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(71) Applicant: THE BOEING COMPANY [US/US]; 100 North Riverside Plaza, Chicago, Illinois 60606-2016 (US).

(72) Inventors: GEORGESON, Gary E.; 100 N. Riverside Plaza, Chicago, Illinois 60606 (US). TROY, James J.; 100 N. Riverside Plaza, Chicago, Illinois 60606 (US). SMITH, Nathan R.; 100 N. Riverside Plaza, Chicago, Illinois 60606 (US). PALMER, JR., Donald D.; 100 N. Riverside Plaza, Chicago, Illinois 60606 (US).

(74) Agents: COREY, Steven et al.; The Boeing Company, P.O. Box 2515, MC 110-SD54, Seal Beach, California 90740-1515 (US).

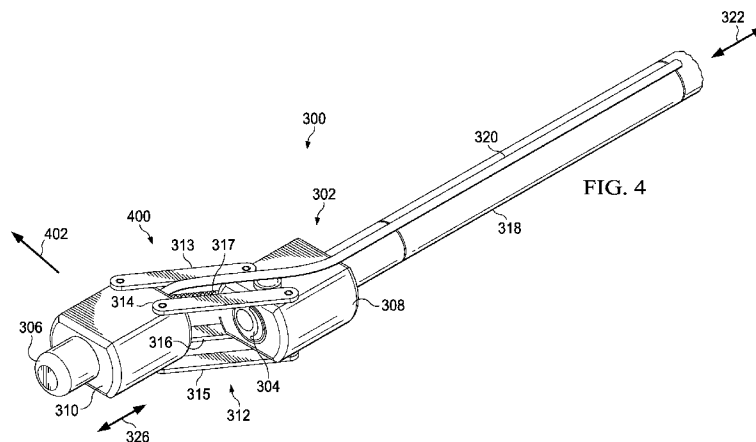
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(54) Title: NONDESTRUCTIVE INSPECTION SYSTEM FOR DIFFICULT TO ACCESS AREAS



(57) Abstract: A method for inspecting an object. A support structure physically associated with a first sensor and a second sensor is moved to an area for inspection. The support structure is in a first configuration and the first sensor and the second sensor are positioned about an axis extending through the support structure when the support structure is in the first configuration. The support structure is changed from the first configuration to a second configuration. The first sensor and the second sensor are configured to generate information when the support structure is in the second configuration.

NONDESTRUCTIVE INSPECTION SYSTEM FOR DIFFICULT TO ACCESS AREAS**BACKGROUND INFORMATION****1. Field:**

The present disclosure relates generally to inspecting objects and, in particular, to performing nondestructive inspection of objects. Still more particularly, the present disclosure relates to a method and apparatus for nondestructive inspection in locations that are difficult to access.

2. Background:

In manufacturing aircraft, vehicles, and other structures, inspection of parts used to form these structures is often performed to determine whether the parts will have desired parameters for a desired performance of the part. Nondestructive testing is commonly performed on these parts. Nondestructive testing is used to evaluate properties of a part without altering the ability of the part to be employed in service. Nondestructive testing may include ultrasound testing, eddy current testing, x-ray testing, visual inspections, and other types of testing.

This type of testing may also be performed after the object has been manufactured. Inspections may be performed while an object is in use to determine whether the object still performs as desired. The inspection may be performed during maintenance or other times to determine whether inconsistencies may be present that may require maintenance, rework, replacement, or some combination thereof.

When inspecting an object, such as an aircraft, a visual inspection may be first made to see if any inconsistencies may be present. An operator may view different areas of the aircraft to determine whether an inconsistency is present that may require an additional inspection.

If an inconsistency is identified in an area of the aircraft through the visual inspection, the nondestructive inspection may be performed to generate information that may be analyzed. For example, the inspection may be performed using an eddy current sensor, an ultrasonic sensor, or some other suitable type of device. The information generated from this inspection may be used to determine the extent of the inconsistency, the depth of the inconsistency, and other information about the inconsistency. With this information, a determination may be made as to what actions may be taken such as increased inspections of the area, rework of the area, replacement of the part, or other suitable actions.

Performing visual inspections and additional nondestructive inspections may be more difficult than desired. Some areas of the aircraft may be difficult to reach. For example, an interior of a wing, a fuel tank, and other areas in the aircraft may be difficult to reach because of the amount of access for using existing types of nondestructive inspection devices.

In some cases, disassembly of a portion of the aircraft may be performed to reach areas for inspection. The disassembly and reassembly of a portion of the aircraft may take more time and effort than desired. As a result, maintenance for an aircraft may be more expensive than desired. Additionally, the aircraft also may be out of service for longer periods than desired to perform needed inspections.

Therefore, it would be desirable to have a method and apparatus that takes into account at least some of the issues discussed above, as well as other possible issues.

SUMMARY

In one illustrative embodiment, an apparatus comprises a sensor, a tool, and a support structure. The support structure is physically associated with the sensor and the tool. The support structure is configured to change between a first configuration and a second configuration. The support structure with the sensor and the tool are configured to move through an opening in an object when the support structure is in the first configuration.

In another illustrative embodiment, a nondestructive inspection system comprises a borescope, a sensor, and a support structure. The support structure is physically associated with the borescope and the sensor. The borescope and the sensor are positioned about an axis extending through the support structure when the support structure is in a first configuration. The support structure is configured to change between the first configuration and a second configuration. The support structure with the borescope and the sensor are configured to move through an opening in a structure when the support structure is in the first configuration. The borescope and the sensor are configured to generate information when the support structure is in the second configuration.

In yet another illustrative embodiment, a method for inspecting an object is presented. A support structure physically associated with a first sensor and a second sensor is moved to an area for inspection. The support structure is in a first configuration and the first sensor and the second sensor are positioned about an axis extending through the support structure when the support structure is in the first configuration. The support structure is changed from the first configuration to a second configuration. The first sensor and the second sensor are configured to generate information when the support structure is in the second configuration.

The features and functions can be achieved independently in various embodiments of the present disclosure or may be combined in yet other embodiments in which further details can be seen with reference to the following description and drawings.

5

BRIEF DESCRIPTION OF THE DRAWINGS

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 features thereof, will best be understood by reference to the following detailed description of an illustrative embodiment of the present disclosure when read in conjunction with the accompanying drawings, wherein:

Figure 1 is an illustration of an inspection environment in accordance with an illustrative embodiment;

Figure 2 is an illustration of a block diagram of an inspection environment in accordance with an illustrative embodiment;

Figure 3 is an illustration of a nondestructive inspection unit with a support structure in a first configuration in accordance with an illustrative embodiment;

Figure 4 is an illustration of a nondestructive inspection unit with a support structure in a second configuration in accordance with an illustrative embodiment;

Figure 5 is an illustration of a nondestructive inspection unit with a support structure in a first configuration in accordance with an illustrative embodiment;

Figure 6 is an illustration of a nondestructive inspection unit with a support structure in a second configuration in accordance with an illustrative embodiment;

Figure 7 is an illustration of a nondestructive inspection unit with a support structure in a first configuration in accordance with an illustrative embodiment;

Figure 8 is an illustration of a nondestructive inspection unit with a support structure in a second configuration in accordance with an illustrative embodiment;

Figure 9 is an illustration of a nondestructive inspection unit with a support structure in a first configuration in accordance with an illustrative embodiment;

Figure 10 is an illustration of a nondestructive inspection unit with a support structure in a second configuration in accordance with an illustrative embodiment;

Figure 11 is an illustration of a flowchart of a process for inspecting an object in accordance with an illustrative embodiment;

Figure 12 is an illustration of a flowchart of a process for inspecting a difficult to access area in accordance with an illustrative embodiment;

Figure 13 is an illustration of an aircraft manufacturing and service method in the form of a block diagram in accordance with an illustrative embodiment; and

Figure 14 is an illustration of an aircraft in the form of a block diagram in which an illustrative embodiment may be implemented.

DETAILED DESCRIPTION

The illustrative embodiments recognize and take into account different considerations. For example, the illustrative embodiments recognize and take into account that visual inspections may be made using an imaging sensor camera. For example, a borescope may be used to inspect areas that may not be easily accessible or reviewable by a human operator. A borescope is an optical device that has a tube. The tube may be rigid, flexible or both. One end has a lens and the other end has an eye piece or an imaging system. An operator may use this device to perform a visual inspection of the aircraft. A

borescope may be placed through openings to reach an area that may be hard to view without disassembling a portion of the aircraft. In this manner, the illustrative embodiments recognize and take into account that an operator may need a better ability to perform a visual inspection of an interior area such as a fuel tank or the interior of a wing.

Illustrative embodiments also recognize and take into account that when an additional inspection is needed, another sensor may be inserted into the area. The borescope may be used by the operator to view the area and to guide the second sensor to the area for performing an additional inspection to generate information about the inconsistency for analysis.

The illustrative embodiments recognize and take into account that in some cases, the opening may not be sufficient in size to allow the entry of both the borescope and the other sensor at the same time. As a result, an operator may be unable to see to direct the second sensor to the area to generate information. In this case, a search for an additional opening to access the area is needed. In some cases, an additional opening is not present without forming that additional opening. As a result, disassembly of a portion of the aircraft may be needed to perform the additional inspection of the area in the aircraft.

Thus, the illustrative embodiments apply to a method and apparatus for inspecting an area for an object. Although the illustrative embodiments may be applied to any area for the object, the illustrative embodiments may also be applied to areas that may be difficult to access.

For example, a support structure physically associated with the first sensor and the second sensor in a first configuration may be moved to an area for inspection. The first sensor and the second sensor are positioned about an axis extending through the support structure when the support structure is in the first configuration. The support structure may be changed from the

first configuration to a second configuration. The first sensor and the second sensor are configured to generate information when the support structure is in the second configuration.

5 In the second configuration, the movement of the support structure may be guided using first information in the information generated by the first sensor to guide the support structure to a position relative to the area for inspection. Second information in the information may be generated with the second sensor when the second sensor is in the desired position
10 relative to the area for inspection.

With reference now to the figures, and in particular, with reference to **Figure 1**, an illustration of an inspection environment is depicted in accordance with an illustrative embodiment. In this illustrative example, inspection
15 environment **100** is an environment in which nondestructive inspections may be performed.

As depicted, cargo floor panel **102** is seen in this exposed view in aircraft **103** in inspection environment **100**. Cargo floor panel **102** is an example of an object that may be inspected with
20 nondestructive inspection system **104**. In this illustrative example, this inspection may be performed using nondestructive inspection unit **106** and nondestructive inspection unit **108** in nondestructive inspection system **104**.

Nondestructive inspection unit **106** is operated by robot
25 **110**. Nondestructive inspection unit **108** is operated by human operator **112**. In particular, the inspection performed using nondestructive inspection unit **106** and nondestructive inspection unit **108** may be in interior **113** of aircraft **103** under cargo floor panel **102**.

30 As depicted, nondestructive inspection unit **106** is configured to reach interior **113** of aircraft **103** under cargo floor panel **102** through opening **114**. In this illustrative example, nondestructive inspection unit **106** may have a first configuration for moving through opening **114**. Nondestructive

inspection unit **106** may then change to a second configuration for performing the inspection in interior **113**.

In a similar fashion, nondestructive inspection unit **108** is configured to reach interior **113** of aircraft **103** through opening **116** in cargo floor panel **102**. Nondestructive inspection unit **108** also has a first configuration. This first configuration is used when moving nondestructive inspection unit **108** through opening **116** in cargo floor panel **102**. Nondestructive inspection unit **108** then changes into a second configuration when performing the inspection of interior **113**.

In these illustrative examples, opening **114** and opening **116** may have a size that does not allow nondestructive inspection unit **106** and nondestructive inspection unit **108** to pass through opening **114** and opening **116** when these nondestructive inspection units are in the second configuration. In these illustrative examples, opening **114** and opening **116** are fastener holes.

