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(54) **EXPLOSIVE INITIATION SAFETY AND HANDLING SYSTEM FOR EXPLOSIVE ORDNANCE DISPOSAL ROBOTS**

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**F41H 7/00** (2006.01)  
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CPC ..... **F41H 11/14** (2013.01); **F41H 7/005** (2013.01); **F41H 11/16** (2013.01); **F42B 33/06** (2013.01)

(58) **Field of Classification Search**  
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See application file for complete search history.

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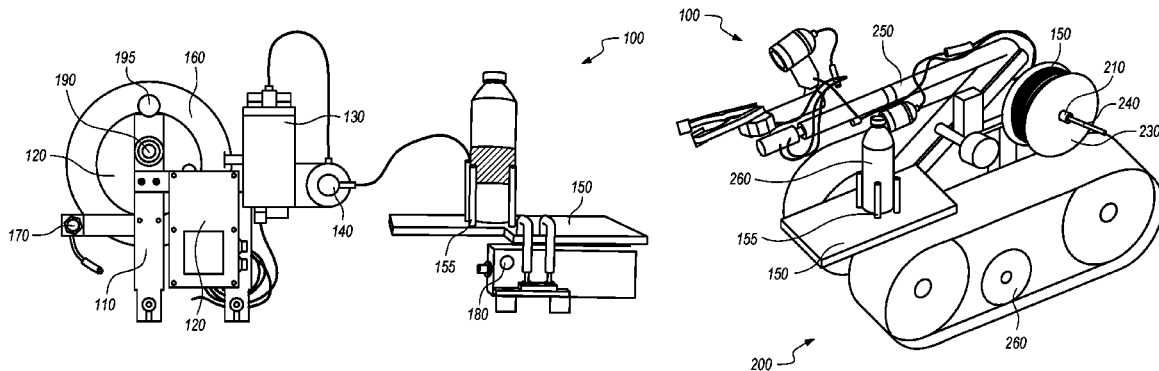
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(57) **ABSTRACT**

A system with a spool base frame having an initiator, an interrupter, control electronics, and a proximity sensor connected thereto, wherein the spool base frame is configured to hold a shock tube spooling mechanism, the interrupter is configured to allow installation and spooling of a spool of shock tube disposed on the shock tube spooling mechanism, the interrupter is configured to cut spooled shock tube from the spool of shock tube, the control electronics are configured to send a signal directing the interrupter to cut the spooled shock tube from the spool, the interrupter is configured to physically redirect and splice the cut shock tube to a second shock tube connected to the initiator, and the interrupter is configured to discharge the cut shock tube after the shock tube is fired and spent.

**10 Claims, 6 Drawing Sheets**



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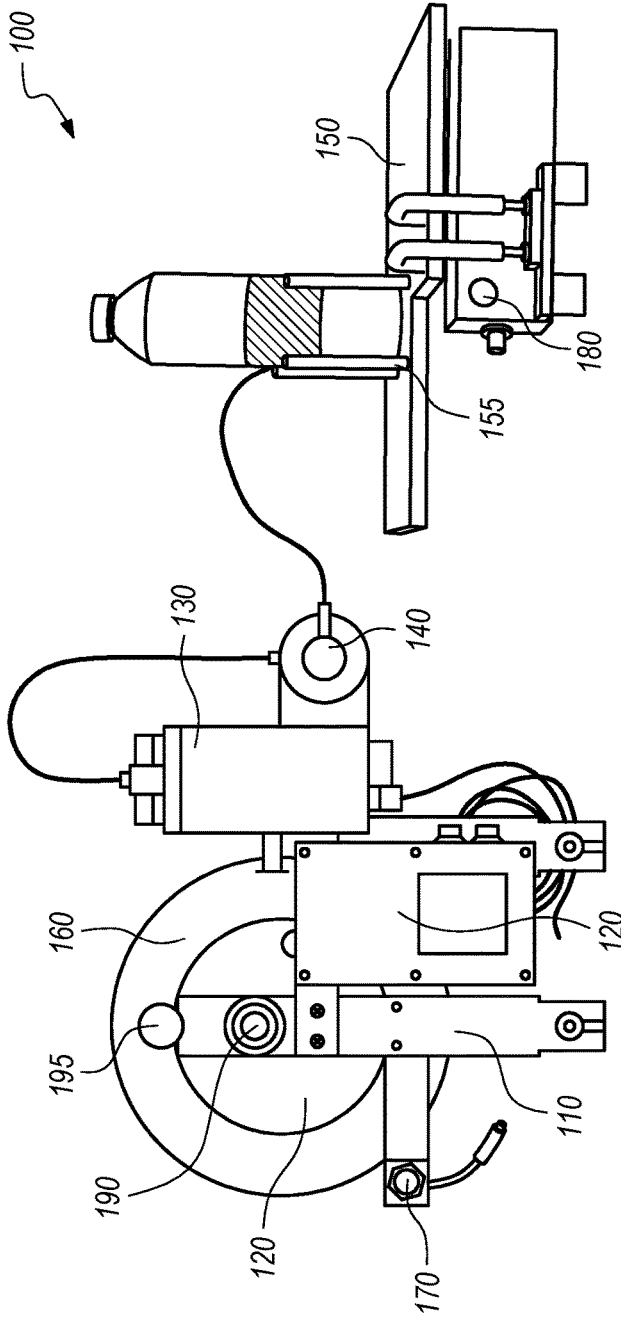


