementation of the electrosurgical instrument shown in FIG. **1**, according to another example.
[0018] FIG. **6**B depicts a side view of the electrosurgical instrument shown in FIG. **6**A, according to an example.
[0019] FIG. **6**C depicts a perspective view of a second example implementation of the electrosurgical instrument shown in FIG. **1**, according to another example.
[0020] FIG. **6**D depicts a side view of the electrosurgical instrument shown in FIG. **6**C, according to an example.
[0021] FIG. **6**E depicts a distal end of a shaft of the electrosurgical instrument of FIGS. **6**A-**6**D with a suction sleeve removed, according to an example.
[0022] FIG. **7**A depicts a perspective view of a user activation device including collar having a plurality of independently movable segments, according to an example.
[0023] FIG. **7**B depicts a side view of the collar and a plurality of switches for the user activation device shown in FIG. **7**A, according to an example.
[0024] FIG. **7**C depicts the collar of FIG. **7**A in a first activation position, according to an example.
[0025] FIG. **7**D depicts the collar of FIG. **7**A in a second activation position, according to the example.
[0026] FIG. **8** depicts a flowchart for a method for operating an electrosurgical instrument, according to an example.
[0027] FIG. **9** depicts a flowchart for a method of operating an electrosurgical instrument that can be used with the method shown in at least FIG. **8**, according to an example.
[0028] FIG. **10** depicts a flowchart for a method of operating an electrosurgical instrument that can be used with the method shown in at least FIG. **8**, according to an example.
[0029] FIG. **11** depicts a flowchart for a method of operating an electrosurgical instrument that can be used with the method shown in at least FIG. **10**, according to an example.
[0030] FIG. **12** depicts a flowchart for a method of operating an electrosurgical instrument that can be used with the method shown in at least FIG. **11**, according to an example.
[0031] FIG. **13** depicts a flowchart for a method of operating an electrosurgical instrument that can be used with the method shown in at least FIG. **8**, according to an example.
[0032] FIG. **14** depicts a flowchart for a method of operating an electrosurgical instrument that can be used with the method shown in at least FIG. **8**, according to an example.
[0033] FIG. **15** depicts a flowchart for a method of operating an electrosurgical instrument that can be used with the method shown in at least FIG. **8**, according to an example.
[0034] FIG. **16** depicts a flowchart for a method of operating an electrosurgical instrument that can be used with the method shown in at least FIG. **8**, according to an example.
[0035] FIG. **17** depicts a flowchart for a method for operating an electrosurgical instrument, according to an example.
[0036] FIG. **18** depicts a simplified block diagram of an electrosurgical system, according to an example.

[0037] FIG. **19**A depicts a side view of an electrosurgical device, according to an example.
[0038] FIG. **19**B depicts a perspective view of the electrosurgical device of FIG. **19**A, according to an example.
[0039] FIG. **19**C depicts a cross-sectional view of the electrosurgical device of FIG. **19**A, according to an example.
[0040] FIG. **20** illustrates an example implementation of an electrosurgical device, according to an example.
[0041] FIG. **21** depicts a flowchart for a method for operating an electrosurgical device, according to an example.
[0042] FIG. **22** depicts a simplified block diagram of a surgical instrument, according to an example.

DESCRIPTION

[0043] Disclosed examples will now be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all of the disclosed examples are shown. Indeed, several different examples may be described and should not be construed as limited to the examples set forth herein. Rather, these examples are described so that this disclosure will be thorough and complete and will fully convey the scope of the disclosure to those skilled in the art.
[0044] By the term “approximately” or “substantially” with reference to amounts or measurement values described herein, it is meant that the recited characteristic, parameter, or value need not be achieved exactly, but that deviations or variations, including for example, tolerances, measurement error, measurement accuracy limitations and other factors known to those of skill in the art, may occur in amounts that do not preclude the effect the characteristic was intended to provide.
[0045] During an electrosurgical operation, it may be beneficial to adjust a rotational position of an electrosurgical electrode relative to a position of a user activation device on a handle of an electrosurgical instrument. This can allow a user to comfortably grip the handle in a position in which their fingers can comfortably operate the user activation devices while the electrosurgical electrode is set at a rotational position selected from among a plurality of rotational positions relative to the handle based on, for example, a location, a size, and/or a shape of a surgical site in which the user is operating. Conventionally, this is accomplished by stopping an operation, manually rotating the electrosurgical electrode relative to the handle using both of the user's hands (e.g., one hand to hold the handle and the other hand to rotate the electrosurgical electrode), and then resuming the operation.
[0046] The present disclosure provides for electrosurgical instruments that can address at least some of the challenges associated with electrosurgical instruments that require manual adjustment of the electrosurgical electrode relative to the handle. As disclosed herein, electrosurgical instruments, such as electrosurgical pencils, allow a user to operate a user activation device from multiple angles or approaches.
[0047] In some examples, the user activation device can include a collar that extends around at least a half of a circumference of a housing the electrosurgical instrument and is movable relative to the housing between a home position on the housing and at least a first activation position on the housing. The user activation device also includes a switch, and the collar can move relative to the switch (e.g., collar can slide over the switch). The switch is configured to prevent a supply of electrosurgical energy to an electrosurgical electrode when the collar is in the home position, and cause the supply of the electrosurgical energy to the electrosurgical electrode when the collar is in the first activation position. Because the collar extends around at least half of the circumference of the housing, the switch can be operated in a plurality of rotational orientations of the housing relative to the hand of the user and regardless of a position of the hand of the user relative to the switch underlying the collar. This provides the user with the capability of holding an electrosurgical instrument in a manner that yields a preferred position and orientation for performing an electrosurgical operation (e.g., cutting, coagulation, etc.) at a surgical site, while comfortably

operating the user activation device according to the mode of operation. Advantageously, this reduces the need to stop and restart a surgical procedure to allow the user to adjust the electrosurgical electrode to maintain the preferred position and orientation for the electrosurgical electrode. Furthermore, this user activation device provides ambidextrous functionality (i.e., accommodates operation by right or left hand).

[0048] In other examples, electrosurgical devices, such as electrosurgical pencils, allow a user to depress and operate a user activation device from multiple angles or approaches. For example, a multi-axial user activation device provides the user with the capability of holding an electrosurgical device in a manner that yields a preferred position and orientation for performing an electrosurgical operation (e.g., cutting, coagulation, etc.) at a surgical site, while comfortably operating the multi-axial user activation device according to the mode of operation. Advantageously, this reduces the need to stop and restart a surgical procedure to allow the user to adjust the electrosurgical electrode to maintain the preferred position and orientation for the electrosurgical electrode. Furthermore, this multi-axial user activation device provides ambidextrous functionality (i.e., accommodates operation by right or left hand).

[0049] Referring to FIG. **1**, an electrosurgical system **100** is shown according to an example. As shown in FIG. **1**, the electrosurgical system **100** includes an electrosurgical generator **110** and an electrosurgical instrument **112**. In general, the electrosurgical generator **110** can generate electrosurgical energy that is suitable for performing electrosurgery on a patient. For instance, the electrosurgical generator **110** can include a power converter circuit **114** that can convert a grid power to electrosurgical energy such as, for example, a radio frequency (RF) output power. As an example, the power converter circuit **114** can include one or more electrical components (e.g., one or more transformers) that can control a voltage, a current, and/or a frequency of the electrosurgical energy.

[0050] Within examples, the electrosurgical generator **110** can include a user interface **116** that can receive one or more inputs from a user and/or provide one or more outputs to the user. As examples, the user interface **116** can include one or more buttons, one or more switches, one or more dials, one or more keypads, one or more touchscreens, one or more display screens, one or more indicator lights, one or more speakers, and/or one or more haptic output devices.

[0051] In an example, the user interface **116** can be operable to select a mode of operation from among a plurality of modes of operation for the electrosurgical generator **110**. As examples, the modes of operation can include a cutting mode, a coagulating mode, an ablating mode, and/or a sealing mode. Combinations of these waveforms can also be formed to create blended modes. In one implementation, the modes of operation can correspond to respective waveforms for the electrosurgical energy. As such, in this implementation, the electrosurgical generator **110** can generate the electrosurgical energy with a waveform selected from a plurality of waveforms based, at least in part, on the mode of operation selected using the user interface **116**.

[0052] The electrosurgical generator **110** can also include one or more sensors **118** that can sense one or more conditions related to the electrosurgical energy and/or the target tissue. As examples, the sensor(s) **118** can include one or more current sensors, one or more voltage sensors, one or more temperature sensors, and/or one or more bioimpedance sensors. Within examples, the electrosurgical generator **110** can additionally or alternatively generate the electrosurgical energy with an amount of electrosurgical energy (e.g., an electrical power) and/or a waveform selected from among the plurality of waveforms based on one or more parameters related to the condition(s) sensed by the sensor(s) **118**.

[0053] In one example, the electrosurgical energy can have a frequency that is greater than approximately 100 kilohertz (kHz) to reduce (or avoid) stimulating a muscle and/or a nerve near the target tissue. In another example, the electrosurgical energy can have a frequency that is between approximately 300 kHz and approximately 500 kHz.

[0054] In FIG. **1**, the electrosurgical generator **110** also includes a connector **120** that can facilitate

coupling the electrosurgical generator **110** to the electrosurgical instrument **112**. For example, the electrosurgical instrument **112** can include a power cord **122** having a plug, which can be coupled to a socket of the connector **120** of the electrosurgical generator **110**. In this arrangement, the electrosurgical generator **110** can supply the electrosurgical energy to the electrosurgical instrument **112** via the coupling between the connector **120** of the electrosurgical generator **110** and the power cord **122** of the electrosurgical instrument **112**.

[0055] The electrosurgical generator **110** can further include a controller **141** that can control operation of the electrosurgical generator **110**. Within examples, the controller **141** can be implemented using hardware, software, and/or firmware. For instance, the controller **141** can include one or more processors and a non-transitory computer readable medium (e.g., volatile and/or non-volatile memory) that stores machine language instructions or other executable instructions. The instructions, when executed by the one or more processors, cause the electrosurgical generator **110** to carry out the various operations described herein. The controller **141**, thus, can receive data and store the data in the memory as well. As shown in FIG. **1**, the controller **141** can be communicatively coupled with the power converter circuit **114**, the user interface **116**, the generator sensor(s) **118**, and/or the connector **120**.

[0056] As shown in FIG. **1**, the electrosurgical instrument **112** can include a housing **123**. The housing **123** can be an elongated structure in and/or on which components of the electrosurgical instrument **112** can be disposed. In some examples, the housing **123** can be an integral, monolithic structure. In other examples the housing **123** can include a plurality of structures that are coupled to each other.

[0057] In FIG. **1**, the housing **123** includes a handle **124** that defines an interior bore, a shaft **126** extending in a distal direction from the handle **124**, and an electrosurgical electrode **128** coupled to the shaft **126**. In general, the handle **124** can be configured to facilitate a user gripping and manipulating the electrosurgical instrument **112** while performing electrosurgery. For example, the handle **124** can have a shape and/or a size that can facilitate a user performing electrosurgery by manipulating the electrosurgical instrument **112** using a single hand. In one implementation, the handle **124** can have a shape and/or a size that facilitates the user holding the electrosurgical instrument **112** in a writing utensil gripping manner (e.g., the electrosurgical instrument **112** can be an electrosurgical pencil).

[0058] Additionally, for example, the handle **124** and/or the shaft **126** can be constructed from one or more materials that are electrical insulators (e.g., a plastic material). This can facilitate insulating the user from the electrosurgical energy flowing through the electrosurgical instrument **112** while performing the electrosurgery.

[0059] In some implementations, the shaft **126** can be coupled to the handle **124** in a fixed and non-moveable manner. This may simplify manufacturing and reduce a cost of manufacture by, for instance, simplifying electrical connections that may otherwise need to account for movement of the shaft **126** and the handle **124** relative to each other (e.g., by omitting slip ring electrical contacts and/or sliding electrical contacts). In one example, the handle **124** and the shaft **126** can be formed as a single, monolithic structure such that the shaft **126** and the handle **124** are fixed and non-moveable relative to each other. In another example, the handle **124** and the shaft **126** can be fixedly coupled to each other by a welding coupling, an adhesive coupling, and/or another coupling that prevents movement between the handle **124** and the shaft **126**.

[0060] In other implementations, the shaft **126** can be telescopically moveable relative to the handle **124**. For example, the shaft **126** can be telescopically moveable in the interior bore defined by the handle **124** to extend the shaft **126** in the distal direction and retract the shaft **126** in a proximal direction relative to the handle **124** (e.g., movable along a longitudinal axis of the electrosurgical instrument **112**). In some examples, the electrosurgical electrode **128** can be coupled to the shaft **126** and, thus, the electrosurgical electrode **128** can move together with the shaft **126** in an axial direction along the longitudinal axis relative to the handle **124**. This can provide for

adjusting a length of the electrosurgical instrument **112**, which can facilitate performing electrosurgery at a plurality of different depths within tissue (e.g., due to different anatomical shapes and/or sizes of patients) and/or at a plurality of different angles. In other examples, the electrosurgical electrode **128** can be fixedly coupled to the handle **124** such that the shaft **126** is axially movable relative to both the electrosurgical electrode **128** and the handle **124**.

[0061] The electrosurgical electrode **128** can be rotationally fixed relative to the handle **124** and/or the shaft **126**. This may, for example, help to simplify manufacturing and reduce a cost of manufacture by, for instance, simplifying electrical connections that may otherwise need to account for movement of the shaft **126** and the handle **124** relative to each other (e.g., by omitting slip ring electrical contacts and/or sliding electrical contacts). As described in further detail below, the user activation device(s) of the electrosurgical instrument **112** described herein can help to reduce or obviate a need to rotate the electrosurgical electrode **128** relative to the handle **124** and/or the shaft **126**.

[0062] As shown in FIG. **1**, the electrosurgical instrument **112** can include one or more user activation devices **130** that are operable to control operation of the electrosurgical instrument **112** and/or the electrosurgical generator **110**. For instance, the user activation device(s) **130** can be operable to select between the modes of operation of the electrosurgical instrument **112** and/or the electrosurgical generator **110**. In one implementation, the user activation device(s) **130** can be configured to select between a cutting mode of operation and a coagulation mode of operation. Responsive to actuation of the user activation device(s) **130** of the electrosurgical instrument **112**, the electrosurgical instrument **112** can (i) receive the electrosurgical energy with a level of power and/or a waveform corresponding to the mode of operation selected via the user activation device(s) **130** and (ii) supply the electrosurgical energy to the electrosurgical electrode **128**.