As depicted, nondestructive inspection unit **106** may generate and send information to computer **118** over wireless communications link **120**. In a similar fashion, nondestructive inspection unit **108** also may send information to computer **118** over wireless communications link **122**. This information may be analyzed to determine whether inconsistencies are present in cargo floor panel **102** and what actions should be taken if inconsistencies are detected in cargo floor panel **102**.

The illustration of inspection environment **100** is provided as one example of an implementation for an inspection environment. Of course, other inspection environments may include other types of objects and numbers of objects for inspection. Additionally, other numbers of nondestructive inspection units may be present in other illustrative examples.

With reference now to **Figure 2**, an illustration of a block diagram of an inspection environment is depicted in accordance with an illustrative embodiment. Inspection environment **100** in

Figure 1 is an example of one implementation for inspection environment **200** shown in block form in **Figure 2**.

As depicted, object **202** may be inspected in inspection environment **200** using nondestructive inspection system **204**.

5 Object **202** may take various forms. For example, object **202** may be cargo floor panel **102** in **Figure 1**. Further, object **202** may be selected from various types of objects. For example, object **202** may be selected from one of a mobile platform, a stationary platform, a land-based structure, an aquatic-based structure, a
10 space-based structure, a deformable structure, a flexible fuel bag, a fuel line, a surface ship, a tank, a personnel carrier, a train, a spacecraft, a space station, a satellite, a submarine, an automobile, a power plant, a bridge, a dam, a house, a manufacturing facility, a building, a fairing, a fuel tank, a
15 fuselage, an engine, and a duct system.

Nondestructive inspection system **204** includes a group of nondestructive inspection units **206**. As used herein, a "group of," when used with reference to items, means one or more items. For example, a group of nondestructive inspection units **206** is
20 one or more nondestructive inspection units.

In the illustrative examples, nondestructive inspection unit **208** within the group of nondestructive inspection units **206** is used to perform an inspection of object **202**. As depicted, nondestructive inspection unit **208** may be moved to area **209** for
25 inspection of object **202**. For example, nondestructive inspection unit **208** may be configured to move through opening **210** into interior **212** of object **202** to perform an inspection of interior **212** of object **202**. Opening **210** may take various forms. For example, opening **210** may be a fastener hole, a slot, an
30 access port, a gap between parts, or some other suitable type of opening.

As depicted, nondestructive inspection unit **208** includes sensors **214**. In this illustrative example, sensors **214** comprise first sensor **216** and second sensor **218**. Sensors **214** may be

implemented using any sensor desired for performing an inspection of object **202**. For example, first sensor **216** may be selected from one of a camera, a video imaging system, a borescope, and other suitable types of sensors. As another illustrative example, second sensor **218** may be selected from one of an eddy current sensor, an ultrasonic transducer, a chemical sensor, a biological sensor, an infrared sensor, a thermocouple temperature sensor, a magnetic field sensor, a vibration sensor, an electrical potential sensor, an electrostatic discharge (ESD) sensor and other suitable types of sensors.

Nondestructive inspection unit **208** also includes support structure **220**. Sensors **214** are physically associated with support structure **220**. In particular, first sensor **216** and second sensor **218** are physically associated with support structure **220**.

When one component is "physically associated" with another component, the association is a physical association in the depicted examples. For example, a first component, first sensor **216**, may be considered to be physically associated with a second component, support structure **220**, by being secured to the second component, bonded to the second component, mounted to the second component, welded to the second component, fastened to the second component, and/or connected to the second component in some other suitable manner. The first component also may be connected to the second component using a third component. The first component may also be considered to be physically associated with the second component by being formed as part of the second component, extension of the second component, or both.

In the illustrative example, support structure **220** is configured to change between first configuration **222** and second configuration **224**. Support structure **220**, with first sensor **216** and second sensor **218**, is configured to move through opening **210** when support structure **220** is in first configuration **222**.

Support structure **220** may take various forms. Support structure **220** may be any type of structure configured to hold sensors **214**.

Further, support structure **220** may be comprised of multiple parts. The different parts may be comprised of various

5 materials. For example, the different parts may be comprised of one or more materials that may be selected from at least one of a metal, aluminum, steel, a composite material, plastic, polycarbonate, or other suitable types of materials. Further, some of the parts may be rigid while other parts may be
10 flexible, depending on the particular implementation.

As used herein, the phrase "at least one of," when used with a list of items, means different combinations of one or more of the listed items may be used and only one of each item in the list may be needed. For example, "at least one of item
15 A, item B, or item C" may include, without limitation, item A, item A and item B, or item B. This example also may include item A, item B, and item C or item B and item C. Of course, any combinations of these items may be present. In other examples, "at least one of" may be, for example, without limitation, two
20 of item A, one of item B, and ten of item C; four of item B and seven of item C; and other suitable combinations. The item may be a particular object, thing, or a category. In other words, at least one of means any combination of items and number of items may be used from the list but not all of the items in the
25 list are required.

For example, support structure **220** may have base section **230** and moveable section **232**. Moveable section **232** may move relative to base section **230** in this depicted example. Base section **230** and moveable section **232** may be connected to each
30 other by connector system **234**. Connector system **234** may be, for example, linkage system **236**. Linkage system **236** comprises one or more structures that facilitate movement of moveable section **232** relative to base section **230**. This movement may be at least

one of rotational movement, translational movement, or other suitable types of movement.

Connector system **234** is configured to facilitate movement of moveable section **232** relative to base section **230** such that
5 second sensor **218** moves relative to first sensor **216** when support structure **220** moves between first configuration **222** and second configuration **224**.

In the illustrative example, movement of support structure **220** between first configuration **222** and second configuration **224**
10 may be performed using movement system **238**. Movement system **238** may take various forms. For example, movement system **238** may be selected from at least one of a cable, an actuator, a motor, or some other suitable type of device.

As depicted, first sensor **216** and second sensor **218** are in
15 first position **240** relative to each other when support structure **220** is in first configuration **222**. For example, second sensor **218** may be located in front of first sensor **216** in first position **240** when support structure **220** is in first configuration **222**. First position **240** of first sensor **216** and
20 second sensor **218** allows for the movement of first sensor **216** and second sensor **218** through opening **210**.

After first sensor **216** and second sensor **218** with support structure **220** move through opening **210** into interior **212** of object **202**, support structure **220** may change into second
25 configuration **224**. This configuration results in first sensor **216** and second sensor **218** having second position **242** relative to each other.

First sensor **216** and second sensor **218** are configured to generate information **226** when support structure **220** is in second
30 configuration **224**. For example, first sensor **216** generates first information **244** in information **226**. Second sensor **218** generates second information **246** in information **226**. For example, first information **244** may be an image or light that may be viewed by operator **248**. Second information **246** may be data

characterizing object **202**. This data may be, for example, readings from eddy currents, a response to ultrasonic signals, or other types of data.

In second configuration **224**, first sensor **216** and second sensor **218** in second position **242** are both in a position such that first sensor **216** and second sensor **218** are configured to generate information **226** in a desired manner.

In this illustrative example, first sensor **216** does not move while second sensor **218** moves when support structure **220** changes between first configuration **222** and second configuration **224**. In first position **240**, second sensor **218** may block first sensor **216** from generating first information **244**. In other illustrative examples, second sensor **218** may not be positioned in a position to generate second information **246** when in first position **240**. Movement of second sensor **218** into second position **242** is one in which first sensor **216** and second sensor **218** generate information **226** in a desired manner when support structure **220** is in second configuration **224**. In other illustrative examples, first sensor **216**, second sensor **218**, or both sensors may move.

As depicted, at least one of first information **244** and second information **246** in information **226** may be sent to computer system **250**. Computer system **250** may be used to analyze this information to determine whether inconsistency **252** is present or may need additional actions.

In this manner, nondestructive inspection unit **208** may be moved to area **209** on object **202** to perform an inspection of object **202**. In these illustrative examples, nondestructive inspection unit **208** may be used when area **209** is difficult to reach. For example, when area **209** is located within interior **212** of object **202**, access to area **209** may be more difficult than desired. In these illustrative examples, support structure **220** may be changed between first configuration **222** and second configuration **224** to reach area **209**. As described above,

support structure **220** with first sensor **216** and second sensor **218** may be moved through opening **210** to reach area **209** when in first configuration **222**. Then, support structure **220** may be changed to second configuration **224** such that both first sensor **216** and second sensor **218** may generate information **226** in a desired manner.

Further, with the use of nondestructive inspection unit **208**, first sensor **216** and second sensor **218** may both be moved through opening **210**. As a result, another opening is not needed to move and position both first sensor **216** and second sensor **218** in area **209** to perform inspection of area **209**. This type of inspection unit may aid operator **248** when operator **248** uses first sensor **216** to guide second sensor **218** within area **209** to perform an inspection using second sensor **218**.

For example, first sensor **216** may be a borescope while second sensor **218** may be an eddy current sensor. Operator **248** may use the borescope to guide movement of support structure **220** such that the eddy current sensor may be used to generate data about a particular portion of area **209**.

The illustration of inspection environment **200** shown in block form in **Figure 2** is not meant to imply physical or architectural limitations to the manner in which an illustrative embodiment may be implemented. Other components in addition to or in place of the ones illustrated may be used. Some components may be unnecessary. Also, the blocks are presented to illustrate some functional components. One or more of these blocks may be combined, divided, or combined and divided into different blocks when implemented in an illustrative embodiment.

For example, computer system **250** may be a separate component from nondestructive inspection system **204** in some illustrative examples. As another example, nondestructive inspection unit **208** may be mounted on a robotic arm. In other words, nondestructive inspection unit **208** may be an end effector for a robot. In other illustrative examples, nondestructive

inspection unit **208** may be attached to a cable, a rod, or some other suitable structure.

Although nondestructive inspection unit **208** has been described with respect to a first sensor and a second sensor, one or more sensors may be included in nondestructive inspection unit **208** in addition to first sensor **216** and second sensor **218**. Additional moveable sections also may be present in addition to moveable section **232**.

Other components such as wires, optical fibers, and other communications links may be present that connect nondestructive inspection unit **208** to computer system **250**. As another example, nondestructive inspection unit **208** may include a wireless communications unit configured to establish a wireless communications link with computer system **250**.

In another illustrative example, second sensor **218** is an example of tool **260**. Of course, tool **260** may take other forms other than second sensor **218**. For example, tool **260** may be selected from one of a marking instrument, a light, a pen, a marker, a sealant applicator, a paint applicator, and other suitable types of tools. As depicted, tool **260** may be modular. In other words, tool **260** may be removable from moveable section **232** such that another tool may be added in place of tool **260**.

For example, when tool **260** takes the form of a marking instrument, tool **260** may be used to mark a location where inconsistency **252** may be seen. As a result, inconsistency **252** may be more easily located in a subsequent inspection.

As another example, when tool **260** takes the form of a marking instrument, indications may be made that identify areas such as area **209** where an inspection has been performed. As a result, when many features of the same type are present, an identification of which features have been inspected may be more easily made. For example, a marking tool may be used to mark fasteners in a long row of fasteners as inspection of the fasteners is performed.

With reference now to **Figure 3**, an illustration of a nondestructive inspection unit with a support structure in a first configuration is depicted in accordance with an illustrative embodiment. In this illustrative example, nondestructive inspection unit **300** is an example of a physical implementation for nondestructive inspection unit **208** shown in block form in **Figure 2**.

As depicted, nondestructive inspection unit **300** includes support structure **302**, borescope **304**, and eddy current sensor **306**. Borescope **304** is an example of an implementation for first sensor **216** shown in block form in **Figure 2**. Eddy current sensor **306** is an example of an implementation for second sensor **218** shown in block form in **Figure 2**. Support structure **302** is physically associated with borescope **304** and eddy current sensor **306**.

