United States Patent Application Publication	20250255634
Kind Code	A1
Publication Date	August 14, 2025
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SURGICAL SYSTEM INCLUDING A CORDLESS SURGICAL INSTRUMENT, COMMUNICATION HUB, AND ONE OR MORE CONNECTED DEVICES

Abstract

A surgical system includes a cordless surgical instrument configured to obtain information regarding preparation of the cordless surgical instrument for use and/or information regarding at least one replaceable component of the cordless surgical instrument. The surgical system further includes a communication hub configured to wirelessly connect to the cordless surgical instrument to receive the information therefrom. The communication hub is configured to instruct. based at least on the information. a connected device to provide an output relating to the preparation of the cordless surgical instrument for use or the replacement of the at least one replaceable component.

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Family ID:	**1000008577692**
Appl. No.:	**18/859328**
Filed (or PCT Filed):	**May 18, 2023**
PCT No.:	**PCT/IB2023/055121**

Related U.S. Application Data

us-provisional-application US 63343231 20220518

Publication Classification

Int. Cl.: **A61B17/32** (20060101); **A61B17/00** (20060101)

U.S. Cl.:

CPC **A61B17/320068** (20130101); A61B2017/00119 (20130101); A61B2017/00221 (20130101); A61B2017/00725 (20130101); A61B2017/00734 (20130101); A61B2017/320071 (20170801); A61B2017/320075 (20170801); A61B2017/320082 (20170801)

Background/Summary

FIELD

[0001] This disclosure relates to surgical systems and, more particularly, to a surgical system including a cordless surgical instrument, e.g., a cordless ultrasonic surgical instrument, a communication hub, and one or more connected devices.

BACKGROUND

[0002] Many surgical instruments incorporate hardware and/or software features that facilitate operation and control. Such surgical instruments are also typically configured to obtain and store data related to the instrument and/or components thereof such as, for example: identification data, use data, and/or performance data. However, such surgical instruments are limited in their ability to process and/or convey information to a user solely from the surgical instruments themselves.

SUMMARY

[0003] As used herein, the term “distal” refers to the portion that is being described which is farther from an operator (whether a human clinician or a surgical robot), while the term “proximal” refers to the portion that is being described which is closer to the operator. Terms including “generally,” “about,” “substantially,” and the like, as utilized herein, are meant to encompass variations, e.g., manufacturing tolerances, material tolerances, use and environmental tolerances, measurement variations, design variations, and/or other variations, up to and including plus or minus 10 percent. To the extent consistent, any of the aspects described herein may be used in conjunction with any or all of the other aspects described herein.

[0004] Provided in accordance with aspects of this disclosure is a surgical system including a cordless surgical instrument and a communication hub. The cordless surgical instrument is configured to obtain information regarding preparation of the cordless surgical instrument for use. The communication hub is configured to wirelessly connect to the cordless surgical instrument to receive the information therefrom. The communication hub is configured to instruct, based at least on the information, a connected device to provide an output relating to the preparation of the cordless surgical instrument for use.

[0005] In an aspect of this disclosure, the information regarding preparation of the cordless surgical instrument for use includes information regarding assembly of the cordless surgical instrument. In such aspects, the information may include information indicating that first and second components of the cordless surgical instrument are engaged with one another.

[0006] In another aspect of this disclosure, the output includes display of at least one step for assembling the cordless surgical instrument for use. In such aspects, the output may include display of a plurality of steps for assembling the cordless surgical instrument for use. Further, the display

may switch between different steps of the plurality of steps based on additional information wirelessly communicated from the cordless surgical instrument to the communication hub.
[0007] In still another aspect of this disclosure, the information regarding preparation of the cordless surgical instrument for use includes identifying information for a plurality of components of the cordless surgical instrument. In such aspects, the output may include display of an indication of whether the plurality of components of the cordless surgical instrument is approved for use.
[0008] In yet another aspect of this disclosure, the information regarding preparation of the cordless surgical instrument for use includes information regarding an instrument test of the cordless surgical instrument. In such aspects, the output may include display of an indication of whether the cordless surgical instrument passed or failed the instrument test. In a case where the cordless surgical instrument failed the instrument test, the output may further include at least one of an indication of a cause of the failed instrument test or a troubleshooting recommendation.
[0009] In still yet another aspect of this disclosure, the cordless surgical instrument includes a battery assembly and a generator configured to drive the cordless surgical instrument. The generator is powered by the battery assembly. The cordless surgical instrument may further include an ultrasonic transducer and an ultrasonic blade coupled to the ultrasonic transducer. The generator is configured to drive the ultrasonic transducer to produce mechanical vibration motion at the ultrasonic blade.
[0010] Another surgical system provided in accordance with this disclosure includes a cordless surgical instrument configured to obtain information regarding at least one replaceable component of the cordless surgical instrument, and a communication hub configured to wirelessly connect to the cordless surgical instrument to receive the information therefrom. The communication hub is configured to instruct, based at least on the information, a connected device to provide an output relating to replacement of the at least one replaceable component of the cordless surgical instrument.
[0011] In an aspect of this disclosure, the at least one replaceable component is a battery assembly. In such aspects, the cordless surgical instrument may include a generator configured to drive the cordless surgical instrument, wherein the generator is powered by the battery assembly.
[0012] In another aspect of this disclosure, the information includes a state of charge of the battery assembly and the communication hub is configured to instruct, based at least on the state of charge of the battery assembly being below a threshold value, the connected device to provide the output. Alternatively, the information includes an indication that a state of charge of the battery assembly is below a threshold value.
[0013] In still another aspect of this disclosure, the output includes display of at least one step for replacing the at least one replaceable component.
[0014] The details of one or more aspects of this disclosure are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the techniques described in this disclosure will be apparent from the description and drawings, and from the claims.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0015] Various aspects and features of this disclosure are described hereinbelow with reference to the drawings wherein like numerals designate identical or corresponding elements in each of the several views.
[0016] FIG. **1** is a schematic illustration of a surgical system provided in accordance with this disclosure;
[0017] FIG. **2** is a perspective view of a cordless ultrasonic surgical instrument configured for use