[0063] The user activation device(s) **130** can be disposed between a proximal end of the housing **123** and a distal end of the housing **123**. As shown in FIG. **1**, the user activation device(s) **130** includes a collar **132** and one or more switches **134**. Within examples, the collar **132** extends around at least a half of a circumference of the housing **123**. This can allow a user to easily and quickly move a hand to a different rotational position on the housing **123** (e.g., on the handle **124**) to adjust a rotational orientation of the hand relative to the electrosurgical electrode **128** while allowing the user to continue to using a preferred grip for performing an electrosurgical operation (e.g., cutting, coagulation, etc.) at a surgical site. Advantageously, this reduces the need to stop and restart a surgical procedure to allow the user to adjust the electrosurgical electrode **128** to maintain the preferred position and orientation for the electrosurgical electrode **128** as required by the conventional electrosurgical instruments described above. Additionally or alternatively, the collar **132** extending around at least half of the circumference of the housing **123** can provide for ambidextrous functionality (i.e., accommodates operation by right or left hand).

[0064] In some examples, the collar **132** extends around an entirety of the circumference of the housing **123**. This can allow the user to hold the housing **123** in all rotational orientations relative to the hand (e.g., 360 degrees of rotational positions) while allowing the user to continue to using a preferred grip for performing an electrosurgical operation (e.g., cutting, coagulation, etc.) at a surgical site.

[0065] The collar **132** is movable between a home position relative to the housing **123** and a first activation position relative to the housing **123**. The switch(es) **134** are configured to control the supply of the electrosurgical energy to the electrosurgical electrode **128** responsive to the collar **132** moving from the home position to the first activation position. For example, responsive to the collar **132** moving from the home position to the first activation position, the switch(es) **134** can cause the electrosurgical energy to be supplied to the electrosurgical electrode **128** with a first waveform (e.g., for cutting tissue or for coagulating tissue). By contrast, when the collar **132** is in the home position, the switch(es) **134** can prevent the electrosurgical energy from being supplied to the electrosurgical electrode **128**.

[0066] In some examples, the user activation device **130** can also include a biasing member **136** that can bias the collar **132** towards the home position. The biasing member **136** can thus help to mitigate inadvertent supply of the electrosurgical energy to the electrosurgical electrode **128**. As examples, the biasing member **136** can include one or more components selected from among a group consisting of: a spring, a magnet, and a mechanical engagement between respective surfaces of the collar **132** and the housing **123** (e.g., ramped surfaces biasing the collar **132** toward the home position).

[0067] In some examples, the collar **132** can be further movable between the home position and a second activation position relative to the housing **123**. In such examples, the home position is between the first activation position and the second activation position. Responsive to the collar **132** moving from the home position to the second activation position, the switch(es) **134** can cause the electrosurgical energy to be supplied to the electrosurgical electrode **128** with a second waveform. The first waveform is different from the second waveform. For instance, in one example, the first waveform can be suitable for a cutting operation and the second waveform can be suitable for a coagulation operation. In another example, the first waveform can be suitable for a coagulation operation and the second waveform can be suitable for a cutting operation

[0068] In examples, in which the collar **132** is movable between the home position and the second activation position and the user activation device **130** includes the biasing member **136**, the biasing member **136** can be further configured to bias the collar **132** toward the home position from the first activation position and the second activation position. As described above, when the collar **132** is in the home position, the switch(es) **134** can prevent the electrosurgical energy from being supplied to the electrosurgical electrode **128**.

[0069] Within examples, the first activation position can be distal of the home position and the second activation position is proximal of the home position. Additionally, the collar **132** can be movable by sliding the collar **132** along an axis that is parallel or collinear with a longitudinal axis of the handle **124** (e.g., an axis extending between the proximal end and the distal end of the handle **124**).

[0070] In FIG. **1**, the electrosurgical instrument **112** includes a plurality of electrical components that facilitate supplying the electrosurgical energy, which the electrosurgical instrument **112** receives from the electrosurgical generator **110**, to the electrosurgical electrode **128**. For example, the electrosurgical instrument **112** can include at least one electrical component selected from a group of electrical components including: the switch(es) **134**, a printed circuit board **138** (e.g., a flexible printed circuit board), a housing conductor **140**, and/or a shaft conductor **142** that can provide a circuit for conducting the electrosurgical energy from the power cord **122** to the electrosurgical electrode **128**. One or more of the electrical components can be positioned in the inner bore defined by the handle **124** and/or in an inner cavity defined by the shaft **126**.

[0071] As described in further detail below with respect to FIGS. **2**A-**7**D, the collar **132** is operable to actuate the switch(es) **134**. As examples, the switch(es) **134** can include one or more components selected from a group consisting of: a rocker switch, a sensor (e.g., a hall effect sensor), a plurality of electrical contacts, and a plurality of piezoelectric devices.

[0072] The switch(es) **134** alone or in combination with the printed circuit board **138** can be operable to control a supply of the electrosurgical energy from the electrosurgical generator **110** to the electrosurgical electrode **128**. For instance, in one implementation, when collar **132** is moved to the first activation position, the switch(es) **134** can cause the printed circuit board **138** to transmit a signal to the electrosurgical generator **110** and cause the electrosurgical generator **110** to responsively supply the electrosurgical energy with a first level of power and/or the first waveform corresponding to a mode of operation associated with the first activation position. Additionally, when collar **132** is moved to the second activation position, the switch(es) **134** can cause the printed circuit board **138** to transmit a signal to the electrosurgical generator **110** and cause the electrosurgical generator **110** to responsively supply the electrosurgical energy with a second level

of power and/or the second waveform corresponding to a mode of operation associated with the second activation position.

[0073] In another implementation, moving the collar **132** to the first activation position and thereby actuating the switch(es) **134** can close the switch(es) **134** to complete a first circuit to the electrosurgical generator **110** to cause the electrosurgical generator **110** to responsively supply the electrosurgical energy with the first level of power and/or the first waveform corresponding to the mode of operation associated with the first activation position. In an example of this implementation including the second activation position, moving the collar **132** to the second activation position and thereby actuating the switch(es) **134** can close the switch(es) **134** to complete a second circuit to the electrosurgical generator **110** to cause the electrosurgical generator **110** to responsively supply the electrosurgical energy with the second level of power and/or the second waveform corresponding to a mode of operation associated with the second activation position. In some examples of this implementation, the printed circuit board **138** can be omitted.

[0074] In both example implementations, the electrosurgical energy supplied by the electrosurgical generator **110** can be supplied from (i) the power cord **122**, the printed circuit board **138**, and/or the switch(es) **134** to (ii) the electrosurgical electrode **128** by the housing conductor **140** and the shaft conductor **142**. As such, as shown in FIG. **1**, the printed circuit board **138** can be coupled to the power cord **122**, the housing conductor **140** can be coupled to the printed circuit board **138** and the shaft conductor **142**, and the shaft conductor **142** can be coupled to the electrosurgical electrode **128**. In this arrangement, the housing conductor **140** can conduct the electrosurgical energy (supplied to the housing conductor **140** via the printed circuit board **138**) to the shaft conductor **142**, and the shaft conductor **142** can conduct the electrosurgical energy to the electrosurgical electrode **128**. The switch(es) **134** can be coupled to the printed circuit board **138** in some examples.

[0075] In general, the housing conductor **140** and the shaft conductor **142** can each include one or more electrically conductive elements that provide an electrically conductive bus for supplying the electrosurgical energy to the electrosurgical electrode **128**. More particularly, the housing conductor **140** can include one or more electrically conductive elements of the handle **124** that can supply the electrosurgical energy to the shaft conductor **142**, and the shaft conductor **142** can include one or more electrically conductive elements of the shaft **126** that can supply the electrical energy from the housing conductor **140** to the electrosurgical electrode **128**. In some examples, the housing conductor **140** and the shaft conductor **142** can be coupled to each other in a manner that is suitable to maintain an electrical coupling between the housing conductor **140**, the shaft conductor **142**, and the electrosurgical electrode **128** while (i) the shaft **126** and/or the electrosurgical electrode **128** telescopically moves relative to the handle **124**, and/or (ii) the electrosurgical electrode **128** rotates relative to the handle **124**.

[0076] As noted above, the electrosurgical electrode **128** can apply the electrosurgical energy to a target tissue to perform an electrosurgical operation (e.g., cutting, coagulating, ablating, and/or sealing the target tissue). Within examples, the electrosurgical electrode **128** can include an electrosurgical substrate formed from an electrically conductive material. As an example, the electrically conductive material can be stainless steel.

[0077] The electrosurgical substrate can extend in an axial direction from a proximal end of the electrosurgical electrode **128** to a distal end of the electrosurgical electrode **128**. The proximal end of the electrosurgical electrode **128** can receive electrosurgical energy from the electrosurgical instrument **112** (e.g., via the housing conductor **140** and the shaft conductor **142** as described above), and a distal working portion of the electrosurgical electrode **128** can apply the electrosurgical energy to the target tissue. In one implementation, the electrosurgical substrate can include a shank portion that extends from the proximal end of electrosurgical electrode **128** to the distal working portion of the electrosurgical electrode **128**. The distal working portion can be configured to use the electrosurgical energy to at least one of cut or coagulate tissue in a monopolar

electrosurgical operation.
[0078] In some examples, the distal working portion can define an electrosurgical blade. For instance, the electrosurgical blade can include (i) a first lateral surface, (ii) a second lateral surface opposite the first lateral surface, (iii) a first major surface extending between the first lateral surface and the second lateral surface on a first side of the electrosurgical blade, and (iv) a second major surface extending between the first lateral surface and the second lateral surface on a second side of the electrosurgical blade that is opposite the first side. The first lateral surface and the second lateral surface have surface areas that are relatively small compared to surface areas of the first major surface and the second major surface such that a thickness (e.g., a dimension between the first major surface and the second major surface) of the electrosurgical blade is relatively small as compared to a length (e.g., a dimension extending between the proximal end and the distal end of the electrosurgical electrode **128**) and a width (e.g., a dimension between the first latera surface and the second lateral surface).
[0079] In some examples, the distal working portion of the electrosurgical electrode **128** can also include an outer layer of material covering at least a portion (or an entirety) of the electrosurgical substrate. For instance, the outer layer of material can be formed from at least one material selected from a group consisting of: a polymeric material, a fluorocarbon material (e.g., polytetrafluoroethylene (PTFE)), silicone, enamel, a ceramic material, and inorganic lubricant material (e.g., titanium nitride, zirconium nitride, titanium aluminum nitride, and nitron). The outer layer of material can help to, for example, inhibit eschar build-up and/or focus the electrosurgical energy to one or more portions of the electrosurgical electrode **128**.
[0080] In some examples, the distal working portion of the electrosurgical electrode **128** can additionally include an intermediate layer between the electrosurgical substrate and the outer layer. The intermediate layer can be configured to provide thermal conductivity to help mitigate heating of the outer layer leading to a breakdown of the outer layer. The intermediate layer can also be configured to maintain the electrical conductivity of the electrosurgical substrate such that the intermediate layer does not degrade the transmission of the electrosurgical energy from the electrosurgical substrate to the target tissue.
[0081] The intermediate layer can be an anisotropic thermally conductive material, whereby the in-plane (e.g., parallel to the electrode surface) thermal conductivity substantially exceeds the out-of-plane (e.g., perpendicular to the electrode surface) thermal conductivity. The anisotropic thermally conductive material having a coefficient of thermal expansion matched (or approximately 10% greater or approximately 10% lower) to the electrosurgical substrate and outer layer. As an example, this intermediate layer can include at least one material selected from a group consisting of pyrolytic graphite/carbon, graphene, and Molybdenum disulfide.
[0082] As shown in FIG. **1**, in some implementations, the electrosurgical instrument **112** can additionally include one or more light sources **144** that are configured to emit light. In some examples that include the light source(s) **144**, the user activation device **130** can be operable to cause the light source(s) **144** to generate light that can be emitted by the electrosurgical instrument **112** to illuminate an area of interest (e.g., a target tissue at the surgical site). In some implementations, the light source(s) **144** can be located at a distal end of the housing **123** and/or a distal end of the shaft **126** to directly provide light in a distal direction and illuminate a surgical distal of the electrosurgical electrode **128**.
[0083] In other implementations, as shown in FIG. **1**, the light source(s) **144** can be optically coupled to an optical structure **146**, which is configured to receive the light emitted by the light source(s) **144** and transmit the light in a distal direction toward a surgical site to illuminate the surgical site while performing electrosurgery using the electrosurgical electrode **128**. Although arranging the light source(s) **144** to directly illuminate a surgical field can help, for instance, to reduce a cost of manufacture, transmitting the light using the optical structure **146** can help to improve a quality of light transmitted from the electrosurgical instrument **112** (e.g., by providing

light with improved uniformity and/or reduced heat generation).
[0084] As examples, in implementations that include the optical structure **146**, the optical structure **146** can include at least one optical structure selected from among a group consisting of an optical lens, a non-fiber optic optical waveguide, and an optical fiber. When the optical structure **146** includes the optical lens (e.g., a parabolic reflector lens, an aspheric lens, and/or a Fresnel lens), the optical structure **146** can help to direct the light emitted by the light source **144** in the distal direction and thereby improve a quality of the light illuminating the surgical site. The optical structure **146** can additionally or alternatively include the non-fiber optic optical waveguide and/or the optical fiber to transmit the light over relatively large distances in the shaft **126**. For instance, the optical waveguide can transmit the light in the distal direction via total internal reflection. In such implementations, the optical waveguide can include a cladding and/or an air gap on an exterior surface of the optical waveguide to help facilitate total internal reflection. In some implementations, the non-fiber optic optical waveguide can be formed as a single, monolithic structure.
[0085] In some examples, the optical structure **146** can additionally or alternatively include other light shaping optical elements such as, for instance, a plurality of facets, one or more prisms, and/or one or more optical gratings. Although the optical structure **146** can help to improve a quality of the light directed to the surgical site, the electrosurgical instrument **112** can omit the optical structure **146** and instead emit the light from the light source **144** directly to the surgical field without transmitting the light through the optical structure **146** in other examples.
[0086] In FIG. **1**, the light source **144** can be coupled to the shaft **126**. As such, the light source **144** can also move telescopically with the shaft **126** relative to the handle **124**. However, in other examples, the light source **144** can be in the interior bore of the handle **124** and/or coupled to an exterior surface of the handle **124**. As examples, the light source **144** can include one or more light emitting diodes (LEDs), organic light emitting diodes (OLEDs), optical fibers, non-fiber optic waveguides, and/or lenses. Additionally, for example, the light source **144** can include a LED printed circuit board having one or more light sources (e.g., LEDs).
[0087] The optical structure **146** can be at a distal end of the shaft **126**. In some examples, the optical structure **146** can circumferentially surround the electrosurgical electrode **128** to emit the light distally around all sides of the electrosurgical electrode **128**. This can help to mitigate shadows and provide greater uniformity of illumination in all rotational alignments of the shaft **126** relative to the housing **123** and/or the electrosurgical instrument **112** relative to the target tissue. However, in other examples, the optical structure **146** can extend partially but not fully around the electrosurgical electrode **128**.
[0088] In implementations that include the light source **144**, the user activation device(s) **130**, the printed circuit board **138**, the switch(e)s **134**, the housing conductor **140**, and/or the shaft conductor **142** can additionally supply an electrical power from a direct current (DC) power source **148** to the light source **144**. In one example, the DC power source **148** can include a battery disposed in the handle **124**, the plug of the power cord **122**, and/or a battery receptacle located along the power cord **122** between the handle **124** and the plug. Although the electrosurgical instrument **112** includes the DC power source **148** in FIG. **1**, the DC power source **148** can be separate and distinct from the electrosurgical instrument **112** in other examples. For instance, in another example, the electrosurgical generator **110** can include the DC power source **148**.
[0089] Additionally, in implementations that include the light source **144**, the user activation device(s) **130** can be operable to cause the light source **144** to emit the light. For instance, in one example, moving the collar **132** to the first activation position can cause (i) the electrosurgical generator **110** to supply the electrosurgical energy with the first waveform to the electrosurgical electrode **128** and (ii) the DC power source **148** to supply DC power to the light source(s) **144**. This can provide for simultaneous illumination and electrosurgical operation. Additionally, in this example, moving the collar **132** to the second activation position can cause the electrosurgical

generator **110** to supply the electrosurgical energy with the first waveform to the electrosurgical electrode **128** without the DC power source **148** supplying DC power to the light source(s) **144**. Therefore, in this example, the same waveform of electrosurgical energy can be supplied in both the first activation position and the second activation position, but light can be emitted in only the first activation position and not the second activation position.