FIG. 1

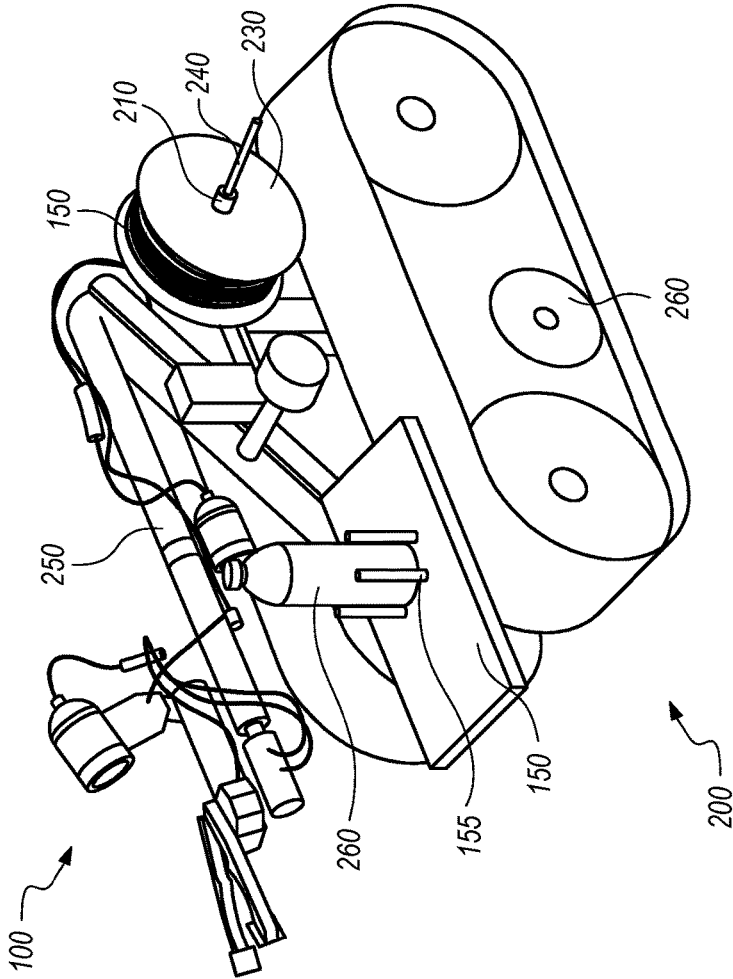
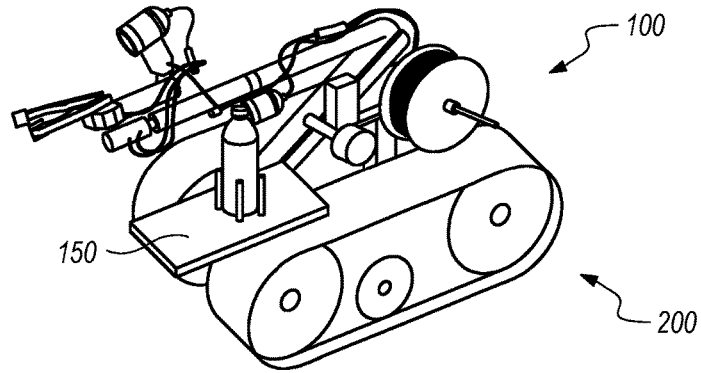
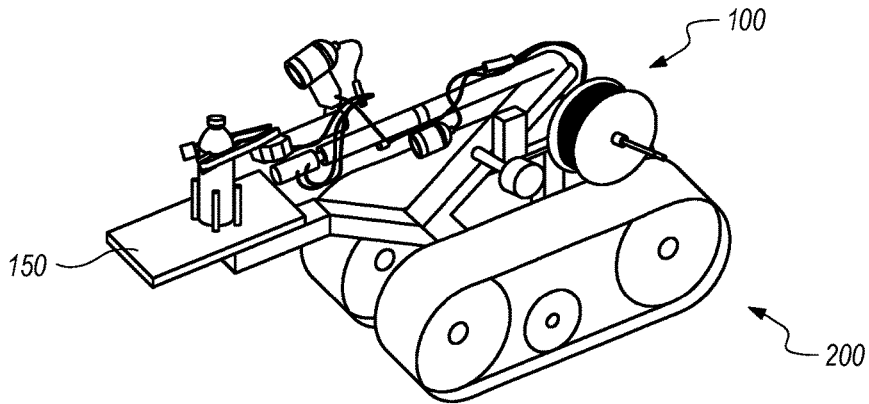