with the surgical system of FIG. **1**;
[0018] FIG. **3** is a longitudinal, cross-sectional view of a proximal portion of the cordless ultrasonic surgical instrument of FIG. **2**;
[0019] FIG. **4** is a schematic illustration of portions of the cordless ultrasonic surgical instrument of FIG. **2**;
[0020] FIG. **5** is a block diagram of a portion of the surgical system of FIG. **1**; and
[0021] FIGS. **6**A-**12** are screen shots of various display screens provided in accordance with this disclosure.

DETAILED DESCRIPTION

[0022] Turning to FIG. **1**, a surgical system provided in accordance with the present disclosure is shown generally identified by reference numeral **2**. Surgical system **2** includes one or more surgical instruments, e.g., a cordless ultrasonic surgical instrument **10**; a communication hub **30**; and one or more connected devices in communication with communication hub **30** such as, for example, a server **40**, a computer **50**, a smartphone or tablet **60**, a display monitor **70**, etc. Communication hub **30** and/or one or more of the connected devices **40**-**70** of surgical system **2** may further be configured to communicate with one or more remote and/or cloud based devices such as, for example, one or more servers **80** and/or one or more computers **90**.
[0023] Cordless ultrasonic surgical instrument **10** is configured to wirelessly communicate with communication hub **30** using any suitable wireless protocol, e.g., radio frequency (RF), optical, Wi-Fi, Bluetooth®, Bluetooth® Low Energy, or ZigBee®. Cordless ultrasonic surgical instrument **10** may be configured to communicate information to communication hub **30** such as, for example: identifying information of cordless ultrasonic surgical instrument **10** and/or components thereof; status information of cordless ultrasonic surgical instrument **10** and/or components thereof; use information associated with cordless ultrasonic surgical instrument **10** and/or components thereof; and/or other information associated with cordless ultrasonic surgical instrument **10** and/or components thereof.
[0024] Continuing with reference to FIG. **1**, communication hub **30** communicates with each of the one or more connected devices **40**-**70** via a wired or wireless connection. With respect to wired connections, any suitable wired communication protocol may be utilized including, for example, transmission control protocol/internet protocol (TCP/IP), datagram protocol/internet protocol (UDP/IP), and/or datagram congestion control protocol (DCCP). With respect to wireless connections, any suitable wireless communication protocol may be utilized such as those detailed above.
[0025] Communication hub **30** may be configured to process information received from cordless ultrasonic surgical instrument **10** and to output the processed information to one or more of the connected devices **40**-**70** for display, further processing, control, notification, and/or any other suitable purposes. Although described with respect to cordless ultrasonic surgical instrument **10**, the aspects and features of this disclosure are also applicable, to the extent consistent, for use with any other suitable surgical instrument communicating with communication hub **30**.
[0026] Referring to FIGS. **2** and **3**, cordless ultrasonic surgical instrument **10** includes a handle assembly **100** and an elongated assembly **200** extending distally from handle assembly **100**. Handle assembly **100** includes a housing **110** defining a body portion **112** and a fixed handle portion **114**. Handle assembly **100** further includes an activation button **120** and a clamp trigger **130**.
[0027] Body portion **112** of housing **110** is configured to releasably support an ultrasonic transducer and generator assembly ("TAG") **300** including a generator **310** and an ultrasonic transducer **320**. Generator **310** includes a housing **312** configured to house the internal electronics **340** of generator **310**, and a cradle **314** configured to rotatably support ultrasonic transducer **320**. Ultrasonic transducer **320** includes a piezoelectric stack **322** and a distally-extending horn **324**. Horn **324** defines a threaded female receiver **326**. A set of connectors **330** and corresponding rotational contacts **334** associated with generator **310** and ultrasonic transducer **320**, respectively,

enable drive signals to be communicated from generator **310** to piezoelectric sack **322** of ultrasonic transducer **320** to drive ultrasonic transducer **320**. Ultrasonic transducer **320** further includes a rotation knob **328** extending proximally therefrom that, when rotated, rotates ultrasonic transducer **320** relative to generator **310** and housing **110**.