Support structure **302** is comprised of base section **308** and moveable section **310**. Borescope **304** is physically associated with base section **308** and eddy current sensor **306** is physically associated with moveable section **310**. Base section **308** and moveable section **310** are connected to each other through links **312**. Links **312** is an example of an implementation for connector system **234** shown in block form in **Figure 2**. In particular, links **312** are an example of an implementation for linkage system **236** shown in block form in **Figure 2**. Links **312** includes link **313**, link **314**, link **315**, and link **316**. Spring **317** also connects base section **308** to moveable section **310**.

As depicted, base section **308** is connected to elongate structure **318**. Elongate structure **318** may be manipulated by an operator such as a human operator or a robotic arm to move support structure **302**.

Elongate structure **318** may take various forms. For example, elongate structure **318** may be a rod, a cable, or some other suitable structure. Elongate structure **318** may be rigid, flexible, or may have rigid and flexible sections. Further,

elongate structure **318** may have features that allow for manipulation of the shape of elongate structure **318**. For example, these features may include actuators or cables (not shown). In the illustrative example, the actuators or cables are controlled from the proximal end of support structure **220** or other location on nondestructive inspection unit **208** exterior to the inspection area.

Additionally, cable **320** is also present and may be used to change the configuration of support structure **302**. In this illustrative example, cable **320** is configured to provide for force transmission. As depicted, cable **320** is connected to moveable section **310**. Cable **320** may be manipulated by an operator to cause movement of moveable section **310** relative to base section **308**. In this illustrative example, the manipulation may be a force that may push or pull cable **320** in the direction of arrow **322**. Cable **320** may be attached to a locking mechanism (not shown) that allows moveable section **310** to maintain a selected position. Additionally, cable **320** also may include one or more wires for operating eddy current sensor **306**.

In this illustrative example, nondestructive inspection unit **300** is in first configuration **324**. In particular, spring **317** biases moveable section **310** and base section **308** to first configuration **324**.

In first configuration **324**, borescope **304** and eddy current sensor **306** are positioned about axis **326** extending through support structure **302** when support structure **302** is in first configuration **324**. In this particular example, axis **326** also extends centrally through borescope **304** and eddy current sensor **306**.

In this configuration, eddy current sensor **306** and borescope **304** are in a first position relative to each other. In this first position, eddy current sensor **306** is located in front of borescope **304**. With this positioning, eddy current

sensor **306** and borescope **304** are considered to be in line with each other.

As a result, an operator may be unable to view images as desired when support structure **302** is in first configuration

5 **324**. However, this configuration allows for nondestructive inspection unit **300** to pass through an opening.

As depicted, support structure **302** with borescope **304** and eddy current sensor **306** has length **328**, width **330**, and height **332**. The values for these dimensions may vary depending on the
10 particular use for nondestructive inspection unit **300**.

For example, if support structure **302** in nondestructive inspection unit **300** is designed for entry through fastener holes, length **328** may be about 1.0 inch, width **330** may be about 0.35 inches, and height **332** may be about 0.25 inches. These
15 values may vary depending on the size of the opening, the shape of the opening, or both the size and shape of the opening.

With reference now to **Figure 4**, an illustration of a nondestructive inspection unit with a support structure in a second configuration is depicted in accordance with an
20 illustrative embodiment. In this illustrative example, support structure **302** has changed from first configuration **324** as depicted in **Figure 3** to second configuration **400**.

As can be seen, moveable section **310** has been moved in the direction of arrow **402** relative to base section **308**. In this
25 illustrative example, this movement may be caused through manipulation of cable **320** in the direction of arrow **322**.

As a result, eddy current sensor **306** is now in a second position relative to borescope **304**. In other words, eddy current sensor **306** has moved laterally with respect to borescope
30 **304**. In this position, eddy current sensor **306** has been moved away from axis **326** out of the way of borescope **304**. With this positioning, a line of sight is present through borescope **304**.

As a result, borescope **304** and eddy current sensor **306** may both generate information in a desired manner. In other words,

eddy current sensor **306** and moveable section **310** no longer obscure the view of borescope **304** when support structure **302** is in second configuration **400**.

In second configuration **400**, borescope **304** may provide a view of an area of an object. This view may be used to guide support structure **302** to a portion of the area such that eddy current sensor **306** may be used to generate data about the area.

For example, in this configuration, borescope **304** may be used by an operator to perform a visual inspection. If the operator sees an inconsistency, the operator may use this view to move support structure **302** in a manner that positions eddy current sensor **306** to generate data about the inconsistency.

In second configuration **400**, support structure **302** is unable to pass through an opening. As a result, when the inspection is completed, support structure **302** may be changed back to first configuration **324** as depicted in **Figure 3**. In first configuration **324**, support structure **302** may be moved back through the opening. In these illustrative examples, spring **317** biases moveable section **310** back into position around axis **326** to return to first configuration **324**. This movement may occur when cable **320** is no longer manipulated or released.

Turning now to **Figure 5**, an illustration of a nondestructive inspection unit with a support structure in a first configuration is depicted in accordance with an illustrative embodiment. In this illustrative example, nondestructive inspection unit **500** is another example of nondestructive inspection unit **208** shown in block form in **Figure 2**.

As depicted, nondestructive inspection unit **500** includes support structure **502**, borescope **504**, and eddy current sensor **506**. Borescope **504** is an example of an implementation for first sensor **216** shown in block form in **Figure 2**. Eddy current sensor **506** is an example of an implementation for second sensor **218** shown in block form in **Figure 2**. Support structure **502** is

physically associated with borescope **504** and eddy current sensor **506**.

Support structure **502** is comprised of base section **508** and moveable section **510**. Borescope **504** is physically associated with base section **508** and eddy current sensor **506** is physically associated with moveable section **510**. Base section **508** and moveable section **510** are connected to each other through rotating connector **512**. Rotating connector **512** is an example of an implementation for connector system **234** shown in block form in **Figure 2**. In particular, rotating connector **512** may be an example of an implementation for linkage system **236** shown in block form in **Figure 2**.

Additionally, base section **508** is connected to elongate structure **513**. Elongate structure **513** may take various forms. For example, elongate structure **513** may be a rod, a cable, or some other suitable structure. Elongate structure **513** may be rigid, flexible, or may have rigid and flexible sections.

Cable **514** extends through base section **508** and rotating connector **512** to moveable section **510**. In this illustrative example, cable **514** also may include wires configured to operate eddy current sensor **506**.

As depicted, support structure **502** is in first configuration **516**. In this configuration, borescope **504** and eddy current sensor **506** are positioned about axis **518** extending through support structure **502** when support structure **502** is in first configuration **516**.

In first configuration **516**, support structure **502** with borescope **504** and eddy current sensor **506** may be moved through an opening. As depicted, the position of eddy current sensor **506** and moveable section **510** may obscure a view of borescope **504**. In particular, eddy current sensor **506** may be in line with borescope **504**.

Cable **514** may be used to cause rotation of moveable section **510** and rotating connector **512** such that eddy current sensor **506**

does not obscure the view of borescope **504**. Cable **514** may be manipulated by an operator to cause rotation of moveable section **510**. In these illustrative examples, cable **514** may be twisted in the direction of arrow **520** to cause this movement of moveable section **510**.

With reference now to **Figure 6**, an illustration of a nondestructive inspection unit with a support structure in a second configuration is depicted in accordance with an illustrative embodiment. In this illustrative example, support structure **502** is in second configuration **600**.

As depicted, moveable section **510** has been moved in the direction of arrow **602**. In this illustrative example, this movement is a rotational movement facilitated by rotating connector **512** and a manipulation of cable **514**. In this illustrative example, the rotational movement in the direction of arrow **602** is about 180 degrees. This rotational movement also results in a translation of eddy current sensor **506** away from axis **518** in the direction of arrow **604**.

In second configuration **600**, eddy current sensor **506** has been moved to a position away from axis **518**. In this position, both borescope **504** and eddy current sensor **506** are in positions for generating information in a desired manner when performing an inspection of an object.

When the inspection is completed, moveable section **510** with eddy current sensor **506** may be moved back into its original position such that support structure **502** returns to first configuration **516** as seen in **Figure 5**. This movement may be caused by manipulating cable **514**. With support structure **502** in first configuration **516**, support structure **502** with borescope **504** and eddy current sensor **506** may then be moved back through an opening.

In this illustrative example, support structure **502** may have length **606** and diameter **608**. In this illustrative example, length **606** may be about 1.0 inch and diameter **608** may be about

0.35 inches. Of course, these values may vary depending on the opening through which support structure **502** is to be passed.

With reference now to **Figure 7**, an illustration of a nondestructive inspection unit with a support structure in a first configuration is depicted in accordance with an illustrative embodiment. In this illustrative example, nondestructive inspection unit **700** is another example of nondestructive inspection unit **208** shown in block form in **Figure 2**.

As depicted, nondestructive inspection unit **700** includes support structure **702**, borescope **704**, and eddy current sensor **706**. Borescope **704** is an example of an implementation for first sensor **216** shown in block form in **Figure 2**. Eddy current sensor **706** is an example of an implementation for second sensor **218** shown in block form in **Figure 2**. Support structure **702** is physically associated with borescope **704** and eddy current sensor **706**.

Support structure **702** is comprised of base section **708** and moveable section **710**. Borescope **704** is physically associated with base section **708** and eddy current sensor **706** is physically associated with moveable section **710**. Base section **708** and moveable section **710** are connected to each other through link **712**. In this illustrative example, link **712** is an example of an implementation for connector system **234** and, in particular, linkage system **236** shown in block form in **Figure 2**.

As depicted, link **712** is connected to base section **708** through hinge **722**. Link **712** is connected to moveable section **710** through hinge **724**. As a result, link **712** may rotate relative to base section **708** and moveable section **710** may rotate relative to link **712**. This rotation may result in a translation of moveable section **710** relative to base section **708**.

As depicted, base section **708** is connected to elongate structure **714**. Additionally, cable **715** is also present. Cable

715 is connected to moveable section **710** through pin **725** of hinge **724** in this illustrative example.

As depicted, support structure **702** is in first configuration **716**. In first configuration **716** of support structure **702**, borescope **704** and eddy current sensor **706** are positioned about axis **718** extending through support structure **702** and, in particular, through base section **708** in support structure **702**.

As depicted, this position of eddy current sensor **706** relative to borescope **704** may obscure the view of borescope **704**. In particular, eddy current sensor **706** and borescope **704** are in line with each other with axis **718** extending centrally through these two sensors. First configuration **716** is used when nondestructive inspection unit **700** is moved through an opening in this illustrative example.

Link **712** and moveable section **710** are rotated out of first configuration **716** to perform an inspection. This movement out of first configuration **716** may be performed by manipulating cable **715**.

In this illustrative example, support structure **702** may have length **726** and diameter **728**. In this illustrative example, length **726** may be about 1.0 inch and diameter **728** may be about 0.35 inches. Of course, these values may vary depending on the opening through which support structure **702** is to be passed.

Turning now to **Figure 8**, an illustration of a nondestructive inspection unit with a support structure in a second configuration is depicted in accordance with an illustrative embodiment. In this illustrative example, support structure **702** is in second configuration **800**.

As depicted, moveable section **710** has been moved in the direction of arrow **802**. In this illustrative example, this movement is a combination of rotational and translational movement facilitated by rotation of link **712** in response to a manipulation of cable **715**. In this example, link **712** rotates

180 degrees about hinge **722** in the direction of arrow **804** and moveable section **710** may rotate an additional 180 degrees about hinge **724** in the direction of arrow **804**, for a total rotation of moveable section **710** by 360 degrees relative to support structure **702**. This rotation results in a translation of eddy current sensor **706** and moveable section **710** in the direction of arrow **802** away from axis **718**. In this illustrative example, the motion of cable **715** is a twisting type of motion instead of the pulling type of motion shown in the **Figure 3** and **Figure 4**.