[0090] In another example, moving the collar **132** to the first activation position can cause (i) the electrosurgical generator **110** to supply the electrosurgical energy with the first waveform to the electrosurgical electrode **128** and (ii) the DC power source **148** to supply DC power to the light source(s) **144**. Additionally, in this example, moving the collar **132** to the second activation position can cause (i) the electrosurgical generator **110** to supply the electrosurgical energy with the second waveform to the electrosurgical electrode **128** and (ii) the DC power source **148** to supply DC power to the light source(s) **144**. Therefore, in this example, the user activation device(s) **130** cause light to be emitted in both the first activation position and the second activation, but with different waveforms of the electrosurgical energy supplied.

[0091] In yet another example, the user activation device(s) **130** can include a button that independently controls the light source(s) 144 separate from the collar **132** and the switch(es) **134** that control the electrosurgical operational modes of the electrosurgical instrument **112**.

[0092] As shown in FIG. **1**, responsive to operation of the user activation device(s) **130** to actuate the light source **144**, the DC power source **148** can supply the electrical power (e.g., a DC voltage) to the light source(es) **144** via the printed circuit board **138**, the housing conductor **140**, and/or the shaft conductor **142**. In this implementation, one or more of the conductive elements of the housing conductor **140** can be configured to supply the electrical power from the DC power source **148** to the light source(s) **144** and/or return the electrical power from the light source(s) **144** to the DC power source **148**. Accordingly, the housing conductor **140** can additionally or alternatively assist in providing electrical communication between the DC power source **148** and the light source(s) **144** as the shaft **126** and the light source(s) **144** telescopically move relative to the handle **124**.

[0093] Although the user activation device(s) **130** on the handle **124** can be operated to control the operation of the light source(s) **144** in the examples described above, the light source(s) **144** can be additionally or alternatively operated by one or more user activation device(s) on the electrosurgical generator **110** (e.g., via the user interface **116**) and/or on the plug of the power cord **122**.

[0094] In some examples, the electrosurgical instrument **112** can additionally or alternatively include features that provide for evacuating surgical smoke from a target tissue to a location external to the surgical site. Surgical smoke is a by-product of various surgical procedures. For example, during surgical procedures, surgical smoke may be generated as a by-product of electrosurgical units (ESU), lasers, electrocautery devices, ultrasonic devices, and/or other powered surgical instruments (e.g., bones saws and/or drills). In some instances, the surgical smoke may contain toxic gases and/or biological products that result from a destruction of tissue. Additionally, the surgical smoke may contain an unpleasant odor. For these and other reasons, many guidelines indicate that exposure of surgical personnel to surgical smoke should be reduced or minimized.

[0095] To reduce (or minimize) exposure to surgical smoke, a smoke evacuation system may be used during the surgical procedure. In general, the smoke evacuation system may include a suction pump **150** that can generate sufficient suction and/or vacuum pressure to draw the surgical smoke away from the surgical site. In some implementations, the smoke evacuation system may be coupled to an exhaust system (e.g., an in-wall exhaust system) that exhausts the surgical smoke out of an operating room. In other implementations, the smoke evacuation system may filter air containing the surgical smoke and return the air to the operating room. Within examples, the suction pump **150** and the electrosurgical generator **110** can be provided as separate devices or integrated in a single device (e.g., in a common housing).

[0096] As shown in FIG. **1**, the shaft **126** can include a smoke evacuation channel **152** in the inner

cavity of the shaft **126**. The smoke evacuation channel **152** can also include a smoke inlet that can extend circumferentially around a center axis of a distal portion of the electrosurgical electrode **128**. In this arrangement, the smoke inlet of the smoke evacuation channel can help to receive surgical smoke into the smoke evacuation channel **152** in all rotational alignments of the electrosurgical electrode **128** relative to the handle **124** and/or the electrosurgical instrument **112** relative to the target tissue. However, in another example, the smoke evacuation channel **152** can include one or more smoke inlets that do not extend circumferentially around the electrosurgical electrode **128**.

[0097] In an example, the smoke evacuation channel **152** of the shaft **126** defines a first portion of a smoke flow path, and the interior bore **125** of the handle **124** defines a second portion of a smoke flow path. In this arrangement, the surgical smoke can be received from the surgical site into the smoke evacuation channel **152** of the shaft **126**, and flow proximally along the smoke evacuation channel **152** to the interior bore **125** of the handle **124**. In the interior bore **125** of the handle **124**, the smoke can further flow to a smoke tube **154** that is coupled to a proximal end of the handle **124** and configured to convey smoke from the handle **124** to the suction pump **150**.

[0098] Additionally, in some implementations that provide for surgical smoke evacuation, the user activation device(s) **130** can be operable to cause the suction pump **150** to generate suction. For instance, in one example, moving the collar **132** to the first activation position can cause (i) the electrosurgical generator **110** to supply the electrosurgical energy with the first waveform to the electrosurgical electrode **128** and (ii) the suction pump **150** to generate suction. This can provide for simultaneous smoke evacuation and electrosurgical operation. Additionally, in this example, moving the collar **132** to the second activation position can cause the electrosurgical generator **110** to supply the electrosurgical energy with the first waveform to the electrosurgical electrode **128** without the suction pump **150** generating suction. Therefore, in this example, the same waveform of electrosurgical energy can be supplied in both the first activation position and the second activation position, but suction can be generated in only the first activation position and not the second activation position.

[0099] In another example, moving the collar **132** to the first activation position can cause (i) the electrosurgical generator **110** to supply the electrosurgical energy with the first waveform to the electrosurgical electrode **128** and (ii) the suction pump **150** to generate suction. Additionally, in this example, moving the collar **132** to the second activation position can cause (i) the electrosurgical generator **110** to supply the electrosurgical energy with the second waveform to the electrosurgical electrode **128** and (ii) the suction pump **150** to generate suction. Therefore, in this example, the suction pump **150** can generate suction in both the first activation position and the second activation, but with different waveforms of the electrosurgical energy supplied.

[0100] In other examples, the suction pump **150** can be activated and/or deactivated responsive to a user input on the suction pump **150** and/or responsive to a sensor signal. For instance, a sensor can be positioned along the smoke flow path and configured to generate the sensor signal responsive to the sensor detecting a presence and/or greater than a threshold amount of smoke.

[0101] FIGS. **2**A-**2**C depict an implementation of the electrosurgical instrument **112** shown and described above with respect to FIG. **1**, according to an example. In particular, FIG. **2**A depicts the electrosurgical instrument **112** with the collar **132** in the home position, FIG. **2**B depicts the electrosurgical instrument **112** with the collar **132** in the first activation position, and FIG. **2**C depicts the electrosurgical instrument **112** in the second activation position, according to the example.

[0102] As shown in FIGS. **2**A-**2**C, the housing **123** extends from a proximal end **223**A to a distal end **223**B, and the electrosurgical electrode **128** extends from the distal end **223**B of the housing **123**. The user activation device **130** disposed between the proximal end **223**A of the housing **123** and the distal end **223**B of the housing **123**, and the user activation device **130** is operable to control a supply of electrosurgical energy to the electrosurgical electrode **128**.

[0103] In this example, the user activation device **130** includes the collar **132** that extends around an entirety of the circumference of the housing **123**. However, as described above, the collar **132** can extend around at least a half of a circumference of the housing **123** in other examples (e.g., the collar **132** can extend around a portion of the circumference of the housing **123** that is between 50 percent to 100 percent of the circumference of the housing **123**). Also, in FIGS. **2**A-**2**C, the housing **123** can have a circular cross-sectional shape or a non-circular cross-sectional shape.
[0104] As shown in FIGS. **2**A-**2**C, the user activation device **130** also includes the switch **134** configured to control the supply of the electrosurgical energy to the electrosurgical electrode responsive to the collar **132** moving from the home position (shown in FIG. **2**A) to the first activation position (shown in FIG. **2**B) and/or the second activation position (shown in FIG. **2**C), as described above. In this example, the switch **134** includes a rocker switch that is mechanically actuatable between a first position (shown in FIG. **2**A), a second position (shown in FIG. **2**B), and a third position (shown in FIG. **2**C). The collar **132** is configured to slide over and mechanically engage the switch **134** such that (i) the switch **134** is in the first position when the collar **132** is in the home position as shown in FIG. **2**A, (ii) the switch **134** is in the second position when the collar **132** is in the first activation position as shown in FIG. **2**B, and (iii) the switch **134** is in the third position when the collar **132** is in the second activation position as shown in FIG. **2**C.
[0105] For instance, the rocker switch can include a rocker paddle **234**A, a first contact **234**B, and a second contact **234**C. When the switch **134** is in the first position corresponding to the home position of the collar **132**, the rocker paddle **234**A does not depress the first contact **234**B or the second contact **234**C as shown in FIG. **2**A. When the switch **134** is in the second position corresponding to the first activation position of the collar **132**, the rocker paddle **234**A depresses the first contact **234**B as shown in FIG. **2**B. When the switch **134** is in the third position corresponding to the second activation position of the collar **132**, the rocker paddle **234**A depresses the second contact **234**C as shown in FIG. **2**C. Because the collar **132** extends around circumference of the housing **123**, the switch **134** can be operated between the first position, the second position, and the third position in any rotational orientation of the housing **123** relative to the hand of the user and regardless of a position of the hand of the user relative to the switch **134** underlying the collar **132**.
[0106] Additionally, in the example shown in FIGS. **2**A-**2**C, the user activation device **130** includes the biasing member **136** that biases the collar **132** towards the home position. In particular, in this example, the biasing member **136** includes one or more springs that bias the rocker paddle **234**A towards the first position shown in FIG. **2**A.
[0107] In this arrangement, when the collar **132** is in the home position relative to the housing **123** shown in FIG. **2**A, the switch **134** is in the first position and the switch **134** and/or the printed circuit board **138** prevent the electrosurgical energy from being supplied to the electrosurgical electrode **128**. When the collar **132** is moved from the home position shown in FIG. **2**A to the first activation position shown in FIG. **2**B (e.g., against a biasing force applied by the biasing member **136**), the collar **132** mechanically contacts and forces rocker paddle **234**A to depress the first contact **234**B. As a result, the switch **134** and/or the printed circuit board **138** cause the electrosurgical electrode **128** to receive the electrosurgical energy with the first level of power and/or the first waveform (and/or causes the light source **144** to emit light and/or causes the suction pump **150** to generate suction). Responsive to the user releasing the collar **132** at the first activation position, the biasing member **136** forces the collar **132** back to the home position and the switch **134** back to the first position.
[0108] When the collar **132** is moved from the home position shown in FIG. **2**A to the second activation position shown in FIG. **2**C (e.g., against a biasing force applied by the biasing member **136**), the collar **132** mechanically contacts and forces rocker paddle **234**A to depress the second contact **234**C. As a result, the switch **134** and/or the printed circuit board **138** cause the electrosurgical electrode **128** to receive the electrosurgical energy with the second level of power

and/or the second waveform (and/or causes the light source **144** to emit light and/or causes the suction pump **150** to generate suction). Responsive to the user releasing the collar **132** at the second activation position, the biasing member **136** forces the collar **132** back to the home position and the switch **134** back to the first position.

[0109] FIGS. **3**A-**3**C depict an implementation of the electrosurgical instrument **112** shown and described above with respect to FIG. **1**, according to another example. In particular, FIG. **3**A depicts the electrosurgical instrument **112** with the collar **132** in the home position, FIG. **3**B depicts the electrosurgical instrument **112** with the collar **132** in the first activation position, and FIG. **3**C depicts the electrosurgical instrument **112** in the second activation position, according to the example.

[0110] As shown in FIGS. **3**A-**3**C, the housing **123** extends from a proximal end **223**A to a distal end **223**B, and the electrosurgical electrode **128** extends from the distal end **223**B of the housing **123**. The user activation device **130** disposed between the proximal end **223**A of the housing **123** and the distal end **223**B of the housing **123**, and the user activation device **130** is operable to control a supply of electrosurgical energy to the electrosurgical electrode **128**.

[0111] In this example, the user activation device **130** includes the collar **132** that extends around an entirety of the circumference of the housing **123**. However, as described above, the collar **132** can extend around at least a half of a circumference of the housing **123** in other examples (e.g., the collar **132** can extend around a portion of the circumference of the housing **123** that is between 50 percent to 100 percent of the circumference of the housing **123**). Also, in FIGS. **3**A-**3**C, the housing **123** can have a circular cross-sectional shape or a non-circular cross-sectional shape.

[0112] As shown in FIGS. **3**A-**3**C, the user activation device **130** also includes the switch **134** configured to control the supply of the electrosurgical energy to the electrosurgical electrode responsive to the collar **132** moving from the home position (shown in FIG. **3**A) to the first activation position (shown in FIG. **3**B) and/or the second activation position (shown in FIG. **3**C), as described above. In this example, the switch **134** includes a first electrical contact **334**A, a second electrical contact **334**B, and a third electrical contact **334**C. The first electrical contact **334**A, the second electrical contact **334**B, and the third electrical contact **334**C can be on an exterior surface of the housing **123**. An electrical potential can be applied to one or more of the first electrical contact **334**A, the second electrical contact **334**B, and the third electrical contact **334**C. As shown in FIG. **3**A, the first electrical contact **334**A, the second electrical contact **334**B, and the third electrical contact **334**C can be separated from each other by respective gaps (e.g., not in direct electrical communication with each other).