[0028] Fixed handle portion **114** of housing **110** defines a compartment **116** configured to receive a battery assembly **400** and a door **118** configured to enclose compartment **116**. An electrical connection assembly **140**, e.g., a flex circuit, is disposed within housing **110** of handle assembly **100** and serves to electrically couple activation button **120**, generator **310** of TAG **300**, and battery assembly **400** with one another when TAG **300** is supported on or in body portion **112** of housing **110** and battery assembly **400** is disposed within compartment **116** of fixed handle portion **114** of housing **110**, thus enabling activation of ultrasonic surgical instrument **10** in response to depression of activation button **120**.

[0029] Referring still to FIGS. **2** and **3**, elongated assembly **200** includes an outer drive sleeve **210**, an inner support sleeve **220** disposed within outer drive sleeve **210**, a waveguide **230** extending through inner support sleeve **220**, a drive assembly **250**, an integrated torque assembly **260**, a rotation knob **270**, and an end effector **280** including a blade **282** and a jaw **284**. A proximal portion of outer drive sleeve **210** is operably coupled to clamp trigger **130** of handle assembly **100** via drive assembly **250**, while a distal portion of outer drive sleeve **210** is operably coupled to jaw **284**. As such, clamp trigger **130** is selectively actuatable to thereby move outer drive sleeve **210** about inner support sleeve **220** to pivot jaw **284** relative to blade **282** of end effector **280** from a spaced-apart position to an approximated position for clamping tissue between jaw **284** and blade **282**. Other suitable configurations are also contemplated. Drive assembly **250** provides a force-limiting feature whereby the clamping pressure applied to tissue is limited to a particular clamping pressure or clamping pressure within a particular clamping pressure range. Rotation knob **270** defines a plurality of alternating flutes **272** and protrusions **274** arranged annularly about an exterior surface of rotation knob **270**.

[0030] Waveguide **230**, as noted above, extends through inner support sleeve **220**. Waveguide **230** defines a body **232** and blade **282** extending from the distal end of body **232**. Blade **282** serves as the blade **282** of end effector **280**. Waveguide **230** further includes a proximal connector **236** configured to enable engagement of waveguide **230** with horn **324** of ultrasonic transducer **320** such that ultrasonic motion produced by ultrasonic transducer **320** is transmitted along waveguide **230** to blade **282** for treating tissue clamping between blade **282** and jaw **284** or positioned adjacent to blade **282**. To this end, proximal connector **236** includes a threaded male shaft **237** that is configured for threaded engagement within threaded female receiver **326** of horn **324** of ultrasonic transducer **320**, although other suitable engagements, releasable or permanent, between horn **324** and waveguide **230** are also contemplated.

[0031] In order to facilitate ultrasonic energy transmission, waveguide **230** and ultrasonic transducer **320** are sufficiently engaged with one another without over-tightening. Integrated torque assembly **260** helps ensure that waveguide **230** and ultrasonic transducer **320** are sufficiently engaged while inhibiting over-tightening, although removable torque assemblies are also contemplated. More specifically, integrated torque assembly **260** is operably coupled about outer drive sleeve **210**, inner support sleeve **220**, and waveguide **230** such that rotation of rotation knob **270** relative to handle assembly **100** rotates elongated assembly **200** relative to handle assembly **100** up to a torque threshold, at which point integrated torque assembly **260** decouples rotation knob **270** from the other components of elongated assembly **200** such that further rotation of rotation knob **270** does not impart rotation to the other components of elongated assembly **200**.

[0032] With additional reference to FIG. **4**, generator electronics **340** of generator **310** are powered by battery assembly **400** and include a controller **342** configured to control the ultrasonic drive signal output to transducer **320**. Controller **342**, more specifically, includes a microprocessor **343** and memory **344**, e.g., storing instructions to be executed by microprocessor **343** to control the

ultrasonic drive signal provided to transducer **320** based on received motional feedback. A motional bridge **346** is configured to sense a mechanical motion, e.g., a magnitude and frequency of mechanical motion, of transducer **320** (although other suitable mechanical motion sensing features are also contemplated). The mechanical motion feedback provided by motional bridge **346** to controller **342** enables controller **342** to control the frequency and/or magnitude of the driving signal provided to an amplifier/filter **348** so that amplifier/filter **348**, in turn, provides a suitable drive signal to transducer **320** to drive transducer **320** at its resonance frequency and to achieve a target amount of mechanical motion of ultrasonic transducer **320** at its resonance frequency. Controller **342** is also configured to monitor the resonant frequency of transducer **320**, which varies throughout use such as, for example, due to changes in load applied to blade **282** (FIG. **2**), temperature of blade **282** (FIG. **2**), and/or other factors.