10 In second configuration **800**, eddy current sensor **706** may generate data when performing an inspection. Borescope **704** is not obscured in this configuration. As a result, borescope **704** may generate an image that may be used to direct movement of eddy current sensor **706** to an area for performing the inspection.

15 When the inspection is completed, support structure **702** may be returned to first configuration **716** as seen in **Figure 7**. In first configuration **716**, support structure **702** may be moved back through an opening.

20 Turning now to **Figure 9**, an illustration of a nondestructive inspection unit with a support structure in a first configuration is depicted in accordance with an illustrative embodiment. In this illustrative example, nondestructive inspection unit **900** is another example of nondestructive inspection unit **208** shown in block form in **Figure 2**.

25 As depicted, nondestructive inspection unit **900** includes support structure **902**, borescope **904**, and eddy current sensor **906**. Borescope **904** is an example of an implementation for first sensor **216** shown in block form in **Figure 2**. Eddy current sensor **906** is an example of an implementation for second sensor **218** shown in block form in **Figure 2**. Support structure **902** is physically associated with borescope **904** and eddy current sensor **906**.

In this illustrative example, support structure **902** includes base section **908** and moveable section **910**. Borescope **904** is physically associated with base section **908** and eddy current sensor **906** is physically associated with moveable section **910**. Base section **908** and moveable section **910** are connected to each other by hinge **912**. In this illustrative example, hinge **912** is an example of an implementation for connector system **234** shown in block form in **Figure 2**.

With hinge **912**, moveable section **910** may rotate relative to base section **908**. Additionally, moveable section **910** takes the form of a frame in this illustrative example. As depicted, eddy current sensor **906** also may move along moveable section **910** in the direction of arrow **914**.

As depicted, base section **908** is connected to elongate structure **916**. Additionally, cable **918** is also present. Cable **918** is connected to eddy current sensor **906** in this illustrative example. Manipulation of cable **918** may cause rotation of moveable section **910**, movement of eddy current sensor **906**, or some combination of the two.

As depicted, support structure **902** is in first configuration **920**. In this configuration of support structure **902**, borescope **904** is positioned in line with axis **922** extending through support structure **902** and, in particular, through base section **908** in support structure **902**. Moveable section **910** holding eddy current sensor **906** is positioned parallel to axis **922** in this illustrative example. In this example, eddy current sensor **906** and borescope **904** are not in line with each other.

As depicted, this position of eddy current sensor **906** relative to borescope **904** may not be a desired position for performing eddy current testing. First configuration **920** is used when nondestructive inspection unit **900** is moved through an opening in this illustrative example.

Support structure **902** is moved out of first configuration **920** to perform an inspection. This movement out of first configuration **920** may be performed by manipulating cable **918**.

In this illustrative example, support structure **902** may have length **924** and diameter **926**. In this illustrative example, length **924** may be about 1.0 inch and diameter **926** may be about 0.35 inches. Of course, these values may vary depending on the particular implementation.

With reference now to **Figure 10**, an illustration of a nondestructive inspection unit with a support structure in a second configuration is depicted in accordance with an illustrative embodiment. In this illustrative example, nondestructive inspection unit **900** is another example of nondestructive inspection unit **208** shown in block form in **Figure 2**.

In this illustrative example, support structure **902** is in second configuration **1000**. As can be seen, moveable section **910** has been rotated in the direction of arrow **1002**. In second configuration **1000**, eddy current sensor **906** may be moved along moveable section **910** in the direction of arrow **1004**. This movement may be used to position eddy current sensor **906** for performing eddy current testing.

For example, movement along moveable section **910** in the direction of arrow **1004** may be used to move eddy current sensor **906** over a line or crack when an inconsistency may be identified from a visual inspection using borescope **904**. The eddy current testing may be used to generate more information about the inconsistency for analysis. In this manner, less movement of support structure **902** may be needed.

This configuration of support structure **902** may be useful when an inconsistency may be close to an opening through which support structure **902** is inserted for performing an inspection.

The illustrations of nondestructive inspection unit **300** in **Figure 3**, nondestructive inspection unit **500** in **Figure 5**,

nondestructive inspection unit **700** in **Figure 7**, and nondestructive inspection unit **900** in **Figure 9** have been presented only as examples of some implementations for nondestructive inspection unit **208** shown in block form in **Figure**

5 **2**. These illustrations are not meant to limit the manner in which other illustrative embodiments may be implemented.

For example, additional linkage systems and moveable sections with additional sensors may be added to nondestructive inspection unit **300** in **Figure 3**. Further, one or more
10 additional rotating connectors may be used in addition to rotating connector **512** between moveable section **510** and base section **508** in **Figure 5**. In this manner, difficult to access locations may be more easily reached using support structure **502**.

15 The different components shown in **Figure 1** and **Figures 3-10** may be combined with components in **Figure 2**, used with components in **Figure 2**, or a combination of the two. Additionally, some of the components in **Figure 1** and **Figures 3-10** may be illustrative examples of how components shown in block
20 form in **Figure 2** can be implemented as physical structures.

With reference now to **Figure 11**, an illustration of a flowchart of a process for inspecting an object is depicted in accordance with an illustrative embodiment. In this illustrative example, the process depicted in **Figure 11** may be
25 implemented in inspection environment **200** using nondestructive inspection system **204** shown in block form in **Figure 2**.

The process begins by moving a support structure physically associated with a first sensor and second sensor to an area of inspection wherein the support structure is in a first
30 configuration (operation **1100**). The process then changes the support structure from the first configuration to a second configuration (operation **1102**).

The process then moves the support structure using first information generated by the first sensor for guiding the

support structure to a position relative to the area for inspection (operation **1104**). In operation **1104**, the support is in the second configuration as the support structure is moved to the position. The process then generates second information with the second sensor when the second sensor is in the desired position relative to the area for inspection (operation **1106**), with the process terminating thereafter.

Of course, other operations (not shown in this figure) may be performed prior to the process terminating. For example, the support structure may be moved to one or more other positions to generate additional second information. As another example, the support structure may be changed back to the first configuration and removed from the area.

In this manner, the first sensor may be used to guide movement of the support structure to generate information for analysis using the second sensor. With a support structure that changes between a first configuration and a second configuration, the support structure may be moved to the area through an opening in the second configuration and used to generate information as desired.

With reference now to **Figure 12**, an illustration of a flowchart of a process for inspecting a difficult to access area is depicted in accordance with an illustrative embodiment. The process illustrated in **Figure 12** may be implemented using nondestructive inspection unit **208** shown in block form in **Figure 2**. For example, this process may be used to inspect interior **113** under cargo floor panel **102** in aircraft **103** in **Figure 1**.

The process begins by identifying an opening to an area for inspection (operation **1200**). A nondestructive inspection unit with a support structure in a first configuration is inserted through the opening into the area (operation **1202**). The process then changes the configuration of the support structure from the first configuration to a second configuration (operation **1204**).

A visual inspection is performed in the area using a first sensor in the nondestructive inspection unit (operation **1206**). In this illustrative example, this first sensor may be a sensor that generates a view of the area for the operator.

5 A determination is made as to whether an inconsistency is identified using the visual inspection (operation **1208**). If an inconsistency is identified, a second sensor is positioned relative to the inconsistency to generate data about the inconsistency (operation **1210**). The second sensor may be
10 positioned using the view of the inconsistency generated by the first sensor.

The process then generates data about the inconsistency (operation **1212**). This data may be analyzed to obtain more information about the inconsistency. This additional
15 information may include the depth of the inconsistency, the shape of the inconsistency, the size of the inconsistency, and other suitable types of information that may not be apparent from a visual inspection. For example, the depth of the inconsistency may not be determined through a visual inspection
20 of the surface. Further, the size of the inconsistency may be greater than what is shown in the surface through the visual inspection.

Next, a determination is made as to whether the inspection has been completed (operation **1214**). If the inspection has been
25 completed, the support structure is placed into the first configuration (operation **1216**). The nondestructive inspection unit is then removed from the area back through the opening (operation **1218**).

The data about the inconsistency is then analyzed
30 (operation **1220**). An action is then identified based on the analysis of the data (operation **1222**), with the process terminating thereafter. In these illustrative examples, this action may take various forms. For example, the action may be

to perform rework, replacement of a part, increased inspection, or other suitable actions.

With reference again to operation **1214**, if the inspection has not been completed, the process returns to operation **1206**.

5 Additionally, the process proceeds to operation **1214** from operation **1208** if an inconsistency is not identified. At this point, the nondestructive inspection unit may be moved to continue inspecting the area.

10 Illustrative embodiments of the disclosure may be described in the context of aircraft manufacturing and service method **1300** as shown in **Figure 13** and aircraft **1400** as shown in **Figure 14**. Turning first to **Figure 13**, an illustration of an aircraft manufacturing and service method is depicted in the form of a block diagram in accordance with an illustrative embodiment.

15 During pre-production, aircraft manufacturing and service method **1300** may include specification and design **1302** of aircraft **1400** in **Figure 14** and material procurement **1304**.

During production, component and subassembly manufacturing **1306** and system integration **1308** of aircraft **1400** in **Figure 14**

20 takes place. Thereafter, aircraft **1400** in **Figure 14** may go through certification and delivery **1310** in order to be placed in service **1312**. While in service **1312** by a customer, aircraft **1400** in **Figure 14** is scheduled for routine maintenance and service **1314**, which may include modification, reconfiguration,

25 refurbishment, and other maintenance or service.

Each of the processes of aircraft manufacturing and service method **1300** may be performed or carried out by a system integrator, a third party, and/or an operator. In these examples, the operator may be a customer. For the purposes of

30 this description, a system integrator may include, without limitation, any number of aircraft manufacturers and major-system subcontractors; a third party may include, without limitation, any number of vendors, subcontractors, and

suppliers; and an operator may be an airline, a leasing company, a military entity, a service organization, and so on.

With reference now to **Figure 14**, an illustration of an aircraft is depicted in the form of a block diagram in which an illustrative embodiment may be implemented. In this example, aircraft **1400** is produced by aircraft manufacturing and service method **1300** in **Figure 13** and may include airframe **1402** with plurality of systems **1404** and interior **1406**. Examples of systems **1404** include one or more of propulsion system **1408**, electrical system **1410**, hydraulic system **1412**, and environmental system **1414**. Any number of other systems may be included. Although an aerospace example is shown, different illustrative embodiments may be applied to other industries, such as the automotive industry.

Apparatuses and methods embodied herein may be employed during at least one of the stages of aircraft manufacturing and service method **1300** in **Figure 13**. For example, an illustrative embodiment may be used to perform inspections of structures for aircraft **1400** during component and subassembly manufacturing **1306**. Additionally, inspections of structures for aircraft **1400** may be inspected during certification and delivery **1310**. Additionally, inspections may be performed using an illustrative embodiment during maintenance and service **1312**. The use of a number of the different illustrative embodiments may substantially expedite the assembly of and/or reduce the cost of aircraft **1400**.

Thus, the illustrative embodiments provide a method and apparatus for inspecting objects. An inspection unit implemented in accordance with an illustrative embodiment may provide an ability to both perform a visual inspection and to generate information for analysis. The visual inspection may be performed to identify inconsistencies for which additional information may be desired. In these illustrative examples, the visual inspection is performed using a first sensor and the

additional information may be generated using a second sensor, both of which are physically associated with the support structure as described above.

The support structure has a first configuration that allows for insertion of the nondestructive inspection unit through an opening such as a fastener hole. In this manner, more than one hole is not needed to perform a visual inspection and to guide the second sensor towards an inconsistency to generate more information about the inconsistency for analysis.