[0113] Additionally, in this example, the collar **132** includes one or more conductive elements **332** (e.g., one or more conductive pads) that are configured to electrical contact one or more of the first electrical contact **334**A, the second electrical contact **334**B, and the third electrical contact **334**C at a given time. The conductive elements **332** can be on an inner surface of the collar **132** (e.g., facing the first electrical contact **334**A, the second electrical contact **334**B, and the third electrical contact **334**C).

[0114] As shown in FIG. **3**A, when the collar **132** is in the home position, the conductive element(s) **332** of the collar **132** contact less than two of the first electrical contact **334**A, the second electrical contact **334**B, and the third electrical contact **334**C such that an open circuit condition exists between the first electrical contact **334**A, the second electrical contact **334**B, and the third electrical contact **334**C. In this state, the switch **134** can prevent the electrosurgical electrode **128** from receiving the electrosurgical energy.

[0115] As shown in FIG. **3**B, when the collar **132** is in the first activation position, the one or more conductive elements **332** electrically contact the first electrical contact **334**A and the second electrical contact **334**B. As such, the conductive element(s) **332** can close a first circuit including the first electrical contact **334**A and the second electrical contact **334**B. In one example, this result in the electrical potential being provided to the printed circuit board **138** to provide a signal for

supplying the electrosurgical energy with the first level of power and/or the first waveform.
[0116] As shown in FIG. **3**C, when the collar **132** is in the second activation position, the one or more conductive elements **332** electrically contact the second electrical contact **334**B and the third electrical contact **334**C. As such, the conductive element(s) **332** can close a second circuit including the second electrical contact **334**B and the third electrical contact **334**C. In one example, this result in the electrical potential being provided to the printed circuit board **138** to provide a signal for supplying the electrosurgical energy with the second level of power and/or the second waveform.
[0117] Because the collar **132** extends around circumference of the housing **123**, the switch **134** can be operated to selectively close the first circuit, close the second circuit, or open both the first circuit and the second circuit any rotational orientation of the housing **123** relative to the hand of the user and regardless of a position of the hand of the user relative to the switch **134** underlying the collar **132**.
[0118] Additionally, as shown in FIGS. **3**A-**3**B, the housing **123** includes a recessed portion **323** that has cross-sectional dimensions that are less than cross-sectional dimensions of the housing **123** on opposing sides of the recessed portion **323** (e.g., in a dimension that is perpendicular to a longitudinal axis of the housing **123**). The collar is disposed and movable in the recessed portion **323** of the housing **123**. The recessed portion **323** can help to limit a range of movement of the collar **132** relative to the housing **123**. For instance, the recessed portion **323** can define a distal stop and a proximal stop that limit the range of movement of the collar **132**. Additionally or alternatively, the recessed portion **323** can have a sloped distal wall and a sloped proximal wall, which can engage correspondingly sloped walls of the collar **132** at the first activation position and the second activation position, respectively. The engagement of the sloped distal wall and the sloped proximal wall with the correspondingly sloped walls of the collar **132** can assist in biasing the collar **132** towards the home position.
[0119] In FIGS. **3**A-**3**C, the collar **132** has cross-sectional dimensions of the collar **132** can be greater than the cross-sectional dimensions of the housing **123** on opposing sides of the recessed portion **323** such that the collar **132** protrudes outwardly from the exterior surface of the housing **123**. This can help with ease of manufacture and assembly. However, in another example, the collar **132** and the recessed portion **323** of the housing **123** can be configured such that an outer surface of the collar **132** is approximately flush with the exterior surface of the housing **123** on opposing sides of the recessed portion **323**. This can help to reduce the overall cross-sectional dimensions of the electrosurgical instrument **112**, which may provide for enhanced lines of sight to the surgical site.
[0120] Although the housing **123** includes the recessed portion **323** in FIGS. **3**A-**3**C, the housing **123** can omit the recessed portion **323** in other examples. For instance, the housing **123** can have the same cross-sectional dimensions at each point along the range of movement of the collar **132** as well as on opposing sides of the range of movement of the collar **132**.
[0121] FIGS. **4**A-**4**C depict an implementation of the electrosurgical instrument **112** shown and described above with respect to FIG. **1**, according to another example. In particular, FIG. **4**A depicts the electrosurgical instrument **112** with the collar **132** in the home position, FIG. **4**B depicts the electrosurgical instrument **112** with the collar **132** in the first activation position, and FIG. **4**C depicts the electrosurgical instrument **112** in the second activation position, according to the example.
[0122] As shown in FIGS. **4**A-**4**C, the housing **123** extends from a proximal end **223**A to a distal end **223**B, and the electrosurgical electrode **128** extends from the distal end **223**B of the housing **123**. The user activation device **130** disposed between the proximal end **223**A of the housing **123** and the distal end **223**B of the housing **123**, and the user activation device **130** is operable to control a supply of electrosurgical energy to the electrosurgical electrode **128**.
[0123] In this example, the user activation device **130** is substantially similar or identical to the user activation device **130** described above with respect to FIGS. **3**A-**3**C, except the switch **134** in FIGS. **4**A-**4**C also include a plurality of flaps **456** covering respective ones of the first electrical

contact **334**A and the third electrical contact **334**C. The flaps **456** can be formed from a material that is an electrical insulator to inhibit or prevent electrical transmission through the flaps **456**. The collar **132** can be configured to move the plurality of flaps **456** to expose the respective ones of the first electrical contact **334**A and the third electrical contact **334**C responsive to the collar **132** moving relative to the housing **123**.

[0124] In this arrangement, when the collar **132** is in the home position shown in FIG. **4**A, the flaps **456** cover the first electrical contact **334**A and the third electrical contact **334**C. The flaps **456** can further assist in inhibiting electrical coupling between the first electrical contact **334**A, the second electrical contact **334**B, and the third electrical contact **334**C when the collar **132** is in the home position (e.g., in the event of liquid ingress into a space between the collar **132** and the electrical contacts **334**A-**334**C).

[0125] As shown in FIG. **4**B, when the collar **132** moves to the first activation position, the collar **132** and/or the conductive element **332** can engage and move the flap **456** over the first electrical contact **334**A such that the first electrical contact **334**A is exposed. As a result, when the collar **132** is in the first activation position, the conductive element(s) **332** can electrically couple the first electrical contact **334**A and the second electrical contact **334**B as described above.

[0126] As shown in FIG. **4**C, when the collar **132** moves to the second activation position, the collar **132** and/or the conductive element **332** can engage and move the flap **456** over the third electrical contact **334**C such that the third electrical contact **334**C is exposed. As a result, when the collar **132** is in the second activation position, the conductive element(s) **332** can electrically couple the second electrical contact **334**B and the third electrical contact **334**C as described above.

[0127] FIGS. **5**A-**5**C depict an implementation of the electrosurgical instrument **112** shown and described above with respect to FIG. **1**, according to another example. In particular, FIG. **3**A depicts the electrosurgical instrument **112** with the collar **132** in the home position, FIG. **3**B depicts the electrosurgical instrument **112** with the collar **132** in the first activation position, and FIG. **3**C depicts the electrosurgical instrument **112** in the second activation position, according to the example.

[0128] As shown in FIGS. **5**A-**5**C, the housing **123** extends from a proximal end **223**A to a distal end **223**B, and the electrosurgical electrode **128** extends from the distal end **223**B of the housing **123**. The user activation device **130** disposed between the proximal end **223**A of the housing **123** and the distal end **223**B of the housing **123**, and the user activation device **130** is operable to control a supply of electrosurgical energy to the electrosurgical electrode **128**.

[0129] In this example, the user activation device **130** includes the collar **132** that extends around an entirety of the circumference of the housing **123**. However, as described above, the collar **132** can extend around at least a half of a circumference of the housing **123** in other examples (e.g., the collar **132** can extend around a portion of the circumference of the housing **123** that is between 50 percent to 100 percent of the circumference of the housing **123**). Also, in FIGS. **5**A-**5**C, the housing **123** can have a circular cross-sectional shape or a non-circular cross-sectional shape.

[0130] As shown in FIGS. **5**A-**5**C, the user activation device **130** also includes the switch **134** configured to control the supply of the electrosurgical energy to the electrosurgical electrode responsive to the collar **132** moving from the home position (shown in FIG. **3**A) to the first activation position (shown in FIG. **3**B) and/or the second activation position (shown in FIG. **3**C), as described above. In this example, the switch **134** includes a Hall Effect sensor **558** that is configured to sense when the collar **132** is in the home position, when the collar **132** is in the first activation position, and when the collar **132** is in the second activation position.

[0131] For instance, in the example shown in FIGS. **5**A-**5**C, the collar **132** can include a first magnet **560** and the housing **123** can include a second magnet **562** such that the first magnet **560** and the second magnet **562** interact to form a magnetic field at a position of the Hall Effect sensor **558**. In FIG. **5**A, when the collar **132** is in the home position, the magnetic field can have a first magnitude and a first direction based on the relative positions of the first magnet **560** and the

second magnet **562**. The Hall Effect sensor **558** can sense the magnetic field having the first magnitude and the first direction and responsively signal to the printed circuit board **138** (shown in FIG. **1**) that the collar **132** is in the home position. In this way, the Hall Effect sensor **558** can cause the printed circuit board **138** to prevent the electrosurgical electrode **128** from receiving the electrosurgical energy.

[0132] In FIG. **5**B, when the collar **132** is in the first activation position, the magnetic field can have a second magnitude and a second direction based on the relative positions of the first magnet **560** and the second magnet **562**. The Hall Effect sensor **558** can sense the magnetic field having the second magnitude and the second direction and responsively signal to the printed circuit board **138** (shown in FIG. **1**) that the collar **132** is in the first activation position. In this way, the Hall Effect sensor **558** can cause the printed circuit board **138** to cause supplying the electrosurgical energy to the electrosurgical electrode **128** with the first level of power and/or the first waveform according to one example.

[0133] In FIG. **5**C, when the collar **132** is in the second activation position, the magnetic field can have a third magnitude and a third direction based on the relative positions of the first magnet **560** and the second magnet **562**. The Hall Effect sensor **558** can sense the magnetic field having the third magnitude and the third direction and responsively signal to the printed circuit board **138** (shown in FIG. **1**) that the collar **132** is in the second activation position. In this way, the Hall Effect sensor **558** can cause the printed circuit board **138** to cause supplying the electrosurgical energy to the electrosurgical electrode **128** with the second level of power and/or the second waveform according to one example.

[0134] FIGS. **6**A-**6**D depict two implementations of the electrosurgical instrument **112** shown and described above with respect to FIG. **1**, according to further examples. In particular, FIG. **6**A depicts a perspective view of a first example implementation of the electrosurgical instrument **112**, FIG. **6**B depicts a side view of the electrosurgical instrument **112** shown in FIG. **6**A, FIG. **6**C depicts a perspective view of a second example implementation of the electrosurgical instrument **112**, and FIG. **6**D depicts a side view of the electrosurgical instrument **112** shown in FIG. **6**C.

[0135] In FIGS. **6**A-**6**B, an outer surface of a central portion **670** of the collar **132** has a cross-sectional dimension (e.g., through a plane that is perpendicular to a longitudinal axis of the handle **124**) that is less than a cross-sectional dimension of a distal portion and a proximal portion of the collar **132**. For instance, the central portion **670** of the collar can have a concave shape. This can help to reduce the overall cross-sectional dimensions of the electrosurgical instrument **112**, which may provide for enhanced lines of sight to the surgical site. By contrast, in FIGS. **6**C-**6**D, the outer surface of the central portion **670** of the collar **132** has a cross-sectional dimension (e.g., through a plane that is perpendicular to a longitudinal axis of the handle **124**) that is greater than a cross-sectional dimension of the distal portion and the proximal portion of the collar **132**. For instance, the central portion **670** of the collar **132** can have a convex shape. This can help to reduce strain on the practioner when moving the collar **132** in a proximal direction.

[0136] Additionally, as shown in FIGS. **6**A-**6**D, the collar **132** can include a grip portion **672**. The grip portion **672** can have a coefficient of friction that is greater than a coefficient of friction of at least a portion of the housing **123**. As such, the grip portion **672** can help to mitigate a finger of the user slipping off of the collar **132** while moving the collar **132** to the first activation position and the second activation position and/or holding the collar **132** at the first activation position or the second activation position. Additionally or alternatively, the grip portion **672** can provide tactile feedback to help differentiate the collar **132** from the housing **123**.

[0137] Also, as shown in FIGS. **6**A-**6**D, the housing **123** can include a grip section **674** that is located proximal on an exterior surface of the housing **123** and proximal of the collar **132**. The grip section **674** can have a coefficient of friction that is greater than a coefficient of friction of at least a portion of the housing **123**. The grip section **674** can provide for enhanced grip by a portion of the hand of the user that holds the housing **123** (e.g., while a finger of the user operates the collar **132**).

Additionally or alternatively, the grip section **674** can help to guide the hand of the user to a preferred position of the hand on the housing **123** (e.g., on the handle **124**).

[0138] FIG. **6**E depicts a distal end of the shaft **126** with a suction sleeve **676** (shown in FIGS. **6**A-**6**D) removed for illustration purposes. As shown in FIG. **6**E, the shaft **126** can include a plurality of smoke inlet **678** on opposing sides of at least a portion of the electrosurgical electrode **128**. Providing the shaft **126** with two smoke inlets **678** can allow each smoke inlet **678** to be relatively large relative to other examples in which the shaft **126** includes more than two smoke inlets **678**. This can, for example, help to reduce clogging of the smoke inlets **678**. Although the shaft **126** includes two smoke inlets **678** in FIG. **6**E, the shaft **126** can include three or more smoke inlets **678** in other examples.

[0139] In the examples shown in FIGS. **6**A-**6**D, the collar **132** is a single, monolithic structure. In other examples, the collar **132** can include a plurality of segments that each extend around a respective portion of the housing **123**. In some implementations, the segments of the collar **132** can be fixed relative to each other such that moving one segment, moves all segments. This can help to reduce or minimize a quantity of the switch(es) **134**.

[0140] In other implementations, the segments of the collar **132** can be movable relative to each other. This can help to reduce a strain on a finger of a user. For instance, if a user holds the electrosurgical instrument **112** with one finger above the collar **132** and another finger below the collar **132**, the user may experience strain while moving the collar **132** from the home position to the first activation position and/or the second activation position due to the placement of the fingers. However, by allowing segments of the collar **132** to move relative to each other, a finger on one segment can be moved relative to a finger on another segment (e.g., which may remain stationary relative to the housing **123**) to actuate the user activation device **130**.