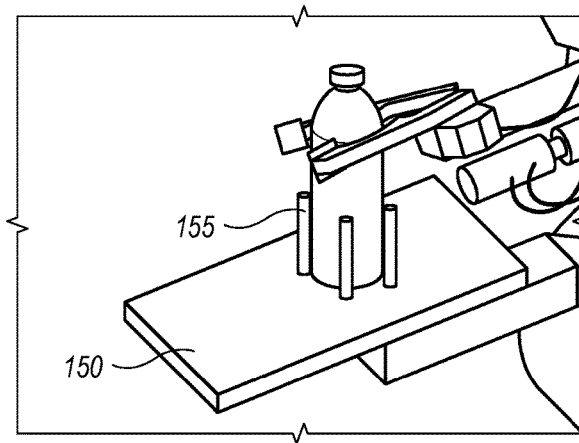
FIG. 2



**FIG. 3A**



**FIG. 3B**



**FIG. 3C**

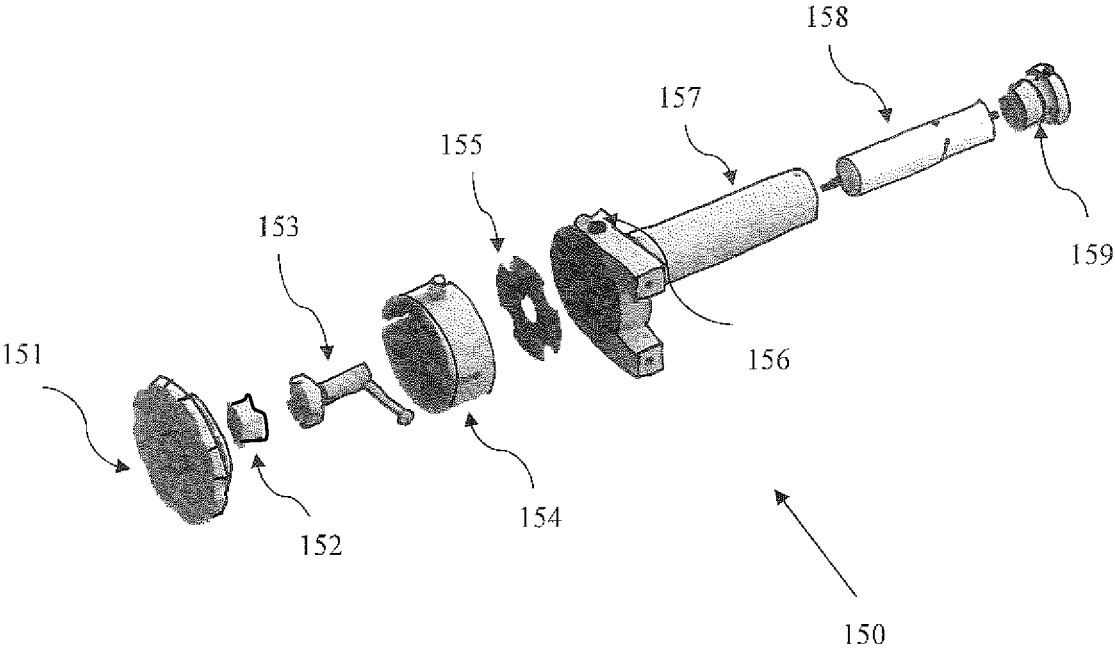
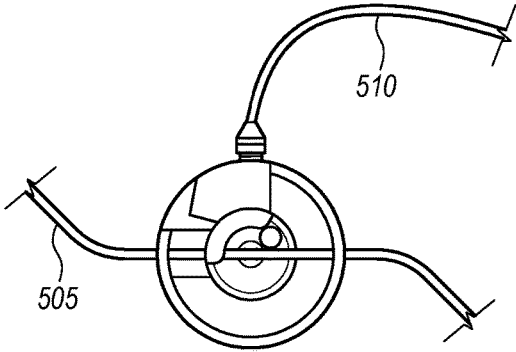
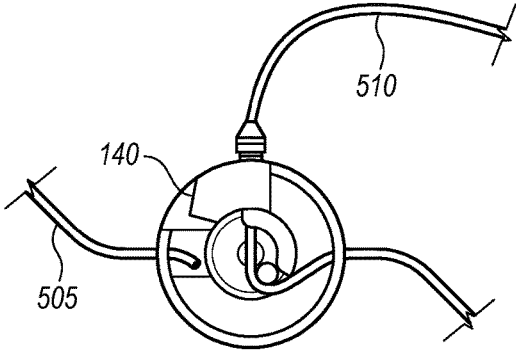