In the illustrative examples, the use of the nondestructive inspection unit reduces a need for disassembly of parts in an object. In this manner, inspections may be made more easily, resulting in less cost and time needed for inspections of an object such as an aircraft. This type of nondestructive inspection may be implemented for surgical nondestructive inspection when openings such as axis holes are smaller than desired for currently available nondestructive inspection units.

With the use of a nondestructive inspection unit, such as nondestructive inspection unit **208** shown in block form in **Figure 2**, inspection of limited access areas in an aircraft as well as other objects may be performed with reduced disassembly of parts in the aircraft. Further, with the use of nondestructive inspection unit **208**, misidentification of inconsistencies and false alerts that occur with only visual inspections may be reduced. In other words, visual inspections may identify inconsistencies that may require disassembly of parts to perform additional testing to generate data to analyze the inconsistency identified through the visual inspection. As a result, unnecessary disassembly of parts and increased costs may be reduced.

With nondestructive inspection unit **208**, a visual inspection may be followed up with the generation of data about an inconsistency identified through the visual inspection. With nondestructive inspection unit **208**, this data may be generated

without disassembly of parts to generate the additional data about an inconsistency.

Further, the disclosure comprises embodiments according to the following clauses:

Clause 1. An apparatus comprising:

a sensor (216);
a tool (260); and

10 a support structure (220) physically associated with the sensor (216) and the tool (260), wherein the support structure (220) is configured to change between a first configuration (222) and a second configuration (224), wherein the support structure (220) with the sensor (216) and the tool (260) are
15 configured to move through an opening (210) in an object (202) when the support structure (220) is in the first configuration (222).

Clause 2. The apparatus of claim 1 further comprising:

20 a movement system (238) configured to move the support structure (220) between the first configuration (222) and the second configuration (224).

Clause 3. The apparatus of claim 1, wherein the sensor (216) is
25 a first sensor (216), and the tool (260) is a second sensor (218) and wherein the first sensor (216) and the second sensor (218) are in a position such that both the first sensor (216) and the second sensor (218) are configured to generate information (226) in a desired manner when the support structure
30 (220) is in the second configuration (224).

Clause 4. The apparatus of claim 1, wherein the sensor (216) and the tool (260) are positioned about an axis (326) extending

through the support structure (220) when the support structure (220) is in the first configuration (222).

Clause 5. The apparatus of claim 4, wherein the tool (260) is
5 located in front of the sensor (216) when the support structure (220) is in the first configuration (222) and wherein the tool (260) is configured to move away from the axis (326) out of the way of the sensor (216) when the support structure (220) changes from the first configuration (222) to the second configuration
10 (224).

Clause 6. The apparatus of claim 1, wherein the support structure (220) comprises:

a base section (230), wherein the sensor (216) is
15 physically associated with the base section (230);
a moveable section (232), wherein the tool (260) is physically associated with the moveable section (232); and
a connector system (234) connected to the base section (230) and the moveable section (232), wherein the moveable
20 section (232) is configured to move relative to the base section (230) such that the tool (260) moves relative to the sensor (216) when the support structure (220) changes between the first configuration (222) and the second configuration (224).

25 Clause 7. The apparatus of claim 6, wherein the connector system (234) is a linkage system (236).

Clause 8. The apparatus of claim 1, wherein the sensor (216) is selected from one of a camera, a video imaging system, and a
30 borescope (304).

Clause 9. The apparatus of claim 1, wherein the tool (260) is selected from one of an eddy current sensor, an ultrasonic transducer, a chemical sensor, a biological sensor, an infrared

sensor, a thermocouple temperature sensor, a magnetic field sensor, a vibration sensor, an electrical potential sensor, an electrostatic discharge sensor, a marking instrument, a light, a pen, a marker, a sealant applicator, and a paint applicator.

5

Clause 10. The apparatus of claim 2, wherein the movement system (238) is selected from at least one of a cable (320) and an actuator.

10 Clause 11. The apparatus of claim 1, wherein the sensor (216), the tool (260), and the support structure (220) with the support structure (220) in the first configuration (222) are configured be moved through a fastener hole.

15 Clause 12. The apparatus of claim 1, wherein the object (202) is selected from one of a mobile platform, a stationary platform, a land-based structure, an aquatic-based structure, a space-based structure, a deformable structure, a flexible fuel bag, a fuel line, a surface ship, a tank, a personnel carrier, a
20 train, a spacecraft, a space station, a satellite, a submarine, an automobile, a power plant, a bridge, a dam, a house, a manufacturing facility, a building, an aircraft wing, a fairing, a fuel tank, a fuselage, an engine, and a duct system.

25 Clause 13. A nondestructive inspection system (204) comprising:

a borescope (304);

a sensor (216); and

a support structure (220) physically associated with the
30 borescope (304) and the sensor (216), wherein the borescope (304) and the sensor (216) are positioned about an axis (326) extending through the support structure (220) when the support structure (220) is in a first configuration (222); the support structure (220) is configured to change between the first

configuration (222) and a second configuration (224); the support structure (220) with the borescope (304) and the sensor (216) are configured to move through an opening (210) in a structure when the support structure (220) is in the first configuration (222); and the borescope (304) and the sensor (216) are configured to generate information (226) when the support structure (220) is in the second configuration (224).

Clause 14. The nondestructive inspection system (204) of claim 13, wherein the borescope (304) and the sensor (216) are positioned about the axis (326) extending through the support structure (220); the sensor (216) is located in front of the borescope (304) when the support structure (220) is in the first configuration (222); and the sensor (216) is configured to move away from the axis (326) when the support structure (220) changes from the first configuration (222) to the second configuration (224).

Clause 15. The nondestructive inspection system (204) of claim 13, wherein the support structure (220) comprises:

a base section (230), wherein the borescope (304) is physically associated with the base section (230);

a moveable section (232), wherein the sensor (216) is physically associated with the moveable section (232); and

a connector system (234) connected to the base section (230) and the moveable section (232), wherein the moveable section (232) is configured to move relative to the base section (230) such that the sensor (216) moves relative to the borescope (304) when the support structure (220) changes between the first configuration (222) and the second configuration (224).

Clause 16. The nondestructive inspection system (204) of claim 15, wherein the connector system (234) is a linkage system (236).

Clause 17. A method for inspecting an object (202), the method comprising:

moving (1100) a support structure (220) physically
5 associated with a first sensor (216) and a second sensor (218)
to an area (209) for inspection, wherein the support structure
(220) is in a first configuration (222) and the first sensor
(216) and the second sensor (218) are positioned about an axis
(326) extending through the support structure (220) when the
10 support structure (220) is in the first configuration (222); and
changing (1102) the support structure (220) from the first
configuration (222) to a second configuration (224), wherein the
first sensor (216) and the second sensor (218) are configured to
generate information (226) when the support structure (220) is
15 in the second configuration (224).

Clause 18. The method of claim 17 further comprising:

moving (1104) the support structure (220) in the second
configuration (224) using first information (226) in the
20 information (226) generated by the first sensor (216) for
guiding the support structure (220) to a desired position
relative to the area (209) for the inspection; and
generating (1106) second information (226) in the
information (226) with the second sensor (218) when the second
25 sensor (218) is in the desired position relative to the area
(209) for inspection.

Clause 19. The method of claim 17, wherein moving the
support structure (220) physically associated with the first
30 sensor (216) and the second sensor (218) in the first
configuration (222) to the area (209) for inspection, wherein
the first sensor (216) and the second sensor (218) are
positioned about the axis (326) extending through the support

structure (220) when the support structure (220) is in the first configuration (222) comprises:

moving the support structure (220) physically associated with the first sensor (216) and the second sensor (218) in the first configuration (222) through an opening (210) to the area (209) for inspection, wherein the first sensor (216) and the second sensor (218) are positioned about the axis (326) extending through the support structure (220) when the support structure (220) is in the first configuration (222).

Clause 20. The method of claim 17, wherein the support structure (220) comprises a base section (230), wherein the first sensor (216) is physically associated with the base section (230); a moveable section (232), wherein the second sensor (218) is physically associated with the moveable section (232); and a connector system (234) connected to the base section (230) and the moveable section (232), wherein the moveable section (232) is configured to move relative to the base section (230) such that the second sensor (218) moves relative to the first sensor (216) when the support structure (220) changes between the first configuration (222) and the second configuration (224).

The description of the different illustrative embodiments 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 illustrative embodiments may provide different features as compared to other illustrative embodiments. The embodiment or embodiments 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:

What is claimed is:

5

1. An apparatus comprising:

a sensor (216);

a tool (260); and

10 a support structure (220) physically associated with the sensor (216) and the tool (260), wherein the support structure (220) is configured to change between a first configuration (222) and a second configuration (224), wherein the support structure (220) with the sensor (216) and the tool (260) are configured to move through an opening (210) in an object (202) when the support structure (220) is in the first configuration (222).

2. The apparatus of claim 1 further comprising:

20 a movement system (238) configured to move the support structure (220) between the first configuration (222) and the second configuration (224).

3. The apparatus of claim 1, wherein the sensor (216) is a first sensor (216), and the tool (260) is a second sensor (218)

25 and wherein the first sensor (216) and the second sensor (218) are in a position such that both the first sensor (216) and the second sensor (218) are configured to generate information (226) in a desired manner when the support structure (220) is in the second configuration (224).

30

4. The apparatus of claim 1, wherein the sensor (216) and the tool (260) are positioned about an axis (326) extending through the support structure (220) when the support structure (220) is in the first configuration (222).

5. The apparatus of claim 4, wherein the tool (260) is located in front of the sensor (216) when the support structure (220) is in the first configuration (222) and wherein the tool (260) is
5 configured to move away from the axis (326) out of the way of the sensor (216) when the support structure (220) changes from the first configuration (222) to the second configuration (224).

6. The apparatus of claim 1, wherein the support structure
10 (220) comprises:

a base section (230), wherein the sensor (216) is physically associated with the base section (230);

a moveable section (232), wherein the tool (260) is physically associated with the moveable section (232); and

15 a connector system (234) connected to the base section (230) and the moveable section (232), wherein the moveable section (232) is configured to move relative to the base section (230) such that the tool (260) moves relative to the sensor (216) when the support structure (220) changes between the first
20 configuration (222) and the second configuration (224).

7. The apparatus of claim 6, wherein the connector system (234) is a linkage system (236).

25 8. The apparatus of claim 1, wherein the sensor (216) is selected from one of a camera, a video imaging system, and a borescope (304).

9. The apparatus of claim 1, wherein the tool (260) is
30 selected from one of an eddy current sensor, an ultrasonic transducer, a chemical sensor, a biological sensor, an infrared sensor, a thermocouple temperature sensor, a magnetic field sensor, a vibration sensor, an electrical potential sensor, an

electrostatic discharge sensor, a marking instrument, a light, a pen, a marker, a sealant applicator, and a paint applicator.

10. The apparatus of claim 1, wherein the sensor (216), the
5 tool (260), and the support structure (220) with the support structure (220) in the first configuration (222) are configured be moved through a fastener hole.

11. The apparatus of claim 1, wherein the object (202) is
10 selected from one of a mobile platform, a stationary platform, a land-based structure, an aquatic-based structure, a space-based structure, a deformable structure, a flexible fuel bag, a fuel line, a surface ship, a tank, a personnel carrier, a train, a spacecraft, a space station, a satellite, a submarine, an
15 automobile, a power plant, a bridge, a dam, a house, a manufacturing facility, a building, an aircraft wing, a fairing, a fuel tank, a fuselage, an engine, and a duct system.

20 12. A method for inspecting an object (202), the method comprising:

moving (1100) a support structure (220) physically associated with a first sensor (216) and a second sensor (218) to an area (209) for inspection, wherein the support structure
25 (220) is in a first configuration (222) and the first sensor (216) and the second sensor (218) are positioned about an axis (326) extending through the support structure (220) when the support structure (220) is in the first configuration (222); and
changing (1102) the support structure (220) from the first
30 configuration (222) to a second configuration (224), wherein the first sensor (216) and the second sensor (218) are configured to generate information (226) when the support structure (220) is in the second configuration (224).