[0141] FIGS. **7**A-**7**B depict an implementation of the collar **132** with a plurality of segments **732** that are independently movable relative to each other, according to an example. FIG. **7**A depicts a perspective view of the collar **132** in the home position, FIG. **7**B depicts a side view of the collar **132** and the switches **134** in the home position, FIG. **7**C depicts the collar **132** in the first activation position, and FIG. **7**D depicts the collar **132** in the second activation position, according to the example.

[0142] As shown in FIGS. **7**A-**7**D, the collar **132** includes the plurality of segments **732** that are movable relative to each other, the housing **123** and the switches **134**. As shown in FIG. **7**B, each segment **732** is configured to actuate a respective one of the switches **134**. The switches **134** can be any of the types of switches described above (e.g., mechanical switches, electrical switches, magnetic switches, piezoelectric switches, etc.).

[0143] In FIG. **7**C, one segment **732** of the collar **132** has been moved to the first activation position while the other segments **732** of the collar **132** remain in the home position. With at least one segment **732** in the first activation position, the respective switch **134** is actuated to cause at least one of (i) the electrosurgical generator **110** to supply the electrosurgical energy with the first waveform to the electrosurgical electrode **128**, (ii) the DC power source **148** to supply DC power to the light source(s) **144**, and/or (iii) the suction pump **150** to generate suction.

[0144] In FIG. **7**D, one segment **732** of the collar **132** has been moved to the second activation position while the other segments **732** of the collar **132** remain in the home position. With at least one segment **732** in the second activation position, the respective switch **134** is actuated to cause at least one of (i) the electrosurgical generator **110** to supply the electrosurgical energy with the second waveform to the electrosurgical electrode **128**, (ii) the DC power source **148** to supply DC power to the light source(s) **144**, and/or (iii) the suction pump **150** to generate suction.

[0145] In some examples, the segments **732** of the collar **132** can have a limited range of movement relative to the housing **123** and/or each other. For instance, each segment **732** can be disposed and movable in a recessed portion of the housing **123** (e.g., as shown and described above with respect to the recessed portion **323** and FIGS. **3**A-**5**C).

[0146] In FIGS. **7**A-**7**D, the collar **132** includes four segments **732**. However, in other examples, the collar **132** can include two segments **732**, three segments **732**, or more than four segments **732**.
[0147] FIG. **8** depicts a flowchart for a process **800** for operating an electrosurgical instrument, according to an example. At block **810**, the process **800** includes coupling a power cord of an electrosurgical instrument to an electrosurgical generator. The electrosurgical instrument includes a housing extending from a proximal end to a distal end, an electrosurgical electrode extending from the distal end of the housing, and a user activation device disposed between the proximal end of the housing and the distal end of the housing. The user activation device is operable to control a supply of electrosurgical energy to the electrosurgical electrode. The user activation device includes a collar that extends around at least a half of a circumference of the housing. The collar is movable between a home position relative to the housing and a first activation position relative to the housing. The user activation device further includes a switch that is configured to control the supply of the electrosurgical energy to the electrosurgical electrode responsive to the collar moving from the home position to the first activation position.
[0148] At block **812**, the process includes moving the collar from the home position to the first activation position. Responsive to moving the collar from the home position to the first activation position at block **812**, the process **800** includes supplying the electrosurgical energy from the electrosurgical generator to the electrosurgical electrode at block **814**.
[0149] FIGS. **9**-**16** depict additional aspects of the process **800** according to further examples. As shown in FIG. **9**, the process **800** can include (i) after supplying the electrosurgical energy at block **814**, moving the collar from the first activation position to the home position at block **816**, and (ii) responsive to moving the collar from the first activation position to the home position at block **816**, ceasing the supply of the electrosurgical energy to the electrosurgical electrode at block **818**.
[0150] As shown in FIG. **10**, moving the collar from the first activation position to the home position at block **816** can include using a biasing member to automatically move the collar from the first activation position to the home position when a user releases the collar at block **820**.
[0151] As shown in FIG. **11**, supplying the electrosurgical energy from the electrosurgical generator to the electrosurgical electrode responsive to moving the collar from the home position to the first activation position at block **814** can include supplying the electrosurgical energy with a first waveform at block **822**.
[0152] As shown in FIG. **12**, the process **800** can further include moving the collar from the home position to a second activation position at block **824**. The home position is between the first activation position and the second activation position. Responsive to moving the collar from the home position to the second activation position at block **824**, the process **800** can include supplying the electrosurgical energy to the electrosurgical electrode with a second waveform at block **826**. The first waveform is different from the second waveform.
[0153] As shown in FIG. **13**, in an example in which the switch includes a rocker switch, moving the collar from the home position to the first activation position at block **812** can include mechanically engaging a rocker paddle of the rocker switch to depress a first contact of the rocker switch at block **828**.
[0154] As shown in FIG. **14**, moving the collar from the home position to the first activation position at block **812** can include closing a circuit between a first electrical contact of the switch, a second electrical contact of the switch, and a conductive element of the collar at block **830**.
[0155] As shown in FIG. **15**, the process **800** can further include (i) sensing, by a Hall Effect sensor, that the collar is in the home position at block **832**, (ii) responsive to sensing that the collar is in the home position at block **832**, preventing supply of the electrosurgical energy to the electrosurgical electrode at block **834**, and (iii) sensing, by the Hall Effect sensor, that the collar is in the first activation position at block **836**. Additionally, as shown in FIG. **15**, supplying the electrosurgical energy from the electrosurgical generator to the electrosurgical electrode at block **814** can be responsive to sensing that the collar is in the first activation position at block **832**.

[0156] As shown in FIG. **16**, in an example in which the collar includes a plurality of segments that are independently movable relative to each other and the housing, moving the collar from the home position to the first activation position at block **812** can include moving one segment of the plurality of segments relative to another segment of the plurality of segments at block **838**.
[0157] FIG. **17** depicts a flowchart for a method **1700** for manufacturing an electrosurgical instrument, according to an example. At block **1710**, the process **1700** can include forming a housing extending from a proximal end to a distal end. At block **1712**, the process **1700** can include coupling an electrosurgical electrode to the housing such that the electrosurgical electrode extends from the distal end of the housing. At block **1714**, the process **1700** can include coupling a user activation device to the housing between the proximal end of the housing and the distal end of the housing.
[0158] The user activation device is operable to control a supply of electrosurgical energy to the electrosurgical electrode. The user activation device includes a collar that extends around at least a half of a circumference of the housing. The collar is movable between a home position relative to the housing and a first activation position relative to the housing. The user activation device also includes a switch that is configured to control the supply of the electrosurgical energy to the electrosurgical electrode responsive to the collar moving from the home position to the first activation position.
[0159] Referring to now to FIG. **18**, an electrosurgical system **1800** is shown according to another example. As shown in FIG. **18**, the electrosurgical system **1800** includes the electrosurgical generator **110** and the electrosurgical device **112**. As described above, the electrosurgical generator **110** can generate electrosurgical energy that is suitable for performing electrosurgery on a patient. For instance, the electrosurgical generator **110** can include the power converter circuit **114** described above, which can convert a grid power to electrosurgical energy such as, for example, a radio frequency (RF) output power. Additionally, as described above, the electrosurgical generator **110** can include the user interface **116**, the one or more generator sensors **118**, the connector **120**, and/or the controller **141**.
[0160] As described above with respect to FIG. **1**, the housing **123** of the electrosurgical instrument **112** can include the handle **124**, the shaft **126**, and the electrosurgical electrode **128**.
[0161] In some implementations, the shaft **126** can be coupled to the handle **124** in a fixed and non-moveable manner. This may simplify manufacturing and reduce a cost of manufacture by, for instance, simplifying electrical connections that may otherwise need to account for movement of the shaft **126** and the handle **124** relative to each other (e.g., by omitting slip ring electrical contacts and/or sliding electrical contacts). In other implementations, the shaft **126** can be telescopically moveable relative to the handle **124**. For example, the shaft **126** can be telescopically moveable in the interior bore defined by the handle **124** to extend the shaft **126** in the distal direction and retract the shaft **126** in a proximal direction relative to the handle **124** (e.g., movable along a longitudinal axis of the electrosurgical device **112**). This can provide for adjusting a length of the electrosurgical device **112**, which can facilitate performing electrosurgery at a plurality of different depths within tissue (e.g., due to different anatomical shapes and/or sizes of patients) and/or at a plurality of different angles.
[0162] In some implementations, the electrosurgical electrode **128** can additionally or alternatively be rotatable about an axis of rotation that is parallel to the longitudinal axis of the electrosurgical device **112**. In some examples, the electrosurgical electrode **128** can be rotatable relative to the handle **124** and the shaft **126**. In other examples, the electrosurgical electrode **128** can be rotationally fixed relative to the shaft **126** such that the shaft **126** and the electrosurgical electrode **128** are rotatable together relative to the handle **124** and at least one additional component in the inner cavity defined by the shaft **126**. Rotating the electrosurgical electrode **128** relative to the handle **124** can facilitate adjusting an angle of the electrosurgical electrode **128** relative to one or more user activation device(s) **130** of the electrosurgical device **112**. In this arrangement, a user can

comfortably grip the handle **124** in a position in which their fingers can comfortably operate the user activation device(s) **130** while the electrosurgical electrode **128** is set at a rotational position selected from among a plurality of rotational positions relative to the handle **124** based on, for example, a location, a size, and/or a shape of a surgical site in which the user is operating.
[0163] In one implementation, the electrosurgical electrode **128** can be rotatable by more than 360 degrees relative to the handle **124**. This can improve an ease of use by allowing an operator to freely rotate the electrosurgical electrode **128** without limitation. However, in other implementations, the electrosurgical electrode **128** can be rotatable by less than or equal to 360 degrees (e.g., rotatable by 180 degrees or rotatable by 360 degrees). This may still allow an operator to achieve a desired rotational arrangement, but with the possibility that the operator may rotate in first direction, reach a stop limiting further rotation, and then rotate back in a second direction to achieve the desired rotational arrangement.
[0164] Although it can be beneficial to provide for rotation of the electrosurgical electrode **128** relative to the handle **124** and/or the shaft **126**, the electrosurgical electrode **128** can be rotationally fixed relative to the handle **124** and the shaft **126** in some implementations. This may, for example, help to simplify manufacturing and reduce a cost of manufacture by, for instance, simplifying electrical connections that may otherwise need to account for movement of the shaft **126** and the handle **124** relative to each other (e.g., by omitting slip ring electrical contacts and/or sliding electrical contacts). As described in further detail below, the user activation device(s) **130** of the electrosurgical device **112** described herein can help to reduce or obviate a need to rotate the electrosurgical electrode **128** relative to the handle **124**.
[0165] As described above, the user activation device(s) **130** can select between the modes of operation of the electrosurgical device **112** and/or the electrosurgical generator **110**. For instance, in one implementation, the user activation device(s) **130** can be configured to select between a cutting mode of operation and a coagulation mode of operation. Responsive to actuation of the user activation device(s) **130** of the electrosurgical device **112**, the electrosurgical device **112** can (i) receive the electrosurgical energy with a level of power and/or a waveform corresponding to the mode of operation selected via the user activation device(s) **130** and (ii) supply the electrosurgical energy to the electrosurgical electrode **128**.
[0166] In FIG. **18**, the electrosurgical device **112** includes a plurality of electrical components that facilitate supplying the electrosurgical energy, which the electrosurgical device **112** receives from the electrosurgical generator **110**, to the electrosurgical electrode **128**. For example, the electrosurgical device **112** can include at least one electrical component selected from a group of electrical components including: the printed circuit board **138** (e.g., a flexible printed circuit board), the housing conductor **140**, and/or the shaft conductor **142** that can provide a circuit for conducting the electrosurgical energy from the power cord **122** to the electrosurgical electrode **128**. One or more of the electrical components can be positioned in the interior bore defined by the handle **124** and/or in the inner cavity defined by the shaft **126**.
[0167] Within examples, the user activation device(s) **130** can include one or more buttons on an exterior surface of the handle **124**. Each button of the user activation device(s) **130** can be operable to actuate a respective one of a plurality of switches **134** coupled to the printed circuit board **138**. In general, the switches **134** and/or the printed circuit board **138** are operable to control a supply of the electrosurgical energy from the electrosurgical generator **110** to the electrosurgical electrode **128**. For instance, in one implementation, when each button is operated (e.g., depressed), the respective switch **138** associated with the button can be actuated to cause the printed circuit board **138** to transmit a signal to the electrosurgical generator **110** and cause the electrosurgical generator **110** to responsively supply the electrosurgical energy with a level of power and/or a waveform corresponding to a mode of operation associated with the button. In another implementation, operating the button and thereby actuating the respective switch **138** associated with the button can close the switch **138** to complete a circuit to the electrosurgical generator **110** to cause the

electrosurgical generator **110** to responsively supply the electrosurgical energy with a level of power and/or a waveform corresponding to a mode of operation associated with the button. In some examples of this implementation, the printed circuit board **138** can be omitted.

[0168] In both example implementations, the electrosurgical energy supplied by the electrosurgical generator **110** can be supplied from (i) the power cord **122**, the printed circuit board **138**, and/or the switches **134** to (ii) the electrosurgical electrode **128** by the housing conductor **140** and the shaft conductor **142**. As such, as shown in FIG. **18**, the printed circuit board **138** can be coupled to the power cord **122**, the housing conductor **140** can be coupled to the printed circuit board **138** and the shaft conductor **142**, and the shaft conductor **142** can be coupled to the electrosurgical electrode **128**. In this arrangement, the housing conductor **140** can conduct the electrosurgical energy (supplied to the housing conductor **140** via the printed circuit board **138**) to the shaft conductor **142**, and the shaft conductor **142** can conduct the electrosurgical energy to the electrosurgical electrode **128**.

[0169] In general, the housing conductor **140** and the shaft conductor **142** can each include one or more electrically conductive elements that provide an electrically conductive bus for supplying the electrosurgical energy to the electrosurgical electrode **128**. More particularly, the housing conductor **140** can include one or more electrically conductive elements of the handle **124** that can supply the electrosurgical energy to the shaft conductor **142**, and the shaft conductor **142** can include one or more electrically conductive elements of the shaft **126** that can supply the electrical energy from the housing conductor **140** to the electrosurgical electrode **128**. As described in further detail below, the housing conductor **140** can engage the shaft conductor **142** to maintain an electrical coupling between the housing conductor **140**, the shaft conductor **142**, and the electrosurgical electrode **128** while (i) the shaft **126** and/or the electrosurgical electrode **128** telescopically moves relative to the handle **124**, and/or (ii) the electrosurgical electrode **128** rotates relative to the handle **124**. As described above, the electrosurgical electrode **128** can apply the electrosurgical energy to a target tissue to perform an electrosurgical operation (e.g., cutting, coagulating, ablating, and/or sealing the target tissue). The electrosurgical electrode **128** can be configured as described above (e.g., with the shapes, the materials, etc. described above).