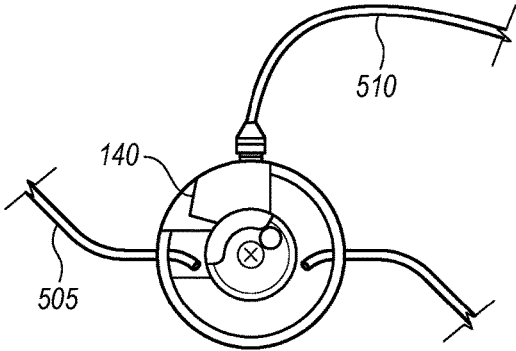
FIG 4



**FIG. 5A**



**FIG. 5B**



**FIG. 5C**

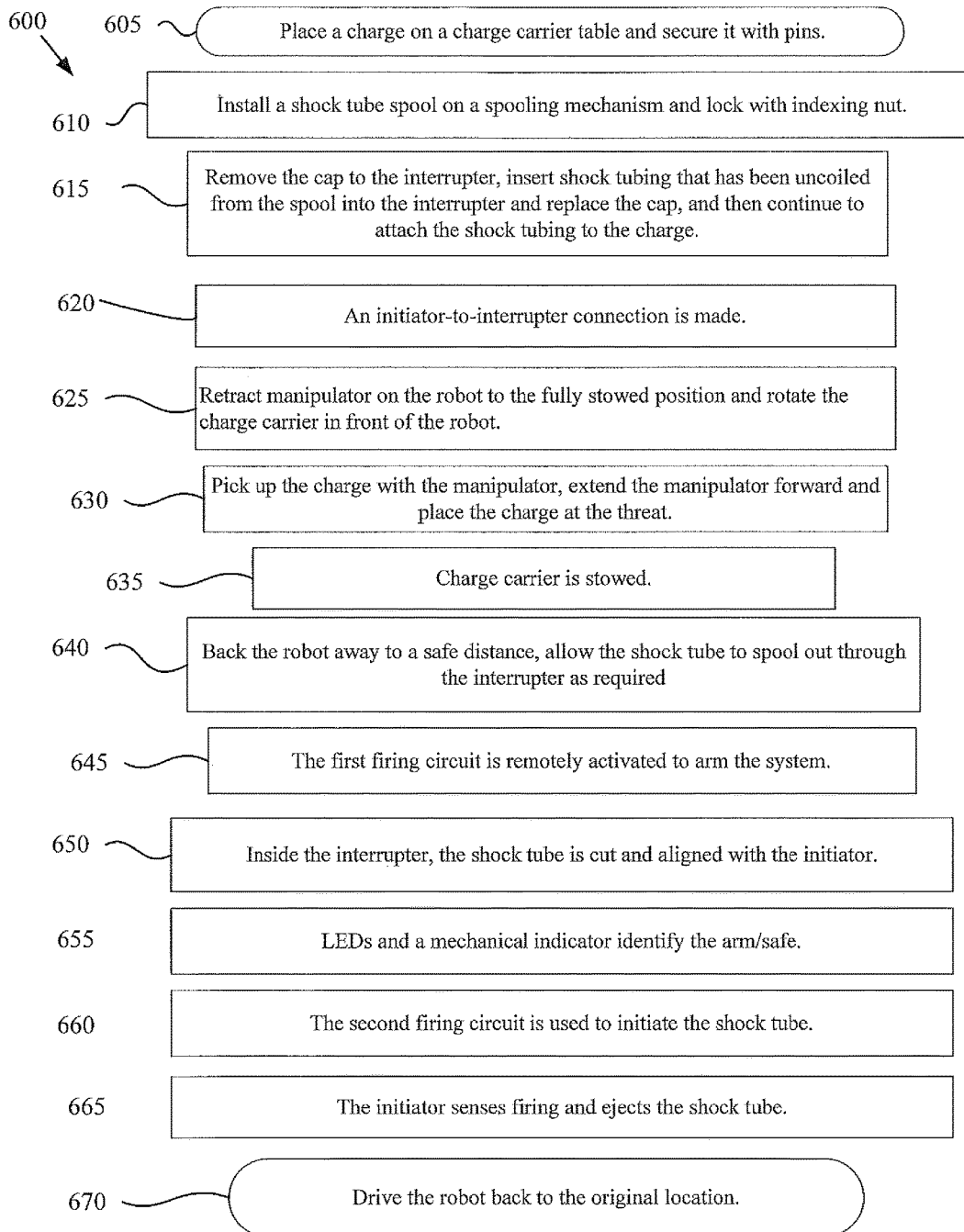


FIG. 6



## EXPLOSIVE INITIATION SAFETY AND HANDLING SYSTEM FOR EXPLOSIVE ORDNANCE DISPOSAL ROBOTS

### FEDERALLY-SPONSORED RESEARCH AND DEVELOPMENT

The Explosive Initiation Safety and Handling System is assigned to the United States Government and is available for licensing for commercial purposes. Licensing and technical inquiries may be directed to the Office of Research and Technical Applications, Space and Naval Warfare Systems Center, Pacific, Code 72120, San Diego, Calif., 92152; voice (619) 553-5118; email ssc\_pac\_T2@navy.mil. Reference Navy Case Number 102318.

### BACKGROUND

Most currently fielded Explosive Ordnance Disposal (EOD) robots are equipped with radio-controlled firing circuits, these are only considered safe for a small subset of operations due to the risk of accidental ignition. Instead, most EOD teams normally use non-electric ignition of countercharges to dispose of hostile Improvised Explosive Devices (IED). Non-electric ignition requires a robot to drag a small plastic shock-tube hundreds of feet from the control unit to the IED. The shock tube can be damaged by obstacles or other causes, greatly reducing reliability of the charge, and often becomes wound in the robot's tracks, crippling the robot and exposing the EOD technicians to danger in order to complete the mission and recover the robot under extremely hazardous conditions, risking mission failure, and potentially injury and fatalities to the Warfighter and/or robot.