[0033] Referring generally to FIGS. **2**-**4**, the assembly, use, and disassembly of cordless ultrasonic surgical instrument **10** are detailed. Initially, TAG **300** is engaged with body portion **112** of housing **110** of handle assembly **100** such that the appropriate contacts associated with TAG **300** are electrically coupled with corresponding contacts of electrical connector **140** of housing **110**. Thereafter, or prior to engagement of TAG **300**, battery assembly **400** is aseptically transferred, e.g., using a guide, into and engaged within compartment **116** of fixed handle portion **114** of housing **110** of handle assembly **100** such that the appropriate contacts associated with battery assembly **400** are electrically coupled with corresponding contacts of electrical connector **140** of housing **110**.

[0034] Next, rotation knob **328** of ultrasonic transducer **320** is grasped with one hand, so as to stabilize and inhibit rotation of ultrasonic transducer **320**, while rotation knob **270** of elongated assembly **200** is grasped with the other hand. Rotation knob **270** of elongated assembly **200** is then rotated in an engagement direction to threadingly engage waveguide **230** and ultrasonic transducer **320** with one another. Rotation of rotation knob **270** is continued until sufficient engagement between waveguide **230** and ultrasonic transducer **320** is achieved. At this point, further rotation of rotation knob **270** causes integrated torque wrench **260** to slip, thereby inhibiting application of additional torque. An audible and/or tactile “click” may be produced to indicate that the torque threshold has been reached.

[0035] Cordless ultrasonic surgical instrument **10**, as assembled above, is now ready for use. In use, ultrasonic instrument **10** is inserted into and manipulated within a surgical site such that end effector **280** is positioned adjacent tissue to be treated. If needed, end effector **280** may be rotated relative to handle assembly **100** by rotating rotation knob **270**. Once positioned as desired, clamp trigger **130** may be actuated to pivot jaw member **282** from the open position towards the clamping position to clamp tissue to be treated between jaw member **282** and blade **284**. As detailed above, drive assembly **250** functions to limit the clamping pressure applied to grasped tissue to a particular clamping pressure or a clamping pressure within a particular clamping pressure range.

[0036] With tissue sufficiently clamped between jaw member **282** and blade **284**, activation button **120** may be activated in either a first, low power or tissue sealing mode or a second, high power or tissue transection mode to initiate the supply power from battery assembly **400** to TAG **300** for driving ultrasonic transducer **320** to, in turn, produce and transmit ultrasonic mechanical motion along waveguide **230** to blade **284** for treating tissue therewith, e.g., for sealing and/or transecting tissue.

[0037] Once the procedure is completed and ultrasonic surgical instrument **10** withdrawn from the surgical site, TAG **300** is disengaged from handle assembly **100** and elongated assembly **200** in the opposite manner as detailed above with respect to the engagement, and is removed from handle assembly **100** for sterilization and/or other cleaning in preparation for further use. Battery assembly **400** is also removed from handle assembly **100** and is cleaned and stored or placed on a charger (not shown) in preparation for further use. Handle assembly **100** and elongated assembly **200** may be discarded or sterilized for subsequent use.

[0038] Referring FIG. **5**, in conjunction with FIGS. **2** and **3**, cordless ultrasonic surgical instrument **10** further includes a processor **510**, a memory **520** storing instructions to be executed by processor **510**, a storage device **530** storing information relating to cordless ultrasonic surgical instrument **10**. Processor **510** and memory **520** may be part of generator electronics **340** (separate from or the same as microprocessor **343** and memory **344**, respectively (see FIG. **4**)), may be part of battery assembly **400**, may be part of handle assembly **100**, or may be part of any other portion(s) or component(s) of cordless ultrasonic surgical instrument **10**. Likewise, storage device **530** may be part of generator electronics **340**, may be part of battery assembly **400**, may be part of handle assembly **100**, or may be part of any other portion(s) or component(s) of cordless ultrasonic surgical instrument **10**.

[0039] Processor **510** may include one or more similar or different processors which may be any suitable processor(s) (e.g., control circuit(s)) adapted to perform the operations, calculations, and/or set of instructions described in this disclosure including, but not limited to, a hardware processor, a field programmable gate array (FPGA), a digital signal processor (DSP), a central processing unit (CPU), a microprocessor, and combinations thereof. Memory **520** and storage device **530** may each include one or more of volatile, non-volatile, magnetic, optical, or electrical media, such as read-only memory (ROM), random access memory (RAM), electrically-erasable programmable ROM (EEPROM), non-volatile RAM (NVRAM), or flash memory.