13. The method of claim 17 further comprising:

moving (1104) the support structure (220) in the second configuration (224) using first information (226) in the information (226) generated by the first sensor (216) for
5 guiding the support structure (220) to a desired position relative to the area (209) for the inspection; and

generating (1106) second information (226) in the information (226) with the second sensor (218) when the second sensor (218) is in the desired position relative to the area
10 (209) for inspection.

14. The method of claim 17, wherein moving the support structure (220) physically associated with the first sensor (216) and the second sensor (218) in the first configuration
15 (222) to the area (209) for inspection, wherein the first sensor (216) and the second sensor (218) are positioned about the axis (326) extending through the support structure (220) when the support structure (220) is in the first configuration (222) comprises:

20 moving the support structure (220) physically associated with the first sensor (216) and the second sensor (218) in the first configuration (222) through an opening (210) to the area (209) for inspection, wherein the first sensor (216) and the second sensor (218) are positioned about the axis (326)
25 extending through the support structure (220) when the support structure (220) is in the first configuration (222).

15. The method of claim 17, wherein the support structure (220) comprises a base section (230), wherein the first sensor (216)
30 is physically associated with the base section (230); a moveable section (232), wherein the second sensor (218) is physically associated with the moveable section (232); and a connector system (234) connected to the base section (230) and the moveable section (232), wherein the moveable section (232)

is configured to move relative to the base section (230) such that the second sensor (218) moves relative to the first sensor (216) when the support structure (220) changes between the first configuration (222) and the second configuration (224).