[0170] As shown in FIG. **18**, in some implementations, the electrosurgical device **112** can additionally include the one or more light sources **144** that are configured to emit light. In examples that include the light source(s) **144**, the light source(s) **144** can generate light that can be emitted by the electrosurgical device **112** to illuminate an area of interest (e.g., a target tissue at the surgical site). In some examples that include the light source(s) **144**, the user activation device **130** can be operable to cause the light source(s) **144** to generate light that can be emitted by the electrosurgical instrument **112** to illuminate an area of interest (e.g., a target tissue at the surgical site). In some implementations, the light source(s) **144** can be located at a distal end of the housing **123** and/or a distal end of the shaft **126** to directly provide light in a distal direction and illuminate a surgical distal of the electrosurgical electrode **128**.

[0171] In other implementations, as shown in FIG. **18**, the light source(s) **144** can be optically coupled to the optical structure **146**, which is configured to receive the light emitted by the light source(s) **144** and transmit the light in a distal direction toward a surgical site to illuminate the surgical site while performing electrosurgery using the electrosurgical electrode **128**. Although arranging the light source(s) **144** to directly illuminate a surgical field can help, for instance, to reduce a cost of manufacture, transmitting the light using the optical structure **146** can help to improve a quality of light transmitted from the electrosurgical device **112** (e.g., by providing light with improved uniformity and/or reduced heat generation).

[0172] As examples, in implementations that include the optical structure **146**, the optical structure **146** can include at least one optical structure selected from among a group consisting of an optical lens, a non-fiber optic optical waveguide, and an optical fiber. When the optical structure **146** includes the optical lens (e.g., a parabolic reflector lens, an aspheric lens, and/or a Fresnel lens), the

optical structure **146** can help to direct the light emitted by the light source **144** in the distal direction and thereby improve a quality of the light illuminating the surgical site. The optical structure **146** can additionally or alternatively include the non-fiber optic optical waveguide and/or the optical fiber to transmit the light over relatively large distances in the shaft **126**. For instance, the optical waveguide can transmit the light in the distal direction via total internal reflection. In such implementations, the optical waveguide can include a cladding and/or an air gap on an exterior surface of the optical waveguide to help facilitate total internal reflection. In some implementations, the non-fiber optic optical waveguide can be formed as a single, monolithic structure.

[0173] In some examples, the optical structure **146** can additionally or alternatively include other light shaping optical elements such as, for instance, a plurality of facets, one or more prisms, and/or one or more optical gratings. Although the optical structure **146** can help to improve a quality of the light directed to the surgical site, the electrosurgical device **112** can omit the optical structure **146** and instead emit the light from the light source **144** directly to the surgical field without transmitting the light through the optical structure **146** in other examples.

[0174] In FIG. **18**, the light source **144** can be coupled to the shaft **126**. As such, the light source **144** can also move telescopically with the shaft **126** relative to the handle **124**. However, in other examples, the light source **144** can be in the interior bore of the handle **124** and/or coupled to an exterior surface of the handle **124**. As examples, the light source **144** can include one or more light emitting diodes (LEDs), organic light emitting diodes (OLEDs), optical fibers, non-fiber optic waveguides, and/or lenses. Additionally, for example, the light source **144** can include a LED printed circuit board having one or more light sources (e.g., LEDs).

[0175] The optical structure **146** can be at a distal end of the shaft **126**. In some examples, the optical structure **146** can circumferentially surround the electrosurgical electrode **128** to emit the light distally around all sides of the electrosurgical electrode **128**. This can help to mitigate shadows and provide greater uniformity of illumination in all rotational alignments of the shaft **126** relative to the housing **123** and/or the electrosurgical device **112** relative to the target tissue. However, in other examples, the optical structure **146** can extend partially but not fully around the electrosurgical electrode **128**.

[0176] In implementations that include the light source **144**, the user activation device(s) **130**, the printed circuit board **138**, the switches **134**, the housing conductor **140**, and/or the shaft conductor **142** can additionally supply an electrical power from a direct current (DC) power source **148** to the light source **144**. In one example, the DC power source **148** can include a battery disposed in the handle **124**, the plug of the power cord **122**, and/or a battery receptacle located along the power cord **122** between the handle **124** and the plug. Although the electrosurgical device **112** includes the DC power source **148** in FIG. **18**, the DC power source **148** can be separate and distinct from the electrosurgical device **112** in other examples. For instance, in another example, the electrosurgical generator **110** can include the DC power source **148**.

[0177] Additionally, in implementations that include the light source **144**, the user activation device(s) **130** can be operable to cause the light source **144** to emit the light. In one example, the user activation device(s) **130** can include a button that independently controls the light source **144** separate from the button(s) that control the electrosurgical operational modes of the electrosurgical device **112**. In another example, the user activation device(s) **130** and the printed circuit board **138** can be configured such that operation of the button(s) that control the electrosurgical operational mode simultaneously control operation of the light source **144** (e.g., the light source **144** can be automatically actuated to emit light when a button is operated to apply the electrosurgical energy at the electrosurgical electrode **128**).

[0178] As shown in FIG. **18**, responsive to operation of the user activation device(s) **130** to actuate the light source **144**, the DC power source **148** can supply the electrical power (e.g., a DC voltage) to the light source **144** via the printed circuit board **138**, the housing conductor **140**, and/or the shaft

conductor **142**. In this implementation, one or more of the conductive elements of the housing conductor **140** can be configured to supply the electrical power from the DC power source **148** to the light source **144** and/or return the electrical power from the light source **144** to the DC power source **148**. Accordingly, the housing conductor **140** can additionally or alternatively assist in providing electrical communication between the DC power source **148** and the light source **144** as the shaft **126** and the light source **144** telescopically move relative to the handle **124**.

[0179] Although the user activation device(s) **130** on the handle **124** can be operated to control the operation of the light source **144** in the examples described above, the light source **144** can be additionally or alternatively operated by one or more user activation device(s) on the electrosurgical generator **110** (e.g., via the user interface **116**) and/or on the plug of the power cord **122**.

[0180] In some examples, the electrosurgical device **112** can additionally or alternatively include features that provide for evacuating surgical smoke from a target tissue to a location external to the surgical site. Surgical smoke is a by-product of various surgical procedures. For example, during surgical procedures, surgical smoke may be generated as a by-product of electrosurgical units (ESU), lasers, electrocautery devices, ultrasonic devices, and/or other powered surgical instruments (e.g., bones saws and/or drills). In some instances, the surgical smoke may contain toxic gases and/or biological products that result from a destruction of tissue. Additionally, the surgical smoke may contain an unpleasant odor. For these and other reasons, many guidelines indicate that exposure of surgical personnel to surgical smoke should be reduced or minimized.

[0181] To reduce (or minimize) exposure to surgical smoke, a smoke evacuation system may be used during the surgical procedure. In general, the smoke evacuation system may include the suction pump **150** that can generate sufficient suction and/or vacuum pressure to draw the surgical smoke away from the surgical site. In some implementations, the smoke evacuation system may be coupled to an exhaust system (e.g., an in-wall exhaust system) that exhausts the surgical smoke out of an operating room. In other implementations, the smoke evacuation system may filter air containing the surgical smoke and return the air to the operating room. Within examples, the suction pump **150** and the electrosurgical generator **110** can be provided as separate devices or integrated in a single device (e.g., in a common housing).

[0182] As shown in FIG. **18**, the shaft **126** can include the smoke evacuation channel **152** in the inner cavity of the shaft **126**. The smoke evacuation channel **152** can also include a smoke inlet that can extend circumferentially around a center axis of a distal portion of the electrosurgical electrode **128**. In this arrangement, the smoke inlet of the smoke evacuation channel can help to receive surgical smoke into the smoke evacuation channel **152** in all rotational alignments of the electrosurgical electrode **128** relative to the handle **124** and/or the electrosurgical device **112** relative to the target tissue. However, in another example, the smoke evacuation channel **152** can include one or more smoke inlets that do not extend circumferentially around the electrosurgical electrode **128**.

[0183] In an example, the smoke evacuation channel **152** can include an outer tube that is separated from the optical lens assembly **142** by an air gap. For instance, the shaft **126** can include a plurality of standoffs that extend between the optical lens assembly **142** and the outer tube of the smoke evacuation channel **152** to provide the air gap between the outer tube and the optical lens assembly **142**. In one implementation, the optical lens assembly **142** can include the standoffs such that the optical lens assembly **142** and the standoffs are formed as a single, monolithic structure. In another implementation, the standoffs can be formed as a single, monolithic structure with the outer tube of the smoke evacuation channel **152**. In another implementation, the standoffs can be separate from the outer tube of the smoke evacuation channel **152** and the optical lens assembly **142**.

[0184] As described above, the electrosurgical electrode **128** shown in FIG. **18** can be rotatable about an axis of rotation that is parallel to the longitudinal axis of the electrosurgical device **112**. Rotating the electrosurgical electrode **128** relative to the handle **124** can facilitate adjusting an

angle of the electrosurgical electrode **128** relative to one or more user activation device(s) **130** of the electrosurgical device **112**. In this arrangement, a user can comfortably grip the handle **124** in a position in which their fingers can comfortably operate the user activation device(s) **130** while the electrosurgical electrode **128** is set at a rotational position selected from among a plurality of rotational positions relative to the handle **124** based on, for example, a location, a size, and/or a shape of a surgical site in which the user is operating. In particular, the user activation device(s) **130** can include one or more buttons on an exterior surface of the handle **124**, where the one or more buttons that are operable to select between a cutting mode of operation and a coagulation mode of operation.

[0185] In alternative examples, electrosurgical devices can be configured to reduce the need to rotate an electrode relative to the handle to allow comfortable operation of user activation device(s). For instance, referring to FIG. **19**A, an electrosurgical device **1912** includes the housing **123** extending along a longitudinal axis **1923**C between a proximal end **1923**A and a distal end **1923**B. The housing **123** includes the handle **124** defining the proximal end **1923**A and the shaft **126** defining the distal end **1923**B. The electrosurgical device **1912** includes the electrosurgical electrode **128** that is coupled to the shaft **126** so that the electrosurgical electrode **128** extends from the distal end **1923**B of the housing **123**. The electrosurgical device **1912** includes user activation devices **130**. In particular, the user activation devices **130** include a first user activation device **1930**A that is operable to control a supply of electrosurgical energy to the electrosurgical electrode **228**. The first user activation device **1930**A extends a sufficient length along a circumference of the housing **123** so that a user's fingers can reach and operate the first user activation device **1930**A while the electrosurgical electrode **128** remains in a preferred position and orientation for cutting, coagulation, etc., at a surgical site. The length of the first user activation device **1930**A around the housing **123** accommodates preferred positioning and orientation of the electrosurgical electrode **128** without needing relative rotation between the electrosurgical electrode **128** and the handle **124** (as described above with reference to FIG. **18**).

[0186] In some implementations, the first user activation device **1930**A extends around at least half of a circumference of the housing **123**. As shown in FIG. **19**B, for example, the first user activation device **1930**A defines a ring that extends around an entirety of the circumference of the housing **123**. The first user activation device **1930**A can be disposed in a channel **1925**A in the housing **123**, where the channel **1925**A is recessed relative to an exterior surface of the housing **123**.

[0187] FIG. **19**C illustrates a cross-sectional view of the electrosurgical device **1912** at the first user activation device **1930**A. The first user activation device **1930**A includes a plurality of segments **1931**, where each segment **1931** extends around a respective portion of the circumference of the housing **123**. As shown in FIG. **19**C, four segments **1931** are positioned respectively at 0°, 90°, 180°, and **2700** around the circumference of the housing **123** to define the ring in the channel **1925**A. The first user activation device **1930**A in other examples, however, can have a different number of segments **1931** (e.g., two, three, five, or more segments **1931**). Furthermore, although the segments **1931** in FIG. **19**C may define a circular arrangement around a circular profile for the housing **123**, the housing **123** in other examples can have a non-circular (e.g., elliptical) profile and the segments **1931** can define a corresponding non-circular shape around the housing **123**.

[0188] As shown in FIG. **19**C, each segment **1931** includes an inner surface **1931**A that faces the housing **123**, an outer surface **1931**B that faces away from the housing **123** and opposes the inner surface **1931**A, a distal surface **1931**C, a proximal surface **1931**D, a first lateral surface **1931**E, and a second lateral surface **1931**F. As shown in FIG. **19**C, the inner surface **1931**A of each segment **1931** has a common radius of curvature, and the plurality of segments **1931** have the same shape and the same size as each other. In other examples, however, the segments **1931** may have different shapes and sizes. For instance, if the housing **123** has an elliptical profile, the first user activation device **1930**A may include two pairs of symmetrically opposing segments **1931**, where the segments **1931** in one pair are different in shape and size from the segments **1931** in the other pair.