[0040] Cordless ultrasonic surgical instrument **10** also includes an input/output (I/O) **540** such as, for example, a wireless transceiver, to enable wireless communication between cordless ultrasonic surgical instrument **10** and communication hub **30**. Thus, processor **510** may direct the output of information from cordless ultrasonic surgical instrument **10** to communication hub **30** via I/O **540** and/or may receive information from communication hub **30** via I/O **540**.

[0041] Various portions of cordless ultrasonic surgical instrument **10** may include electronic components configured to provide information to processor **510**. For example, handle assembly **100** may include an EEPROM or other suitable read or read/write storage device (such as those noted above) storing information pertaining to handle assembly **100** such as, for example, identifying data (e.g., serial number, model number, manufacture date, etc.) and/or use data (e.g., whether used or number of uses, TAG's used therewith, battery assemblies used therewith, etc.). As another example, battery assembly **400** may include a control chip that controls charging and discharging of the battery cells of battery assembly **400**, implements safety protections (for over current, over voltage, temperature limits, etc.), etc. The control chip may include a storage device (such as those noted above) that stores identifying data (e.g., serial number, model number, manufacture date, etc.), use data (e.g., number of uses and/or sterilizations, number of charges, amount of time used, TAG's used therewith, handle assemblies used therewith, etc.) and/or performance data (e.g., charge and discharge information, fault logging, etc.). Further, as still another example, generator electronics **340** may include a storage device (such as those noted above) storing identifying data (e.g., serial number, model number, manufacture date, etc.), use data (e.g., number of uses, amount of time used, battery assemblies used therewith, handle assemblies used therewith, etc.) and/or performance data (e.g., driving signal information, transducer operation information, activation information, generator operating parameters, fault logging, etc.). Alternative or additional electronic components associated with removable and/or integrated portions of cordless ultrasonic surgical instrument **10** are also contemplated. The electronic components, e.g., of handle assembly **100**, battery assembly **400**, and/or TAG **300**, may communicate with one another and/or processor **510** via electrical connector **140** or any other suitable wired or wireless connection. In addition to communicating identifying, use, and/or performance data, present signals may be communicated to processor **510**, actively or passively, to enable processor **510** to indicate when the various components are connected to one another and/or other components of cordless ultrasonic surgical instrument **10**.

[0042] Continuing with reference to FIG. **5**, communication hub **30** includes a processor **32** and a

memory **34** storing instructions to be executed by processor **32**. Any suitable one or more processors **32** and memories **34** may be provided, such as those noted above. Communication hub **30** further includes at least one I/O **36** such as, for example, a wireless transceiver, one or more wired communication ports, etc. The at least one I/O **36** enables communication hub **30** to communicate wirelessly with cordless ultrasonic surgical instrument **10** and to communicate via a wired or wireless connection with the one or more connected devices **40**-**70** (FIG. **1**), e.g., display monitor **70**. Display monitor **70** likewise includes a processor **72**, a memory **74** storing instructions to be executed by processor **72**, and an I/O **76** to enable communication with communication hub **30** and/or other devices. Display monitor **70** further includes a user interface (UI) **78**, e.g., a display screen.

[0043] In aspects, communication hub **30** is configured to receive information from cordless ultrasonic surgical instrument **10**, to process the information, and to direct a corresponding output on one or more of the connected devices **40**-**70** (FIG. **1**), e.g., the display of information on UI **78** of display monitor **70**, activating an audible notification, etc., based upon the information received from cordless ultrasonic surgical instrument **10**. In aspects, communication hub **30** is further configured to receive information from one or more of the connected devices **40**-**70** (FIG. **1**) to facilitate processing the information received from cordless ultrasonic surgical instrument **10** and/or to facilitate directing the corresponding output. For example, a user may input information into one or more of the connected devices **40**-**70** (FIG. **1**), e.g., in response to a prompt from communication hub **30**.

[0044] Turning to FIGS. **6**-**12**, in conjunction with FIGS. **1**-**5**, as noted above, communication hub **30** may be configured to receive information from cordless ultrasonic surgical instrument **10** and/or one or more of the connected devices **40**-**70**, to process the information, and to direct a corresponding output. For example, as described in greater detail below, communication hub **30** may be configured, based upon the received information, to direct an output, e.g., as a visual display screen on UI **78** of display monitor **70**: indicating steps to assemble cordless ultrasonic surgical instrument **10** (see, e.g., FIGS. **6**A-**6**E); indicating completion of a start-up check or detected start-up errors (see, e.g., FIGS. **7**-**8**B); promoting a user to perform an instrument check and indicating the results of the instrument check (see, e.g., FIGS. **9**-**11**); indicating steps to replace battery assembly **400** of cordless ultrasonic surgical instrument **10** (see, e.g., FIGS. **6**A-**6**E); indicate steps to disassemble cordless ultrasonic surgical instrument **10**; indicating troubleshooting recommendations; and/or indicating the availability of component, software, firmware, and/or hardware updates.