1/13

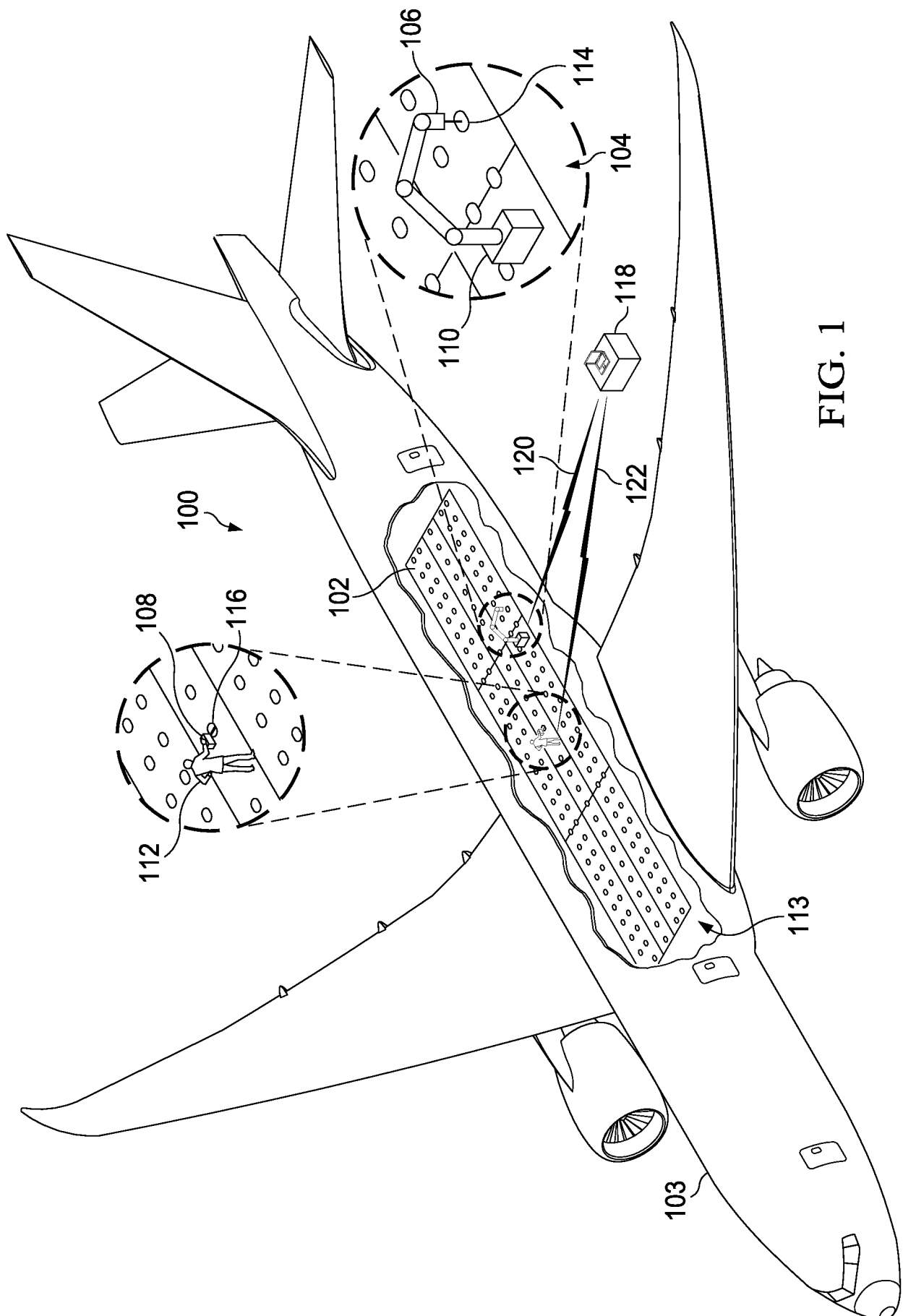


FIG. 1

2/13

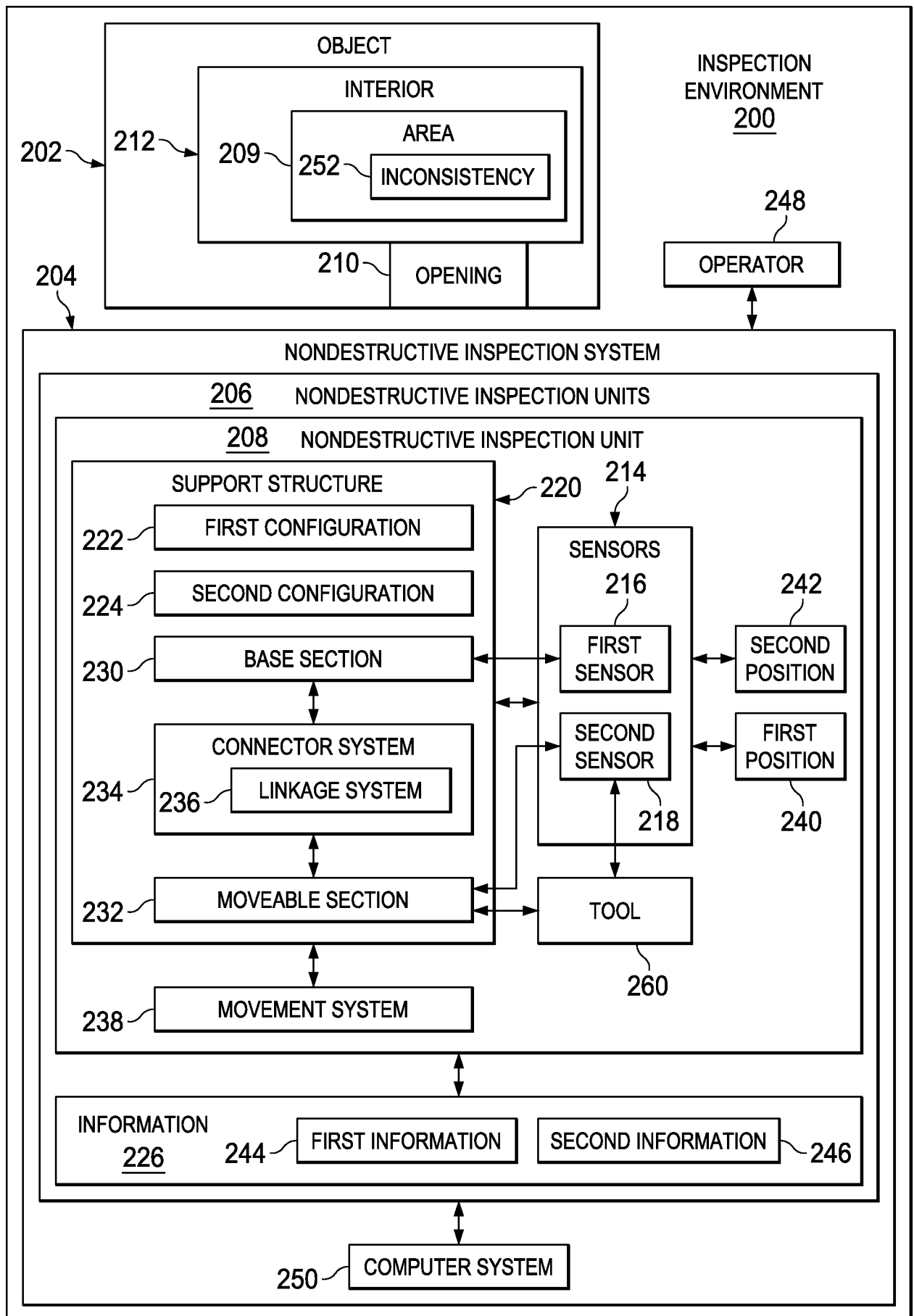
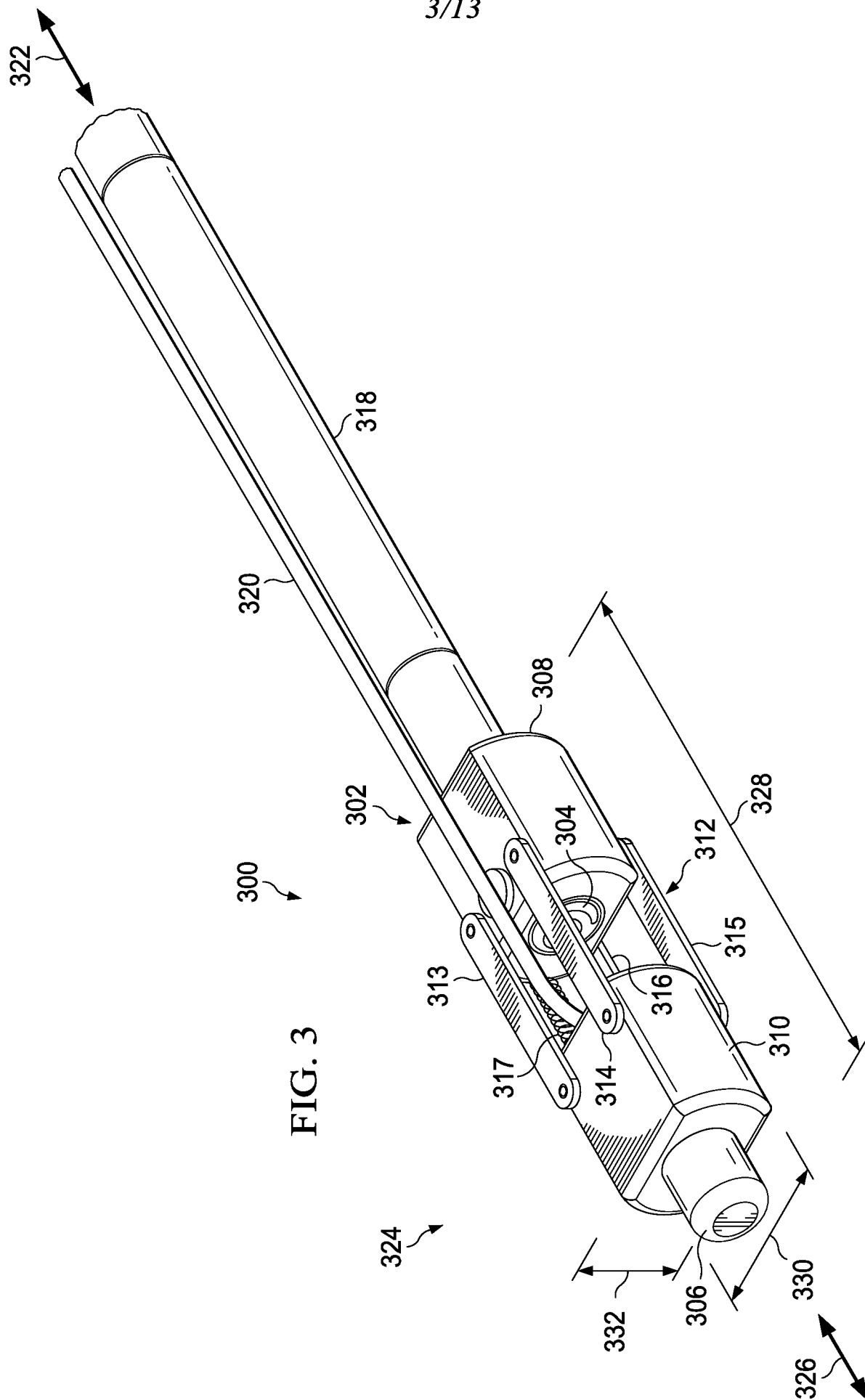
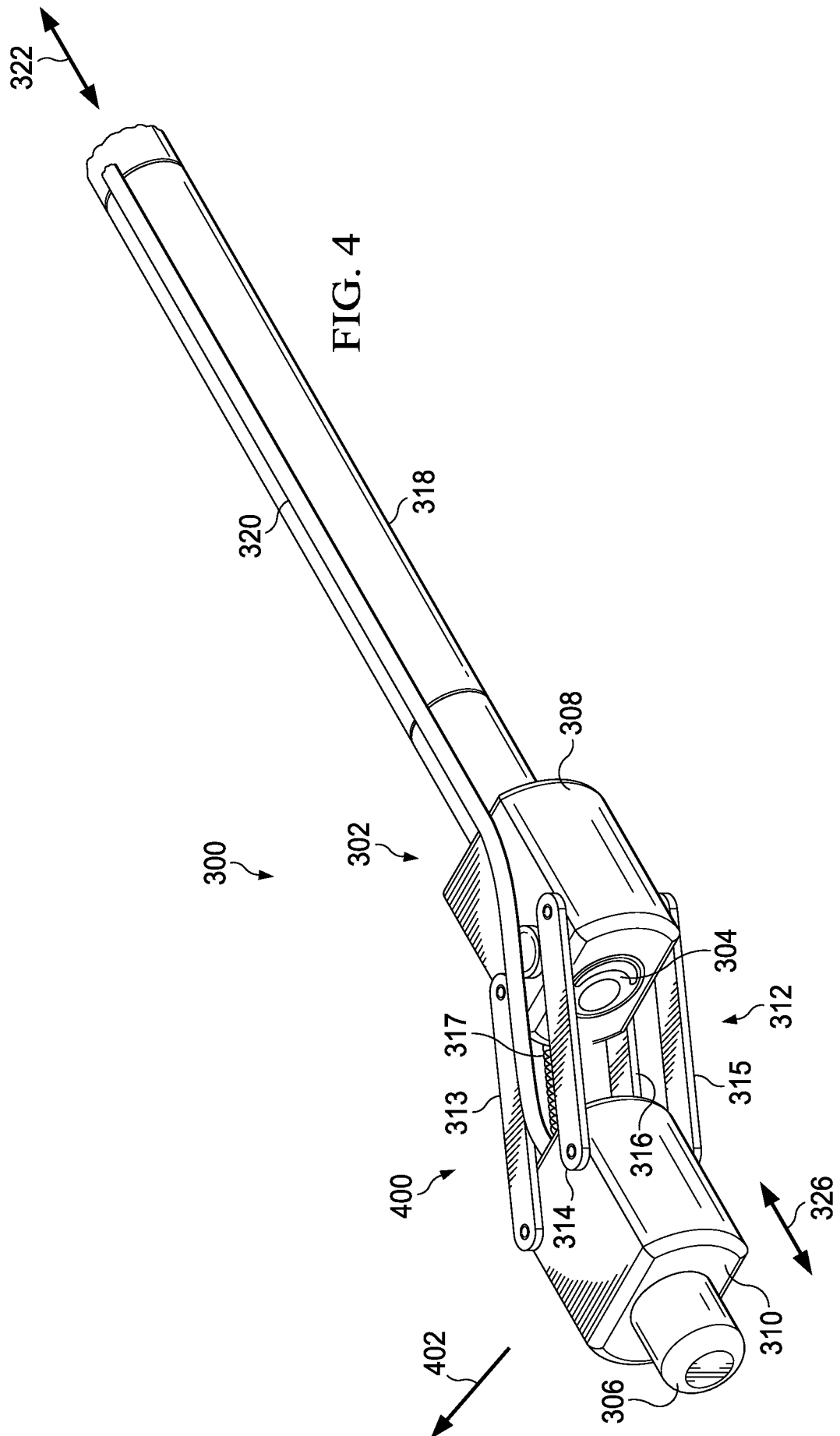
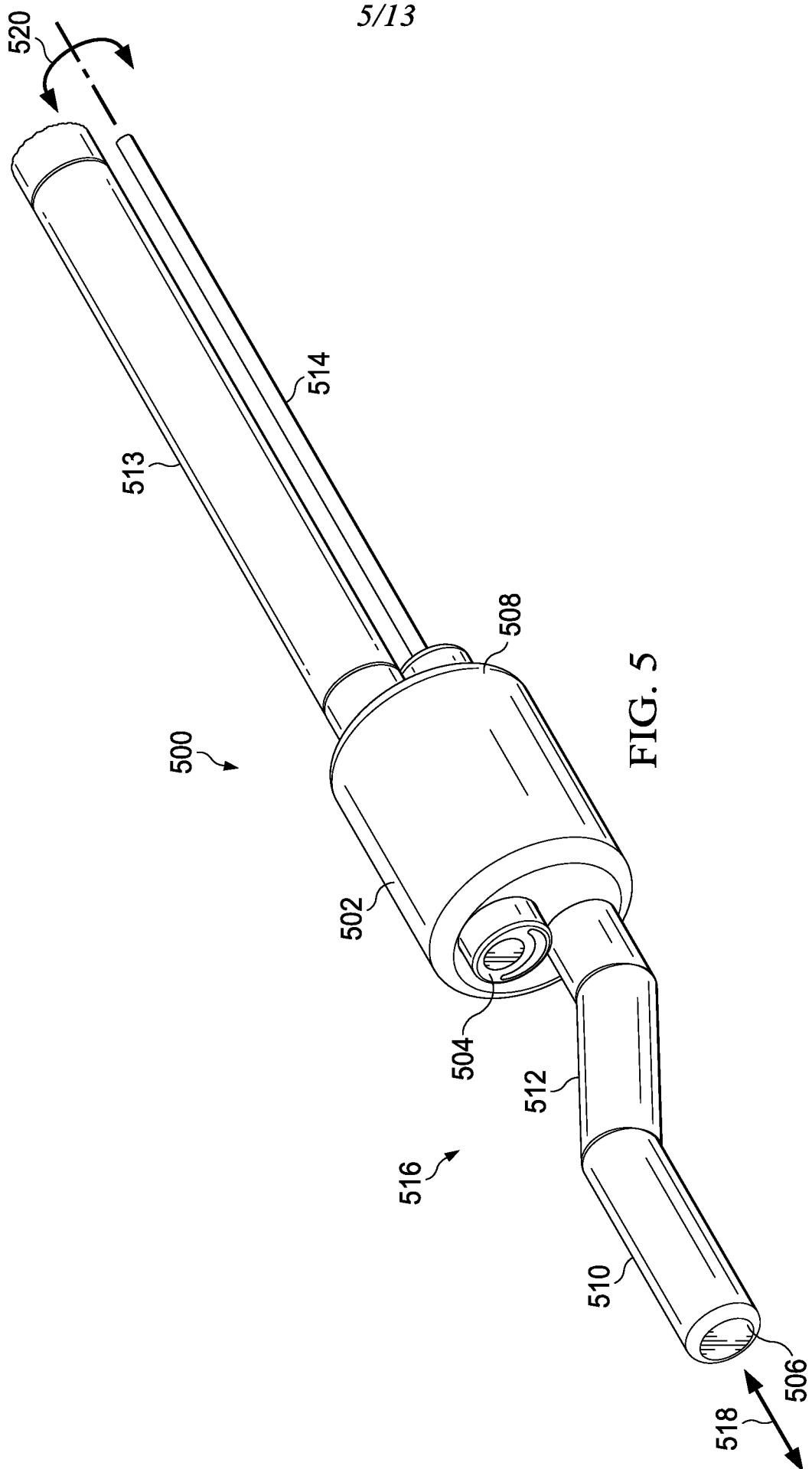
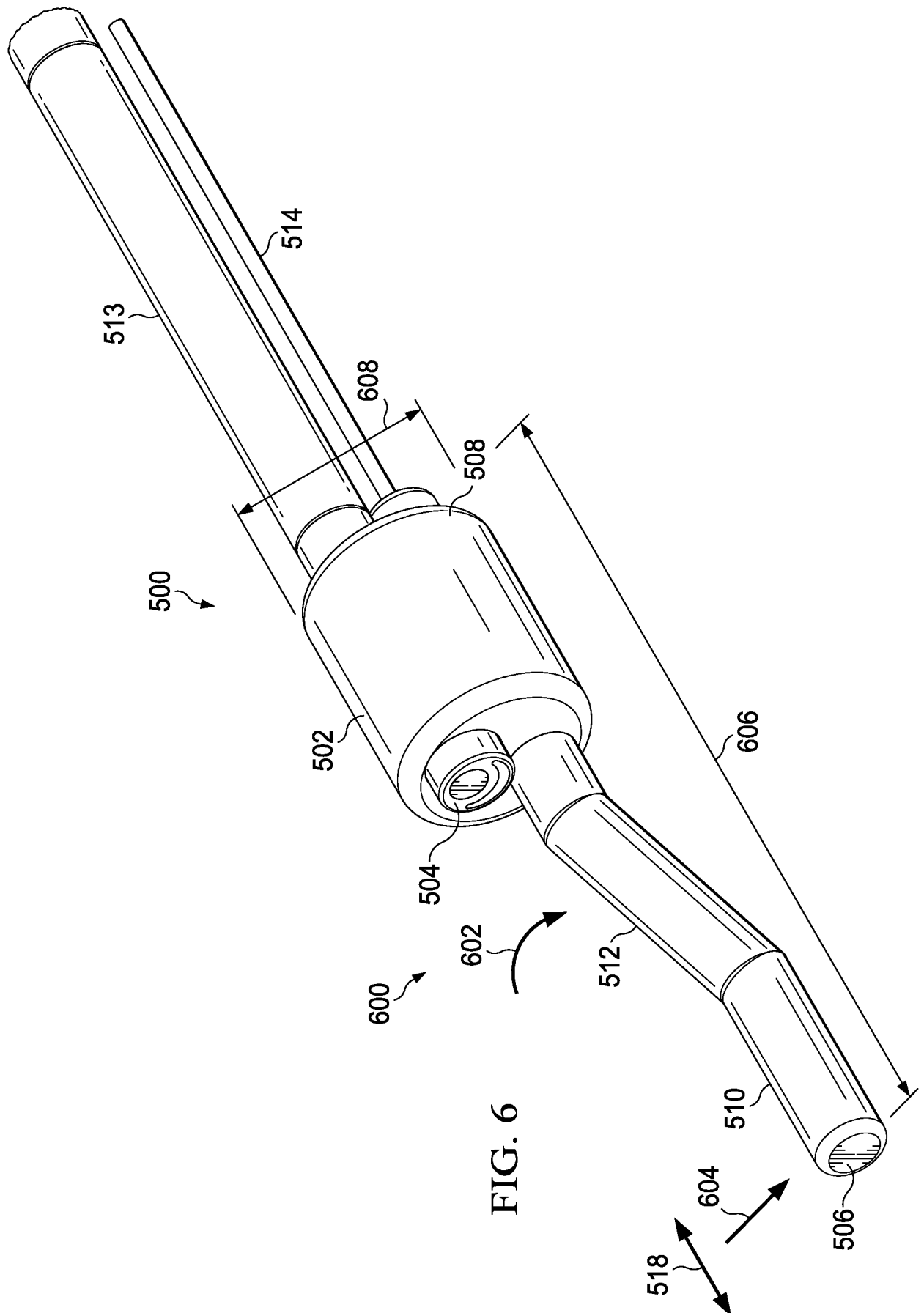