Additionally, placing the countercharge in a manipulator limits the robot's maneuverability and flexibility, as the manipulator cannot be used for its normally intended functions. A few other systems have been developed which allow for the spool to be carried by the robot, but none of them allow for remote detonation from the robot. The system disclosed herein allows for such remote detonation.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an embodiment of an Explosive Initiation Safety and Handling System (EISS).

FIG. 2 shows an embodiment of an Explosive Initiation Safety and Handling System mounted on a robot.

FIGS. 3A-3C show an embodiment of an Explosive Initiation Safety and Handling System mounted on a robot, where 3A shows the charge carrier in the stowed position, 3B shows the charge carrier in the deployed position, and 3C shows a close-up view of the charge carrier having multiple pins for different sized charges.

FIG. 4 shows a three-dimensional, exploded view of an Interrupter.

FIGS. 5A-5C show the various interrupter functions.

FIG. 6 shows a flow chart of a method for using the EISS.

### DETAILED DESCRIPTION OF SOME EMBODIMENTS

Reference in the specification to "one embodiment" or to "an embodiment" means that a particular element, feature, structure, or characteristic described in connection with the embodiments is included in at least one embodiment. The appearances of the phrases "in one embodiment", "in some

embodiments", and "in other embodiments" in various places in the specification are not necessarily all referring to the same embodiment or the same set of embodiments.