[0045] With reference to FIGS. **6**A-**6**E, in conjunction with FIGS. **1**-**5**, in preparation for performing a surgical procedure, communication hub **30** may direct display monitor **70** to display assembly steps for cordless ultrasonic surgical instrument **10** on UI **78**. UI **78**, more specifically, may display screens **610**, **620**, **630**, **640**, **650** including graphics **612**, **622**, **632**, **642**, **652** and/or text **614**, **624**, **634**, **644**, **654**, respectively, indicating the sequential steps of assembly for cordless ultrasonic surgical instrument **10**. An initial step or steps may be displayed upon receipt, at communication hub **30**, of a user input, e.g., from one or more of the connected devices **40**-**70**, indicating that cordless ultrasonic surgical instrument **10** is to be assembled. The initial steps may include, for example one or more of: positioning the guide about the instrument, as indicated on screen **610** (FIG. **6**A); inserting the battery through the guide into the compartment of the instrument, as indicated on screen **620** (FIG. **6**B); closing the door to retain the battery within the compartment of the instrument, as indicated on screen **630** (FIG. **6**C); and sliding the TAG onto the handle assembly, as indicated on screen **640** (FIG. **6**D).

[0046] The initial step or steps may be sequentially displayed on UI **78** with each screen **610**, **620**, **630**, and/or **640** being displayed for a pre-determined amount of time (on a continuous loop and/or including sub-loops). Alternatively, user input, e.g., from one or more of the connected devices **40**-**70**, may be required to move from one screen **610**, **620**, **630**, and/or **640** to the next screen **610**,

620, **630**, and/or **640** in sequence (and/or to go back to previous screens **610**, **620**, **630**, and/or **640**).
[0047] As another alternative, information received at communication hub **30** from cordless ultrasonic surgical instrument **10** (or portions thereof) may be utilized to determine when to move from one screen **610**, **620**, **630**, and/or **640** to the next screen **610**, **620**, **630**, and/or **640** in sequence and/or from one group of screens **610**, **620**, **630**, and/or **640** to the next group of screens **610**, **620**, **630**, and/or **640**. For example, screens **610**-**630** may initially be displayed (for a pre-determined amount of time, on a loop, in response to user input, etc.). Once the steps assocaited with screens **610**-**630** are completed and, thus, battery assembly **400** is engaged within handle assembly **100**, I/O **540** (in aspects where electronic components **510**-**540** are part of battery assembly **400** or handle assembly **100**) may communicate a signal to communication hub **30** indicating that battery assembly **400** and handle assembly **100** are connected to one another. Upon receiving this signal, communication hub **30** provides instructions to move to screen **640**, for example.
[0048] Screen **640** directs the user to assemble TAG **300** to the handle assembly **100**. Once TAG **300** is engaged with handle assembly **100**, I/O **540** may communicate a signal to communication hub **30** indicating that handle assembly **100**, TAG **300**, and battery assembly **400** are connected to one another. Upon receiving this signal, communication hub **30** provides instructions to move to screen **650**, for example. Screen **650** illustrates to the user how to torque transducer **320** of TAG **300** to engage transducer **320** and waveguide **230** with one another. It is noted that the above-detailed assembly and corresponding screens **610**-**650** are exemplary and that additional or alternative assembly steps and/or corresponding screens may be provided.
[0049] Referring to FIGS. **7**-**8**B, in conjunction with FIGS. **1**-**5**, once communication hub **30** determines that assembly is complete, e.g., based on receipt of a signal from I/O **540** of cordless ultrasonic surgical instrument **10** indicating the same, communication hub **30** may request information from cordless ultrasonic surgical instrument **10** regarding, for example, handle assembly **100**, TAG **300**, and battery assembly **400** to perform a start-up check, e.g., to determine that handle assembly **100**, TAG **300**, and battery assembly **400** are approved for use and/or compatible for use with one another. Such information may include identification information (to determine whether the components are on a blocked list and/or to determine whether the components are capable of being used with one another), use information (to determine whether the components are permitted to be used further), and/or performance information (to determine whether there are any faults with the components). Alternatively, cordless ultrasonic surgical instrument **10** may perform the start-up check and communicate the results to communication hub **30**.
[0050] Where cordless ultrasonic surgical instrument **10** passes the start-up check, communication hub **30** may provide instructions to output display screen **700** on UI **78**. Alternatively, if cordless ultrasonic surgical instrument **10** did not pass the start-up check, communication hub **30** may provide instructions to output a display screen on UI **78** that notifies the user as to the error(s). For example, communication hub **30** may provide instructions to output display screen **810** on UI **78** where the handle assembly **100** is not approved for use (e.g., as a result of being previously used), or provide instructions to output display screen **820** on UI **78** where TAG **300** is not approved for use (e.g., as a result of failure to authenticate generator **320**, as a result of an error condition, etc.). Further, where applicable, UI **78** may include a notification indicating the availability of component, software, firmware, and/or hardware updates, regardless of whether cordless ultrasonic surgical instrument **10** passed the start-up check. Additionally, or alternatively, troubleshooting recommendations may be provided if cordless ultrasonic surgical instrument **10** does not pass the start-up check (or any other errors are detected during the start-up check, instrument check, or at any other point).
[0051] Turning to FIG. **9**, in conjunction with FIGS. **1**-**5**, if cordless ultrasonic surgical instrument **10** passes the start-up check, or in aspects where the start-up check is not provided, communication hub **30** may provide instructions to output display screen **900** on UI **78**, to direct the user to