[0189] In some implementations, only one segment **1931** of the plurality of segments **1931** is operable at a time, i.e., when one segment **1931** is depressed, the other segments **1931** cannot be concurrently depressed. For example, the first user activation device **1930**A can be configured such that, when one segment **1931** (e.g., at 0°) is depressed towards the housing **123**, the one segment **1931** engages adjacent segments **1931** (e.g., at 900 and 270°) and stops the adjacent segments **1931** from being depressed towards the housing **123**.
[0190] In an implementation, the electrosurgical device **1912** can include the plurality of switches **134**, where the first user activation device **1930**A engages the plurality of switches **134**. Each switch **134** is disposed between a respective one of the plurality of segments **1931** and the housing **123** and is configured to be actuated to control the supply of electrosurgical energy to the electrosurgical electrode **128**. For example, the switches **134** can be positioned at 0°, 90°, 180°, and 270° corresponding to positions of the segments **1931**. A switch **134** can be individually actuated when the respective segment **1931** is depressed radially inward into the switch **134**. In an implementation, depressing the segment **1931** and thereby actuating the respective switch **134** associated with the segment **1931** can close the switch **134** to complete a circuit to a electrosurgical generator **110** coupled to the electrosurgical device **1912** (as described above). The completed circuit causes the electrosurgical generator **110** to supply the electrosurgical energy to the electrosurgical electrode **128** with a level of power and/or a waveform corresponding to a mode of operation associated with the first user activation device **1930**A.
[0191] In some implementations, the electrosurgical device **1912** includes one or more flexible printed circuit boards **138**, where the plurality of switches **134** are configured to cause the one or more flexible printed circuit boards **138** to control the supply of electrosurgical energy to the electrosurgical electrode **128**. The one or more flexible printed circuit boards **138** are disposed between the switches **134** and the housing **123**. In an example, the switches **134** engage a common flexible printed circuit board **138**. In another example, each switch **134** engages a respective one of a plurality of flexible printed circuit boards **138** (e.g., positioned at 0°, 90°, 180°, and 270°). When actuated, each switch **134** causes a flexible printed circuit board **134** to transmit a signal to an electrosurgical generator **110**. The electrosurgical generator **110** then responsively supplies electrosurgical energy to the electrosurgical electrode **128** with a level of power and/or a waveform corresponding to a mode of operation associated with the first user activation device **1930**A.
[0192] As shown in FIG. **19**C, the combination of a segment **1931** and a switch **134** at each of multiple positions around the longitudinal axis **1923**C (e.g., at 0°, 90°, 180°, and 270°) allows a user to depress and operate the first user activation device **1930**A from multiple angles or approaches. As such, the first user activation device **1930**A is considered a multi-axial user activation device. This multi-axial user activation device allows the user to hold the electrosurgical device **1912** in a manner that accommodates a preferred position and orientation for the electrosurgical electrode **128** while comfortably operating the first user activation device **1930**A according to the mode of operation. Advantageously, this reduces the need to stop and restart a surgical procedure to allow the user to rotate the electrosurgical electrode **128** relative to the handle **124** to maintain the preferred position and orientation for the electrosurgical electrode **128**. Furthermore, this multi-axial user activation device provides ambidextrous functionality (i.e., accommodates operation by right or left hand).
[0193] In an example, each segment **1931** moves or deforms appreciably radially inward into the corresponding switch **134** when depressed and moves or reforms appreciably radially outward when no longer depressed. With this inward and outward radial movement or deformation, a user can receive sufficient tactile feedback when operating the first user activation device **1930**A. To provide such feedback, the segment **1931** can be formed from a compressible material that is reversibly deformed when the segment **1931** is depressed. Examples of a compressible material can include, but are not limited to, any elastomer (e.g., silicone), nitrile butadiene rubber (NBR), ethylene propylene diene monomer (EPDM) rubber, or the like. Alternatively, the segment **1931**

can be formed from a non-compressible material, including, but not limited to, acrylonitrile butadiene styrene (ABS), high impact polystyrene (HIPS), poly(methyl methacrylate) (PMMA), or any hard engineering plastic. A bias element, such as a spring, can be disposed between each segment **1931** and the housing **123**, where the bias element acts to bias the segment **1931** radially outward when not depressed.

[0194] Each segment **1931** can be movably coupled to the housing **123**. Alternatively or additionally, each segment **1931** can be movably coupled to adjacent segments **1931**. Alternatively or additionally, a sheath formed from a flexible material or similar device can fit over the segments **1931** to hold the segments **1931** in place in the channel **1925**A.

[0195] In further implementations, the first user activation device **1930**A includes at least one sensor **1933** that is configured to sense an extent to which each segment **1931** is depressed towards the housing **123**. The at least one sensor **1933** can be one or more pressure sensors, one or more optical sensors, one or more capacitive sensors, one or more inductive sensors, one or more infrared sensors, one or more piezoelectric sensors, one or more ultrasonic sensors, one or more resistive sensors, and/or one or more image sensors (e.g., camera). In one implementation, as shown in FIG. **19**C, each segment **1931** is coupled to a respective sensor **1933** to sense the extent to which the segment **1931** is depressed. The switch **134** can be actuated when the sensor **1933** detects sufficient contact or movement when the respective segment **1931** is depressed. For example, each switch **134** can be actuated when the sensor **1933** detects that the respective segment **1931** has been depressed to apply a pressure that exceeds a threshold pressure over a threshold period of time. As such, the sensor **1933** reduces the chance of accidental actuation with the first user activation device **1930**A. In general, the sensors **1933** can detect operation of the first user activation device **1930**A irrespective of what part of the first user activation device **1930**A is depressed.

[0196] As shown in FIGS. **19**B-C, the electrosurgical device **1912** can also include a second user activation device **1930**B that is offset along the longitudinal axis **1923**C of the housing **123** relative to the first user activation device **1930**A, where the longitudinal axis **1923**C extends between the proximal end **1923**A and the distal end **1923**B of the housing **123**. According to one implementation, the first user activation device **1930**A is operable to supply the electrosurgical energy with a first waveform that is configured for cutting tissue with the electrosurgical electrode **128**, while the second user activation device **1930**B is operable to supply electrosurgical energy with a second waveform that is configured for coagulating tissue with the electrosurgical electrode **128**, where the first waveform is different than the second waveform.

[0197] The second user activation device **1930**B can include the features of the first user activation device **1930**A described herein. In particular, similar to the first user activation device **1930**A, the second user activation device **1930**B extends a sufficient length along a circumference of the housing **123** so that a user's fingers can reach and operate the second user activation device **1930**B while the electrosurgical electrode **128** remains in a preferred position and orientation at a surgical site. The length of the second user activation device **1930**B accommodates preferred positioning and orientation of the electrosurgical electrode **128** without needing relative rotation between the electrosurgical electrode **128** and the handle **124** (as described above with reference to FIG. **18**). In general, the second user activation device **1930**B can provide another a multi-axial user activation device for additional operation of the electrosurgical electrode **128**.

[0198] In some implementations, the second user activation device **1930**B extends around at least half of the circumference of the housing **123**. As shown in FIG. **19**B, for example, the second user activation device **1930**B defines a second ring that extends around an entirety of the circumference of the housing **123**. The second user activation device **1930**B can be disposed in a channel **1925**B in the housing **123**, where the channel **1925**B is recessed relative to an exterior surface of the housing **123**. In other implementations, the electrosurgical device **1912** can include additional user activation devices with similar features.

[0199] Referring to an example system illustrated in FIG. **20**, the first user activation device **1930**A

includes at least one first sensor **1933**A that is configured to sense a first distance by which the first user activation device **1930**A is depressed towards the housing **123**, and the second user activation device **1930**B includes at least one second sensor **1933**B that is configured to sense a second distance by which the second user activation device **1930**B is depressed towards the housing **123**. In some cases, the first user activation device **1930**A and the second user activation device **1930**B might be depressed at the same time. In such cases, the electrosurgical device **1912** can determine whether to respond to the first user activation device **1930**A or the second user activation device **1930**B. In particular, the electrosurgical device **1912** includes a controller **2035** that is in communication with the at least one first sensor **1933**A and the at least one second sensor **1933**B. In an act **2002**, the controller **2035** receives, from the at least one first sensor **1933**A, a first signal indicative of the first distance sensed by the at least one first sensor **1933**A at a first time. In an act **2004**, the controller **2035** receives, from the at least one second sensor **1933**B, a second signal indicative of the second distance sensed by the at least one second sensor **1933**A at the first time. In an act **2006**, the controller **2035** makes a determination, based on the first signal and the second signal, which of the first distance and the second distance is greater. If the determination is that the first distance is greater than the second distance, then controller **2035** in act **2008**A supplies the electrosurgical energy the electrosurgical electrode **128** with the first waveform, which causes the electrosurgical electrode **128** to cut tissue. On the other hand, if the determination is that the second distance is greater than the first distance, then controller **2035** in act **2008**B supplies the electrosurgical energy the electrosurgical electrode **128** with the second waveform, which causes the electrosurgical electrode **128** to coagulate tissue. Accordingly, in this example, the electrosurgical device **1912** can determine what mode of operation the user intends to actuate.

[0200] FIG. **21** depicts a flowchart for a method **2100** for operating an electrosurgical device, according to an example. In the method **2100**, act **2102** includes providing an electrosurgical device, where the electrosurgical device includes: (i) a housing extending between a proximal end and a distal end; (ii) an electrosurgical electrode extending from the distal end of the housing; and (iii) a first user activation device extending around at least half of a circumference of the housing. Act **2104** includes positioning and orienting the electrosurgical electrode at a surgical site. Act **2106** includes operating the first user activation device to control a supply of electrosurgical energy to the electrosurgical electrode. Advantageously, the user activation device can be operated in act **2106** without needing to adjust the electrosurgical electrode to maintain a preferred position and orientation for the electrosurgical electrode established in act **404**.

[0201] Although the features above may be described in relation to electrosurgery, it is understood that such features can be more generally implemented in any medical instrument for any medical procedure. In particular, one or more multi-axial user activation devices may be employed to allow comfortable hand operation of a medical instrument while maintaining a preferred position and orientation for the medical instrument.

[0202] As an example, FIG. **22** depicts a surgical instrument **2212** that is operable to perform a surgical task during a surgical procedure. As examples, the surgical instrument **2212** can include at least one instrument selected from among a group consisting of a drill, a bone cutter, an aspiration tool, an irrigation tool, a shaver, a microscope, a camera (e.g., an endoscope), a surgical retractor, an electrosurgical instrument, and an illumination device. Within examples, the surgical instrument **2212** can include a working element **228** that is operable to perform the at least one surgical task selected from a group consisting of a drilling operation, a cutting operation, a shaving operation, a tissue retraction operation, a suctioning operation, an irrigation operation, a probing operation, a clamping operation, a coagulation operation, a heating operation, a cooling operation, an ablation operation, an electrical stimulation operation, an image capture operation, a sawing operation, and a grinding operation. For instance, the working element **2228** can include a drill bit, an electrosurgical electrode (e.g., the electrode **128** described above), an ablation end effector (e.g., a cryoablation balloon, an electrode, a laser light emitter, and/or a heating element), a fluid valve, a

vacuum source, and a cutting blade.
[0203] As shown in FIG. **22**, the surgical instrument **2212** can include a housing **2223** and the working element **2228** can be coupled to the housing **2223**. The housing **2223** can be similar to the housing **123** described above. For instance, in some examples, the housing **2223** can include the handle **124** and the shaft **126**. More generally, the housing **123** can be gripped, manipulated, and moved by the surgeon during the surgical procedure.
[0204] Additionally, as shown in FIG. **22**, the surgical instrument **2212** includes one or more of the activation devices **130** described above with respect to FIGS. **1-21**. In this arrangement, the user activation device(s) **130** that can be actuated to operate the working element **2228** of the surgical instrument **2212** from multiple angles or approaches. As described above, this reduces the need to stop and restart a surgical procedure to allow the user to adjust the working element **2228** to maintain the preferred position and orientation for the working element **2228**. Furthermore, this user activation device provides ambidextrous functionality (i.e., accommodates operation by right or left hand).
[0205] The description of the different advantageous arrangements has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. Further, different advantageous embodiments may provide different advantages as compared to other advantageous embodiments. The implementation or implementations selected are chosen and described in order to best explain the principles of the embodiments, the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

Claims

1. An electrosurgical instrument, comprising: a housing extending from a proximal end to a distal end; an electrosurgical electrode extending from the distal end of the housing; and a user activation device disposed between the proximal end of the housing and the distal end of the housing, wherein the user activation device is operable to control a supply of electrosurgical energy to the electrosurgical electrode, wherein the user activation device comprises: a collar that extends around at least a half of a circumference of the housing, wherein the collar is movable between a home position relative to the housing and a first activation position relative to the housing, and a switch that is configured to control the supply of electrosurgical energy to the electrosurgical electrode responsive to the collar moving from the home position to the first activation position.
2. The electrosurgical instrument of claim 1, wherein the collar extends around an entirety of the circumference of the housing.
3. The electrosurgical instrument of any one of claims 1-2, wherein the collar is further movable between the home position and a second activation position relative to the housing, wherein the home position is between the first activation position and the second activation position, and wherein, responsive to the collar moving from the home position to the first activation position, the switch is configured to cause the electrosurgical energy to be supplied to the electrosurgical electrode with a first waveform, wherein, responsive to the collar moving from the home position to the second activation position, the switch is configured to cause the electrosurgical energy to be supplied to the electrosurgical electrode with a second waveform, wherein the first waveform is different from the second waveform, and wherein, wherein when the collar is in the home position, the switch is configured to prevent the electrosurgical energy from being supplied to the electrosurgical electrode.
4. The electrosurgical instrument of claim 3, wherein the switch comprises a rocker switch that is mechanically actuatable between a first position, a second position, and a third position, and wherein the collar is configured to mechanically engage the switch such that (i) the switch is in the

first position when the collar is in the home position, (ii) the switch is in the second position when the collar is in the first activation position, and (iii) the switch is in the third position when the collar is in the second activation position.

5. The electrosurgical instrument of claim 3, wherein the switch comprises a hall effect sensor that is configured to sense when the collar is in the home position, when the collar is in the first activation position, and when the collar is in the second activation position.

6. The electrosurgical instrument of claim 3, wherein the switch comprises a first electrical contact, a second electrical contact, and a third electrical contact, wherein the collar comprises one or more conductive elements, wherein, when the collar is in the first activation position, the one or more conductive elements electrically contact the first electrical contact and the second electrical contact, and wherein, when the collar is in the second activation position, the one or more conductive elements electrically contact the second electrical contact and the third electrical contact.

7. The electrosurgical instrument of claim 6, wherein the switch further comprises a plurality of flaps that cover respective ones of the first electrical contact and the third electrical contact, and wherein the collar is configured to move the plurality of flaps to expose the respective ones of the first electrical contact and the third electrical contact responsive to the collar moving relative to the housing.

8. The electrosurgical instrument of any one of claims 1-7, wherein the housing comprises a recessed portion, wherein the recessed portion has cross-sectional dimensions that are less than cross-sectional dimensions of the housing on opposing sides of the recessed portion, and wherein the collar is disposed and movable in the recessed portion of the housing.

9. The electrosurgical instrument of any one of claims 1-8, wherein a central portion of the collar has a concave shape.

10. The electrosurgical instrument of any one of claims 1-8, wherein a central portion of the collar has a convex shape.

11. The electrosurgical instrument of any one of claims 1-10, wherein the collar comprises a grip portion, and wherein the grip portion has a coefficient of friction that is greater than a coefficient of friction of at least a portion of the housing.

12. The electrosurgical instrument of any one of claims 1-11, wherein the housing comprises a grip section located proximal on an exterior surface of the housing and proximal of the collar, wherein the grip section has a coefficient of friction that is greater than a coefficient of friction of at least a portion of the housing.

13. The electrosurgical instrument of any one of claims 1-12, wherein the user activation device further comprises a biasing member that biases the collar towards the home position.

14. The electrosurgical instrument of any one of claims 1-13, wherein the collar comprises a plurality of segments that are independently movable relative to each other and the housing.

15. The electrosurgical instrument of claim 14, wherein the switch comprises a plurality of switches, wherein each segment is configured to actuate a respective one of the plurality of switches.