Some embodiments may be described using the expression "coupled" and "connected" along with their derivatives. For example, some embodiments may be described using the term "coupled" to indicate that two or more elements are in direct physical or electrical contact. The term "coupled," however, may also mean that two or more elements are not in direct contact with each other, but yet still co-operate or interact with each other. The embodiments are not limited in this context.

As used herein, the terms "comprises," "comprising," "includes," "including," "has," "having" or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. Further, unless expressly stated to the contrary, "or" refers to an inclusive or and not to an exclusive or.

Additionally, use of the "a" or "an" are employed to describe elements and components of the embodiments herein. This is done merely for convenience and to give a general sense of the invention. This detailed description should be read to include one or at least one and the singular also includes the plural unless it is obviously meant otherwise.

The Explosive Initiation Safety and Handling System (EISS) for Explosive Ordnance Disposal (EOD) robots provides an effective and reliable remotely operated mechanical interrupter in the non-electric firing circuit which permits EOD technicians to safely use the built-in electric firing circuits on EOD robots with all types of countercharges. This system eliminates problems with damaged shock tubes, provides a mechanical safety interlock that can be visually verified, enables the use of the manipulator while carrying a countercharge, and significantly reduces instances of crippled robots, thus increasing the robot flexibility, reliability, and safety for the Warfighter and robot.

The EISS described herein has various embodiments that can be designed and configured to work with other shock tube initiators as well as other unmanned ground vehicles (UGVs), based on the size of the shock-tube, the location and particular terrain, or any other variable.

FIG. 1 shows an embodiment of an EISS 100 separated into five subsystems: spool base 110, control electronics 120, initiator 130, interrupter 140, and charge carrier 150. Charge carrier 150 allows for pins 155 to secure charges of varying sizes. Spool base 110 is the structural base for half of EISS 100, and physically supports shock-tube spooling mechanism 160, control electronics 120, initiator 130, interrupter 140, and proximity sensor 170. Proximity sensor 170 senses when a manipulator, not visible in this figure, is in a stowed position. Control electronics 120 are rigidly mounted to spool base frame 110, and are electrically connected to initiator 130, interrupter 140, charge carrier 150, proximity sensor 170, and a firing circuit that is not visible in this figure. Control electronics 120 receive a signal from rear, fully stowed proximity sensor 170, and instruct charge carrier 150 to rotate in front of a robot not visible in this figure. A proximity sensor 180 senses when a manipulator, not visible in this figure, extends forward to place a charge. Control electronics 120 takes the input from the first firing

circuit not visible here to arm interrupter **140**, and the input from a second firing circuit also not visible here to activate initiator **130**.

Initiator **130** is rigidly mounted to spool base **110**. One example of an initiator **130** that may be used with system **100** is a Duke Pro initiator manufactured by Duke Pro, Inc. Various mounting brackets can be designed to accommodate different embodiments of initiators. Interrupter **140** is rigidly mounted to spool base frame **110**, and acts as an automatic shock tube splicing mechanism, further detailed in FIG. **5**. An alternate initiator can be configured to work with EISS **100**. An adjustable braking mechanism **190** allows for a user to optimize the spooling tension to avoid over-spooling and backlash. Adjustable indexing nut **195** sits above adjustable braking mechanism **190**.

FIG. **2** shows an embodiment of robot **200** having an EISS **100** described in FIG. **1** mounted on top. As shown, robot **200** is a Talon robot manufactured by QinetiQ. However, other robotic platforms may be used with EISS **100** without departing from the scope of the system disclosed herein. Two push connect pins not visible here can attach EISS **100** to robot **200** for easy removal and installation. A manually removable collet **210** allows EISS **100** to accommodate varying shock-tube diameters and thicknesses. An adjustable indexing nut **195** visible in FIG. **1** connects spool **230** rigidly to rotating shaft **240**, and adjustable braking mechanism **190** visible in FIG. **1** allows for the user to optimize the spooling tension to avoid over-spooling and backlash. Manipulator **250** picks up countercharge **260**, and manipulator **250** extends forward and sets down charge **260** in front of robot **200**, then moves back into a stowed position. Adjustable proximity sensor **170** (visible FIG. **1**) senses when manipulator **250** is back in the stowed position.