perform an instrument test or to indicate that an instrument test will be performed. Communication hub **30** may, in aspects, communicate with cordless ultrasonic surgical instrument **10** to perform the instrument test automatically or upon user-initiation, e.g., depression of activation button **120**. The instrument test may include, for example, a brief controlled activation of cordless ultrasonic surgical instrument **10** to determine whether cordless ultrasonic surgical instrument **10** is operating properly, e.g., that resonance can be achieved within a pre-determined time upon activation and/or maintained, that the motional feedback indicates an appropriate output based on the drive signal provided, that power, current, and voltages associated with battery assembly **400** and/or TAG **300** are within acceptable ranges, etc. Cordless ultrasonic surgical instrument **10** may provide the information to communication hub **30** for the instrument test as pass/fail information or real-time data associated with the activation of cordless ultrasonic surgical instrument **10**, e.g., resonance, power, voltage, etc. Such real-time data (as well as such pass/fail data) may additionally or alternatively be communicated from cordless ultrasonic surgical instrument **10** to communication hub **30** at other times not limited to the instrument test, such as during use in surgery.

[0052] With reference to FIGS. **10**A-**11**, in conjunction with FIGS. **1**-**5**, if cordless ultrasonic surgical instrument **10** fails the instrument test, communication hub **30** may provide instructions to output a display screen on UI **78** that notifies the user as to the error(s). For example, where a potentially under torque condition is detected, display screen **1010** may be provided. As another example, where an error with generator **310** or transducer **320** is detected, display screen **1020** may be provided. If cordless ultrasonic surgical instrument **10** passes the instrument test, display screen **1100** may be provided.

[0053] Before, during, or after the start-up test and/or the instrument test, or any other suitable point during setup or use, communication hub **30** may retrieve from cordless ultrasonic surgical instrument **10** the current settings associated with cordless ultrasonic surgical instrument **10** and provide instructions to a user input device, e.g., UI **78**, to display, output, or otherwise enable a user interface from which the settings may be viewed, set, modified, and/or confirmed. Additionally or alternatively, a request may be input to a user input device associated with communication hub **30**, e.g., UI **78**, to display, output, or otherwise enable a user interface from which the current settings associated with cordless ultrasonic surgical instrument **10** may be viewed, set, modified, and/or confirmed. The request for viewing, setting, modifying, and/or confirming the settings and/or the viewing, setting, modifying, and/or confirming of the settings may be any suitable interactions with the user input device (e.g., UI **78**) such as, as voice commands, gestures, inputs to cordless ultrasonic surgical instrument **10**, or any other suitable interactions. In response to any received setting or modification to settings associated with cordless ultrasonic surgical instrument **10**, communication hub **30** provides instructions to cordless ultrasonic surgical instrument **10** to adjust the settings accordingly. Thus, wireless (and, in aspects, remote) adjustment of the settings associated with cordless ultrasonic surgical instrument **10** can be viewed, set, modified, and/or confirmed, e.g., using user interfaces that are more easily navigated as compared to the user interface(s) of cordless ultrasonic surgical instrument **10** itself.

[0054] The settings associated with cordless ultrasonic surgical instrument **10** that may be viewed, set, modified, and/or confirmed by the user via communication hub **30** may include, without limitation: assigning different energy levels or modes to each of the activated positions of button **120** (FIG. **2**); disabling or enabling certain energy levels or modes; setting the corresponding energy levels (blade velocities, for example) associated with the different activation levels (min & max, for example); modifying the brightness of any LED indicators; modifying the volume of any audible indicators; selecting notification and/or alarm profiles (or individual settings) to indicate the notifications and/or alarms to be provided and/or the manner of the notifications and/or alarms; etc.

[0055] Referring to FIG. **12**, in conjunction with FIGS. **1**-**5**, communication hub **30** may provide instructions to output a display screen on UI **78** to notify the user as to one or more conditions of

cordless ultrasonic surgical instrument **10** during a surgical procedure. For example, I/O **540** may continuously, periodically, or upon request, output information relating to a state of charge of battery assembly **400** and/or other information relating to the use or performance of battery assembly **400** to communication hub **30**. Communication hub **30**, in turn, determines whether battery assembly **400** should be replaced, e.g., based upon whether the state of charge of battery assembly **400** is below a threshold value. Alternatively, cordless ultrasonic surgical instrument **10** may determine when battery assembly **400** should be replaced (e.g., based on if the state of charge of battery assembly **400** is below a threshold value) and may output an indication of the same to communication hub **30** via I//O **540**. In either configuration, when it is determined that battery assembly **400** should be replaced, communication hub **30** may provide instructions to output one or more display screens, e.g., display screen **1200**, on UI **78**, notifying the user that battery assembly **400** should be replaced and indicating the steps for removal and/or replacement of battery assembly **400**.