16. A method of operating an electrosurgical instrument, comprising: coupling a power cord of an electrosurgical instrument to an electrosurgical generator, wherein the electrosurgical instrument comprises: a housing extending from a proximal end to a distal end, an electrosurgical electrode extending from the distal end of the housing, and a user activation device disposed between the proximal end of the housing and the distal end of the housing, wherein the user activation device is operable to control a supply of electrosurgical energy to the electrosurgical electrode, wherein the user activation device comprises a collar that extends around at least a half of a circumference of the housing, wherein the collar is movable between a home position relative to the housing and a first activation position relative to the housing, wherein the user activation device further comprises a switch that is configured to control the supply of the electrosurgical energy to the electrosurgical electrode responsive to the collar moving from the home position to the first activation position;

moving the collar from the home position to the first activation position; and responsive to moving the collar from the home position to the first activation position, supplying the electrosurgical energy from the electrosurgical generator to the electrosurgical electrode.

17. The method of claim 16, further comprising: after supplying the electrosurgical energy, moving the collar from the first activation position to the home position; and responsive to moving the collar from the first activation position to the home position, ceasing the supply of the electrosurgical energy to the electrosurgical electrode.

18. The method of claim 17, wherein moving the collar from the first activation position to the home position comprises using a biasing member to automatically move the collar from the first activation position to the home position when a user releases the collar.

19. The method of any one of claims 16-18, wherein supplying the electrosurgical energy from the electrosurgical generator to the electrosurgical electrode responsive to moving the collar from the home position to the first activation position comprises supplying the electrosurgical energy with a first waveform.

20. The method of claim 19, further comprising moving the collar from the home position to a second activation position, wherein the home position is between the first activation position and the second activation position, and responsive to moving the collar from the home position to the second activation position, supplying the electrosurgical energy to the electrosurgical electrode with a second waveform, wherein the first waveform is different from the second waveform.

21. The method of any one of claim 16-20, wherein the switch comprises a rocker switch, and wherein moving the collar from the home position to the first activation position comprises mechanically engaging a rocker paddle of the rocker switch to depress a first contact of the rocker switch.

22. The method of any one of claim 16-20, wherein moving the collar from the home position to the first activation position comprises closing a circuit between a first electrical contact of the switch, a second electrical contact of the switch, and a conductive element of the collar.

23. The method of any one of claims 16-20, further comprising: sensing, by a Hall Effect sensor, that the collar is in the home position; responsive to sensing that the collar is in the home position, preventing supply of the electrosurgical energy to the electrosurgical electrode; and sensing, by the Hall Effect sensor, that the collar is in the first activation position, wherein supplying the electrosurgical energy from the electrosurgical generator to the electrosurgical electrode is responsive to sensing that the collar is in the first activation position.

24. The method of any one of claims 16-23, wherein the collar comprises a plurality of segments that are independently movable relative to each other and the housing, and wherein moving the collar from the home position to the first activation position comprises moving one segment of the plurality of segments relative to another segment of the plurality of segments.

25. A method of making an electrosurgical instrument, comprising: forming a housing extending from a proximal end to a distal end; coupling an electrosurgical electrode to the housing such that the electrosurgical electrode extends from the distal end of the housing; and coupling a user activation device to the housing between the proximal end of the housing and the distal end of the housing, wherein the user activation device is operable to control a supply of electrosurgical energy to the electrosurgical electrode, wherein the user activation device comprises: a collar that extends around at least a half of a circumference of the housing, wherein the collar is movable between a home position relative to the housing and a first activation position relative to the housing, and a switch that is configured to control the supply of the electrosurgical energy to the electrosurgical electrode responsive to the collar moving from the home position to the first activation position.

26. An electrosurgical device, comprising: a housing extending between a proximal end and a distal end; an electrosurgical electrode extending from the distal end of the housing; and a first user activation device that is operable to control a supply of electrosurgical energy to the electrosurgical electrode, wherein the first user activation device extends around at least half of a circumference of

the housing.
27. The electrosurgical device of claim 26, wherein the first user activation device extends around an entirety of the circumference of the housing.
28. The electrosurgical device of any one of claims 26-27, wherein the first user activation device comprises a plurality of segments, and wherein each segment extends around a respective portion of the circumference of the housing.
29. The electrosurgical device of claim 28, wherein only one segment of the plurality of segments is operable at a time.
30. The electrosurgical device of claim 29, wherein the first user activation device is configured such that, when one segment of the plurality of segments is depressed towards the housing, the one segment engages adjacent segments of the plurality of segments and stops the adjacent segments from being depressed towards the housing.
31. The electrosurgical device of any one of claims 28-30, wherein each segment comprises an inner surface that faces the housing, an outer surface that faces away from the housing an opposes the inner surface, a distal surface, a proximal surface, a first lateral surface, and a second lateral surface, and wherein the inner surface of each segment has a common radius of curvature.
32. The electrosurgical device of any one of claims 3-6, wherein the plurality of segments have the same shape and the same size as each other.
33. The electrosurgical device of any one of claims 28-32, further comprising a plurality of switches, wherein the first user activation device engages the plurality of switches, and each switch is disposed between a respective one of the plurality of segments and the housing and is configured to be actuated to control the supply of electrosurgical energy to the electrosurgical electrode.
34. The electrosurgical device of any one of claim 33, further comprising one or more flexible printed circuit boards, wherein the plurality of switches are configured to cause the one or more flexible printed circuit boards to control the supply of electrosurgical energy to the electrosurgical electrode.
35. The electrosurgical device of any one of claims 28-34, wherein the first user activation device comprises at least one sensor that is configured to sense an extent to which each segment is depressed towards the housing.
36. The electrosurgical device of claim 35, wherein the at least one sensor comprises at least one device selected from a group consisting of: one or more pressure sensors, one or more optical sensors, one or more capacitive sensors, one or more inductive sensors, one or more infrared sensors, one or more piezoelectric sensors, one or more ultrasonic sensors, one or more resistive sensors, and one or more image sensors.
37. The electrosurgical device of any one of claims 26-36, further comprising a second user activation device that is offset along a longitudinal axis of the housing relative to the first user activation device, wherein the longitudinal axis of the housing extends between the proximal end and the distal end of the housing, and wherein the second user activation device extends around at least half of the circumference of the housing.
38. The electrosurgical device of claim 37, wherein the first user activation device is operable to supply the electrosurgical energy with a first waveform that is configured for cutting tissue, wherein the second user activation device is operable to supply the electrosurgical energy with a second waveform that is configured for coagulating tissue, and wherein the first waveform is different than the second waveform.
39. The electrosurgical device of claim 38, wherein the first user activation device comprises at least one first sensor that is configured to sense a first distance by which the first user activation device is depressed towards the housing, and wherein the second user activation device comprises at least one second sensor that is configured to sense a second distance by which the second user activation device is depressed towards the housing.
40. The electrosurgical device of claim 39, further comprising a controller in communication with

the first sensor and the second sensor, wherein the controller is configured to: receive, from the at least one first sensor, a first signal indicative of the first distance sensed by the first sensor at a first time, receive, from the at least one second sensor, a second signal indicative of the second distance sensed by the second sensor at the first time, make a determination, based on the first signal and the second signal, which of the first distance and the second distance is greater, if the determination is that the first distance is greater than the second distance, then supply the electrosurgical energy with the first waveform, and if the determination is that the second distance is greater than the first distance, then supply the electrosurgical energy with the second waveform.

41. The electrosurgical device of any one of claims 26-40, wherein the first user activation device is disposed in a channel in the housing, and wherein the channel is recessed relative to an exterior surface of the housing.

42. A method for operating an electrosurgical device, comprising: providing an electrosurgical device, the electrosurgical device comprising: a housing extending between a proximal end and a distal end; an electrosurgical electrode extending from the distal end of the housing; and a first user activation device extending around at least half of a circumference of the housing; positioning and orienting the electrosurgical electrode at a surgical site; and operating the first user activation device to control a supply of electrosurgical energy to the electrosurgical electrode.

43. The method of claim 42, wherein the first user activation device extends around an entirety of the circumference of the housing.

44. The method of any one of claims 42-43, wherein the first user activation device comprises a plurality of segments, wherein each segment extends around a respective portion of the circumference of the housing, and operating the first user activation device comprises operating one of the segments.

45. The method of claim 44, wherein only one segment of the plurality of segments is operable at a time.

46. The method of claim 45, wherein the first user activation device is configured such that, when one segment of the plurality of segments is depressed towards the housing, the one segment engages adjacent segments of the plurality of segments and stops the adjacent segments from being depressed towards the housing.

47. The method of any one of claims 44-46, wherein each segment comprises an inner surface that faces the housing, an outer surface that faces away from the housing an opposes the inner surface, a distal surface, a proximal surface, a first lateral surface, and a second lateral surface, and wherein the inner surface of each segment has a common radius of curvature.

48. The method of any one of claims 44-47, wherein the plurality of segments have the same shape and the same size as each other.

49. The method of any one of claims 44-48, wherein the electrosurgical device further comprises a plurality of switches, the first user activation device engages the plurality of switches, and each switch is disposed between a respective one of the plurality of segments and the housing and is configured to be actuated to control the supply of electrosurgical energy to the electrosurgical electrode.

50. The method of any one of claim 49, wherein the electrosurgical device further comprises one or more flexible printed circuit boards, wherein the plurality of switches are configured to cause the one or more flexible printed circuit boards to control the supply of electrosurgical energy to the electrosurgical electrode.

51. The method of any one of claims 44-50, wherein the first user activation device comprises at least one sensor that is configured to sense an extent to which each segment is depressed towards the housing.

52. The method of claim 51, wherein the at least one sensor comprises at least one device selected from a group consisting of: one or more pressure sensors, one or more optical sensors, one or more capacitive sensors, one or more inductive sensors, one or more infrared sensors, one or more

piezoelectric sensors, one or more ultrasonic sensors, one or more resistive sensors, and one or more image sensors.

53. The method of any one of claims 42-52, further comprising a second user activation device that is offset along a longitudinal axis of the housing relative to the first user activation device, wherein the longitudinal axis of the housing extends between the proximal end and the distal end of the housing, and wherein the second user activation device extends around at least half of the circumference of the housing.

54. The method of claim 53, wherein operating the first user activation device supplies the electrosurgical energy with a first waveform that is configured for cutting tissue, wherein the second user activation device is operable to supply the electrosurgical energy with a second waveform that is configured for coagulating tissue, and wherein the first waveform is different than the second waveform.

55. The method of claim 54, wherein the first user activation device comprises at least one first sensor that is configured to sense a first distance by which the first user activation device is depressed towards the housing, and wherein the second user activation device comprises at least one second sensor that is configured to sense a second distance by which the second user activation device is depressed towards the housing.

56. The method of claim 55, wherein the electrosurgical device includes a controller in communication with the first sensor and the second sensor, and wherein the controller is configured to: receive, from the at least one first sensor, a first signal indicative of the first distance sensed by the first sensor at a first time, receive, from the at least one second sensor, a second signal indicative of the second distance sensed by the second sensor at the first time, make a determination, based on the first signal and the second signal, which of the first distance and the second distance is greater, if the determination is that the first distance is greater than the second distance, then supply the electrosurgical energy with the first waveform, and if the determination is that the second distance is greater than the first distance, then supply the electrosurgical energy with the second waveform.

57. The method of any one of claims 42-56, wherein the first user activation device is disposed in a channel in the housing, and wherein the channel is recessed relative to an exterior surface of the housing.

58. A method for assembling an electrosurgical device, comprising: providing a housing extending between a proximal end and a distal end; coupling an electrosurgical electrode to the housing such that the electrosurgical electrode extends from the distal end of the housing; and coupling a first user activation device to the housing wherein the first user activation device extends around at least half of a circumference of the housing and is operable to control a supply of electrosurgical energy to the electrosurgical electrode.

59. The method of claim 58, wherein the first user activation device extends around an entirety of the circumference of the housing.

60. The method of any one of claims 58-59, further comprising assembling the first user activation device from a plurality of segments, wherein each segment extends around a respective portion of the circumference of the housing.

61. The method of claim 60, further comprising configuring the first user activation device such that only one segment of the plurality of segments is operable at a time.

62. The method of claim 61, further comprising configuring the first user activation device such that, when one segment of the plurality of segments is depressed towards the housing, the one segment engages adjacent segments of the plurality of segments and stops the adjacent segments from being depressed towards the housing.

63. The method of any one of claims 60-62, wherein each segment comprises an inner surface that faces the housing, an outer surface that faces away from the housing an opposes the inner surface, a distal surface, a proximal surface, a first lateral surface, and a second lateral surface, and wherein

the inner surface of each segment has a common radius of curvature.
64. The method of any one of claims 60-63, wherein the plurality of segments have the same shape and the same size as each other.
65. The method of any one of claims 60-64, further comprising coupling the first user activation device to a plurality of switches, wherein each switch is disposed between a respective one of the plurality of segments and the housing.
66. The method of claim 65, wherein further comprising coupling the plurality of switches to one or more flexible printed circuit boards, wherein the plurality of switches are configured to cause the one or more flexible printed circuit boards to control the supply of electrosurgical energy to the electrosurgical electrode.
67. The method of any one of claims 60-66, further comprising providing the first user activation device with at least one sensor that is configured to sense an extent to which each segment is depressed towards the housing.
68. The method of claim 67, wherein the at least one sensor comprises at least one device selected from a group consisting of: one or more pressure sensors, one or more optical sensors, one or more capacitive sensors, one or more inductive sensors, one or more infrared sensors, one or more piezoelectric sensors, one or more ultrasonic sensors, one or more resistive sensors, and one or more image sensors.
69. The method of any one of claims 58-68, further comprising coupling a second user activation device to the housing, wherein the second user activation device is offset along a longitudinal axis of the housing relative to the first user activation device, wherein the longitudinal axis of the housing extends between the proximal end and the distal end of the housing, and wherein the second user activation device extends around at least half of the circumference of the housing.
70. The method of claim 69, wherein the first user activation device is operable to supply the electrosurgical energy with a first waveform that is configured for cutting tissue, wherein the second user activation device is operable to supply the electrosurgical energy with a second waveform that is configured for coagulating tissue, and wherein the first waveform is different than the second waveform.
71. The method of claim 70, further comprising: providing the first user activation device with at least one first sensor that is configured to sense a first distance by which the first user activation device is depressed towards the housing; and providing the second user activation device with at least one second sensor that is configured to sense a second distance by which the second user activation device is depressed towards the housing.
72. The method of claim 71, further comprising providing a controller in communication with the first sensor and the second sensor, wherein the controller is configured to: receive, from the at least one first sensor, a first signal indicative of the first distance sensed by the first sensor at a first time, receive, from the at least one second sensor, a second signal indicative of the second distance sensed by the second sensor at the first time, make a determination, based on the first signal and the second signal, which of the first distance and the second distance is greater, if the determination is that the first distance is greater than the second distance, then supply the electrosurgical energy with the first waveform, and if the determination is that the second distance is greater than the first distance, then supply the electrosurgical energy with the second waveform.
73. The method of any one of claims 58-72, wherein coupling the first user activation device to the housing comprises positioning the first user activation device in a channel in the housing, and wherein the channel is recessed relative to an exterior surface of the housing.