Charge carrier **150** attaches to robot **200** with a removable pin not visible here, and allows for the storing of countercharge **260** to the side of robot **200** enabling the use of manipulator **250** during IED approach and interrogation. An adjustable pin pattern on top of charge carrier **150** allows for convenient placement of countercharge **260** with easily removable pins **155**. Once the operator (a command from a person driving robot **200** remotely) retracts manipulator **250** to the fully stowed position, interrupter **140** rotates charge carrier **150** out in front of robot **200**, so that manipulator **250** can pick up countercharge **260**.

FIGS. **3A-3C** show an embodiment of an EISS **100** mounted on a robot **200**, where **3A** shows charge carrier **150** in the stowed position, **3B** shows charge carrier **150** in the deployed position, and **3C** shows a close-up view of charge carrier **150** having multiple pins **155** for different sized charges.

FIG. **4** shows an exploded view of Interrupter **150**. Interrupter **150** has a removable lid **151**, which allows for easy installation of a shock tube. It allows for a shock tube to spool through while robot **200** backs away after countercharge **260** has been placed by manipulator **250**, visible in FIG. **2**. Interrupter **150** also has a cutter **152**, a rotor **153**, a rotor housing **154**, a circuit board **155**, arm/safe indicators **156**, motor housing **157**, a motor **158**, and a motor cap **159**. When an arm signal is received from the control electronics **130** (visible in FIG. **1**), interrupter **150** cuts the spooled shock tube from the spool mechanism **120** (visible in FIG. **1**), and physically redirects and splices the cut shock tube to the shock tube connected to initiator **140** (FIG. **1**). Additionally, interrupter **150** visually displays status via red or green LED **156**. After a shock tube is fired and spent, interrupter **150** automatically discharges the spent shock tube to prevent fouling upon retrieval of a robot.

FIGS. **5A-5C** show the various different interrupter **140** functions. In FIG. **5A**, shock tube **505** is passed through interrupter **140**, whereas shock tube **510** attaches from initiator **130** (FIG. **1**) to interrupter **140** (FIG. **1**). In FIG. **5B**, a motor **515** rotates, cutting shock tube **505** and aligning and attaching it to shock tube **510** connected to initiator **130** (FIG. **1**). The initiator fires, igniting the shock tube and the charge. After firing of shock tube **505**, motor **515** rotates back to the original position and shock tube **505** is free to fall out of interrupter **140**, as seen in FIG. **5C**.

FIG. **6** is a flow chart depicting the steps for using an EISS.

Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

We claim:

**1.** A system comprising:

a spool base frame having an initiator, an interrupter, control electronics, and a proximity sensor connected thereto;

wherein the spool base frame is configured to hold a shock tube spooling mechanism;

wherein the interrupter is configured to allow installation and spooling of a spool of shock tube disposed on the shock tube spooling mechanism;

wherein the interrupter is configured to cut spooled shock tube from the spool of shock tube;

wherein the control electronics are configured to send a signal directing the interrupter to cut the spooled shock tube from the spool;

wherein the interrupter is configured to physically redirect and splice the cut shock tube to a second shock tube connected to the initiator; and

wherein the interrupter is configured to discharge the cut shock tube after the shock tube is fired and spent.

**2.** The system of claim **1** wherein the spool base frame is operably coupled to a robot.

**3.** The system of claim **2** wherein the robot has at least one firing circuit.

**4.** The system of claim **3** further comprising a charge carrier operably coupled to the robot, such that it can be rotated out in front of the robot.

**5.** The system of claim **4** wherein the charge carrier comprises an adjustable pin pattern configured to allow carrying charges of varying sizes.

**6.** The system of claim **5**, further comprising a manipulator operably coupled to the robot, and wherein the manipulator is configured to extend in front of the robot.

**7.** The system of claim **6** further comprising at least two proximity sensors electrically coupled to the control electronics.

**8.** The system of claim **7**, wherein the control electronics are further electrically connected to the interrupter, the charge carrier, the initiator, the firing circuit.

9. The system of claim 8 further comprising a manually removable collet configured to allow the shock tube spooling mechanism to accommodate varying shock-tube diameters and thicknesses.

10. A system for remote Explosive Ordnance Disposal (EOD) comprising:

a spool base frame operatively coupled to a spooler, control electronics, an initiator, an interrupter, a charge carrier, and a manipulator, wherein the spooler further comprises a spool of shock tube, and wherein the spool base frame is operatively coupled to a robot, and wherein the interrupter cuts the shock tube from the spool and physically redirects and splices the cut shock tube connected to the initiator.

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