[0056] Turning back to FIGS. **1-5**, after a surgical procedure is completed, communication hub **30** may additionally or alternatively be configured to receive information from cordless ultrasonic surgical instrument **10** and, in response thereto, to direct display monitor **70** to display disassembly steps for cordless ultrasonic surgical instrument **10** in one or more display screens on UI **78**. The disassembly steps may be, for example, the opposite of the above-detailed assembly steps (in opposite sequence). Screens associated with disassembly may be displayed for a pre-determined time before moving to the next screen, UI **78** may move to the next screen in response to user input, or UI **78** may move to the next screen in response to information received from cordless ultrasonic surgical instrument **10**, similarly as detailed above.

[0057] The display screens detailed herein may be static or animated and may include real images, videos, or any other suitable representations of instruments or components. Further, either or any suitable combination of both graphics and text may be provided. The particular display screens and actions or conditions represented thereby that are detailed above are exemplary as it is understood that various modifications may be made to the aspects and features disclosed herein. Therefore, the above description should not be construed as limiting, but merely as exemplifications of various configurations. Those skilled in the art will envision other modifications within the scope and spirit of the claims appended hereto.

Claims

1. A surgical system, comprising: a cordless surgical instrument configured to obtain information regarding preparation of the cordless surgical instrument for use; and a communication hub configured to wirelessly connect to the cordless surgical instrument to receive the information therefrom, the communication hub configured to instruct, based at least on the information, a connected device to provide an output relating to the preparation of the cordless surgical instrument for use.

2. The surgical system according to claim 1, wherein the information regarding preparation of the cordless surgical instrument for use includes information regarding assembly of the cordless surgical instrument.

3. The surgical system according to claim 2, wherein the information regarding assembly of the cordless surgical instrument includes information indicating that first and second components of the cordless surgical instrument are engaged with one another.

4. The surgical instrument according to claim 2, wherein the output includes display of at least one step for assembling the cordless surgical instrument for use.

5. The surgical instrument according to claim 4, wherein the output includes display of a plurality of steps for assembling the cordless surgical instrument for use, and wherein the display switches between different steps of the plurality of steps based on additional information wirelessly

communicated from the cordless surgical instrument to the communication hub.
6. The surgical system according to claim 1, wherein the information regarding preparation of the cordless surgical instrument for use includes identifying information for a plurality of components of the cordless surgical instrument.
7. The surgical system according to claim 6, wherein the output includes display of an indication of whether the plurality of components of the cordless surgical instrument is approved for use.
8. The surgical system according to claim 1, wherein the information regarding preparation of the cordless surgical instrument for use includes information regarding an instrument test of the cordless surgical instrument.
9. The surgical system according to claim 8, wherein the output includes display of an indication of whether the cordless surgical instrument passed or failed the instrument test.
10. The surgical system according to claim 9, wherein, in a case where the cordless surgical instrument failed the instrument test, the output further includes at least one of an indication of a cause of the failed instrument test or a troubleshooting recommendation.
11. The surgical system according to claim 1, wherein the cordless surgical instrument includes a battery assembly and a generator, the generator configured to drive the cordless surgical instrument, the generator powered by the battery assembly.
12. The surgical system according to claim 11, wherein the cordless surgical instrument further includes an ultrasonic transducer and an ultrasonic blade coupled to the ultrasonic transducer, the generator configured to drive the ultrasonic transducer to produce mechanical vibration motion at the ultrasonic blade.
13. A surgical system, comprising: a cordless surgical instrument configured to obtain information regarding at least one replaceable component of the cordless surgical instrument; and a communication hub configured to wirelessly connect to the cordless surgical instrument to receive the information therefrom, the communication hub configured to instruct, based at least on the information, a connected device to provide an output relating to replacement of the at least one replaceable component of the cordless surgical instrument.
14. The surgical system according to claim 13, wherein the at least one replaceable component is a battery assembly.
15. The surgical system according to claim 14, wherein the cordless surgical instrument includes a generator configured to drive the cordless surgical instrument, the generator powered by the battery assembly.
16. The surgical system according to claim 14, wherein the information includes a state of charge of the battery assembly, and wherein the communication hub is configured to instruct, based at least on the state of charge of the battery assembly being below a threshold value, the connected device to provide the output.
17. The surgical system according to claim 14, wherein the information includes an indication that a state of charge of the battery assembly is below a threshold value.
18. The surgical system according to claim 13, wherein the output includes display of at least one step for replacing the at least one replaceable component.