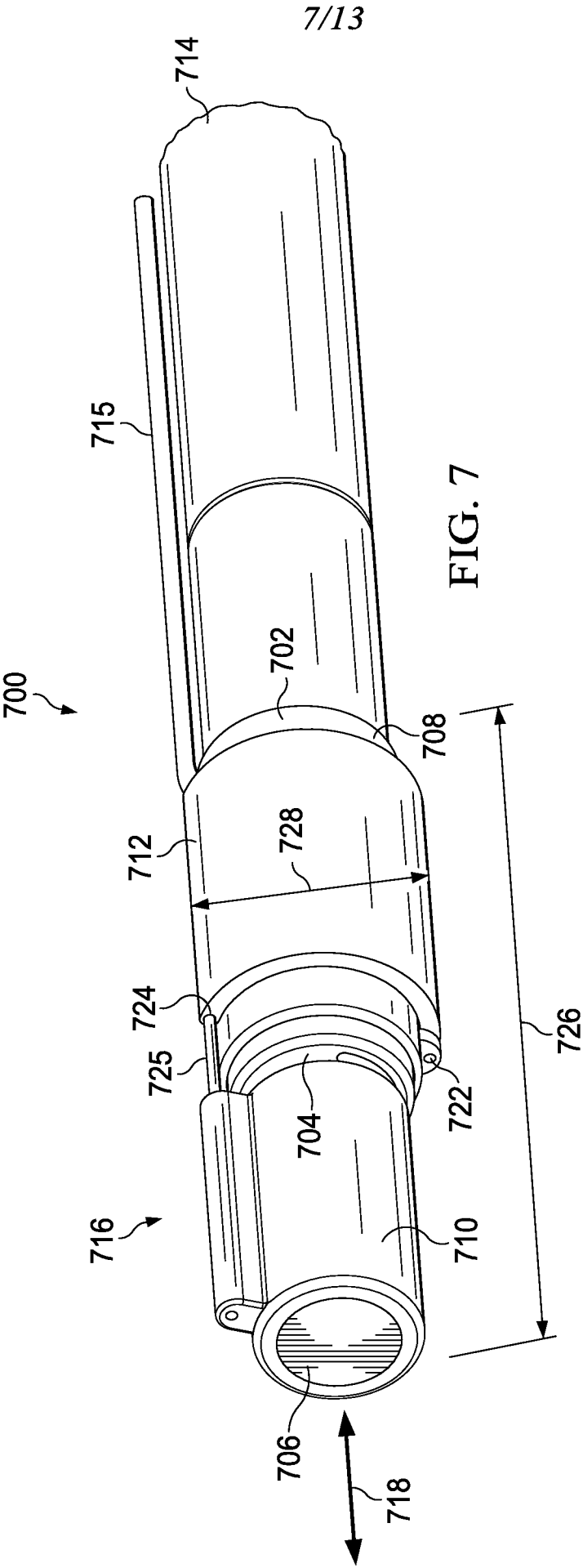
FIG. 2











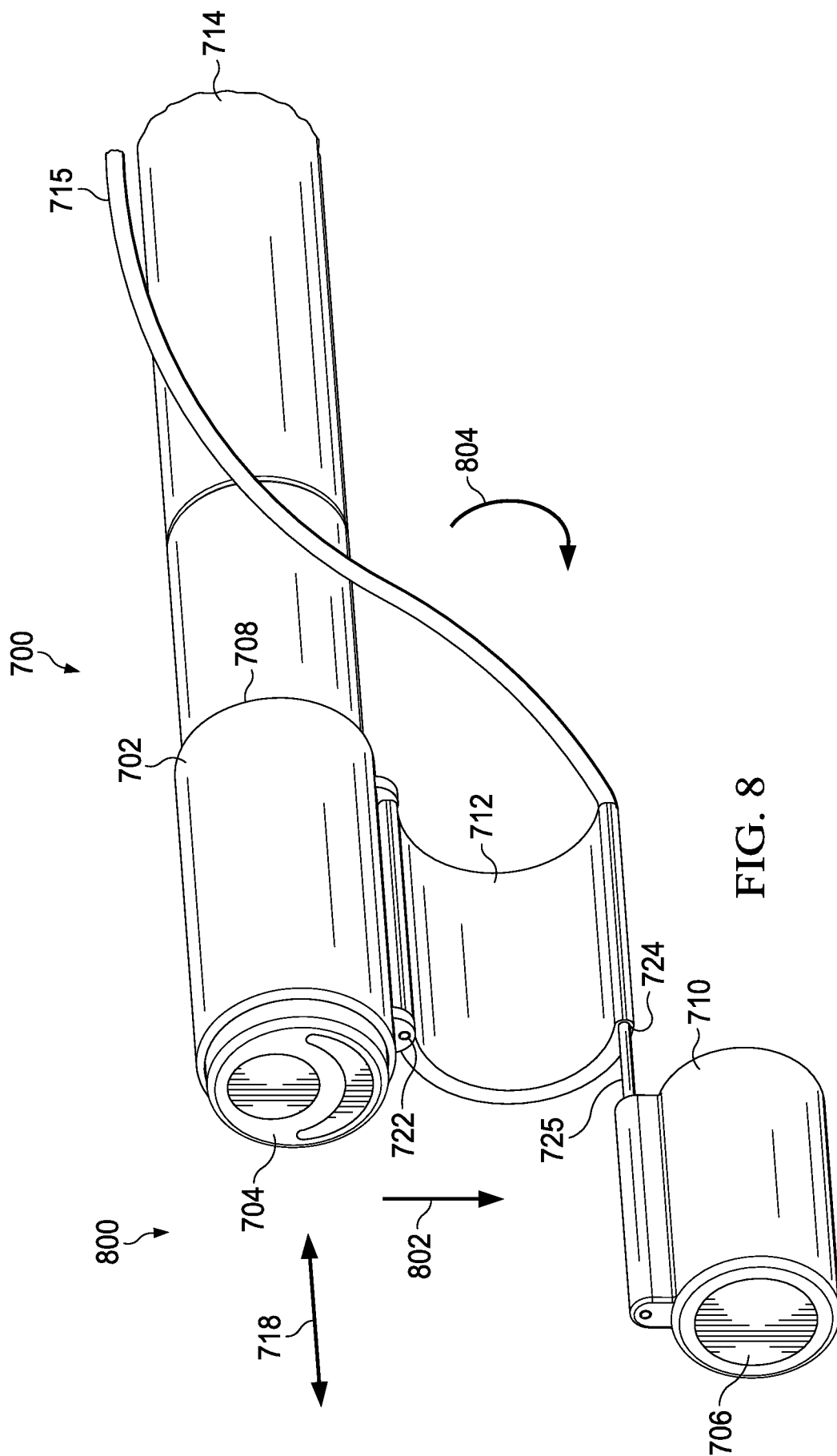
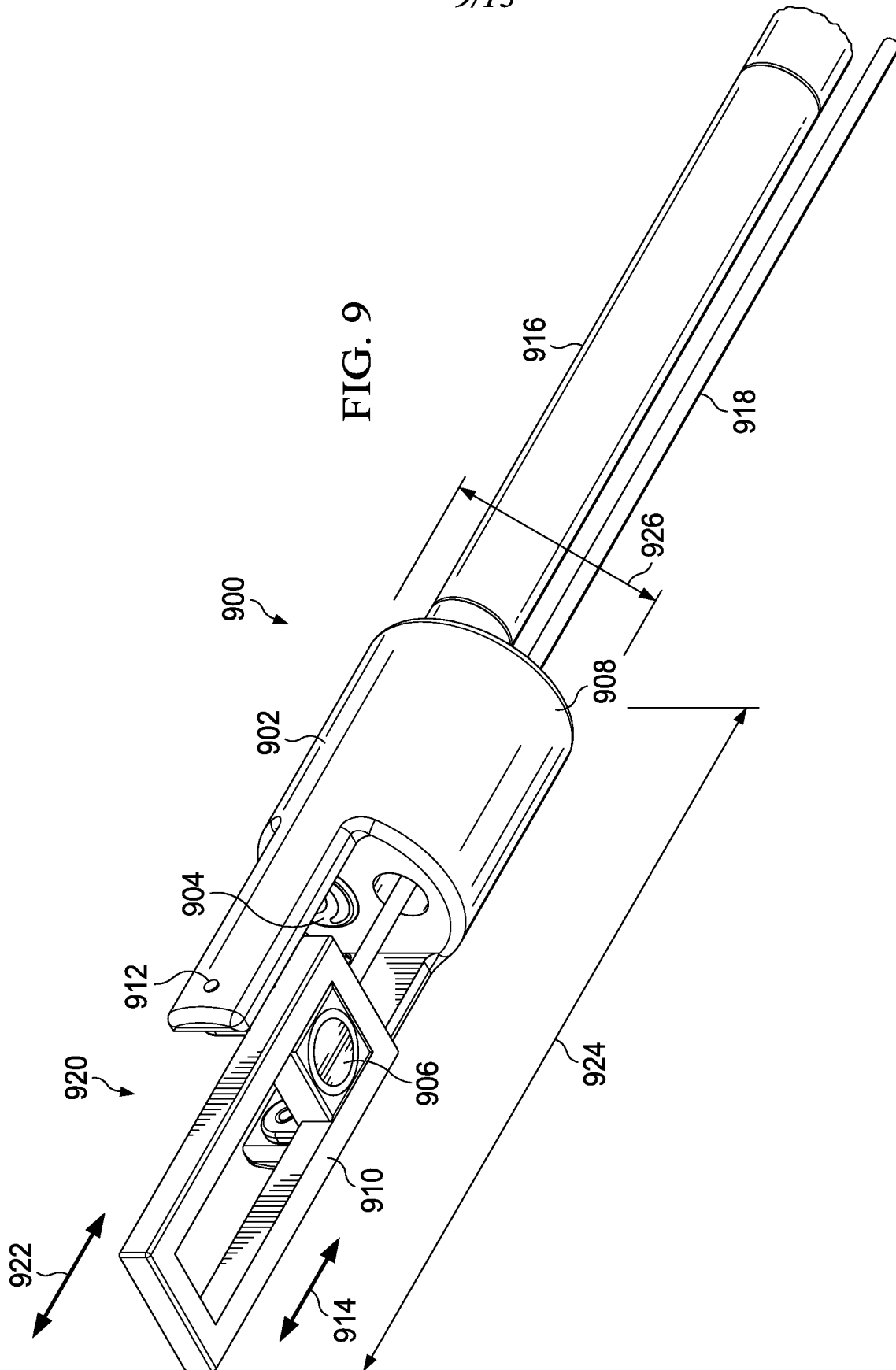
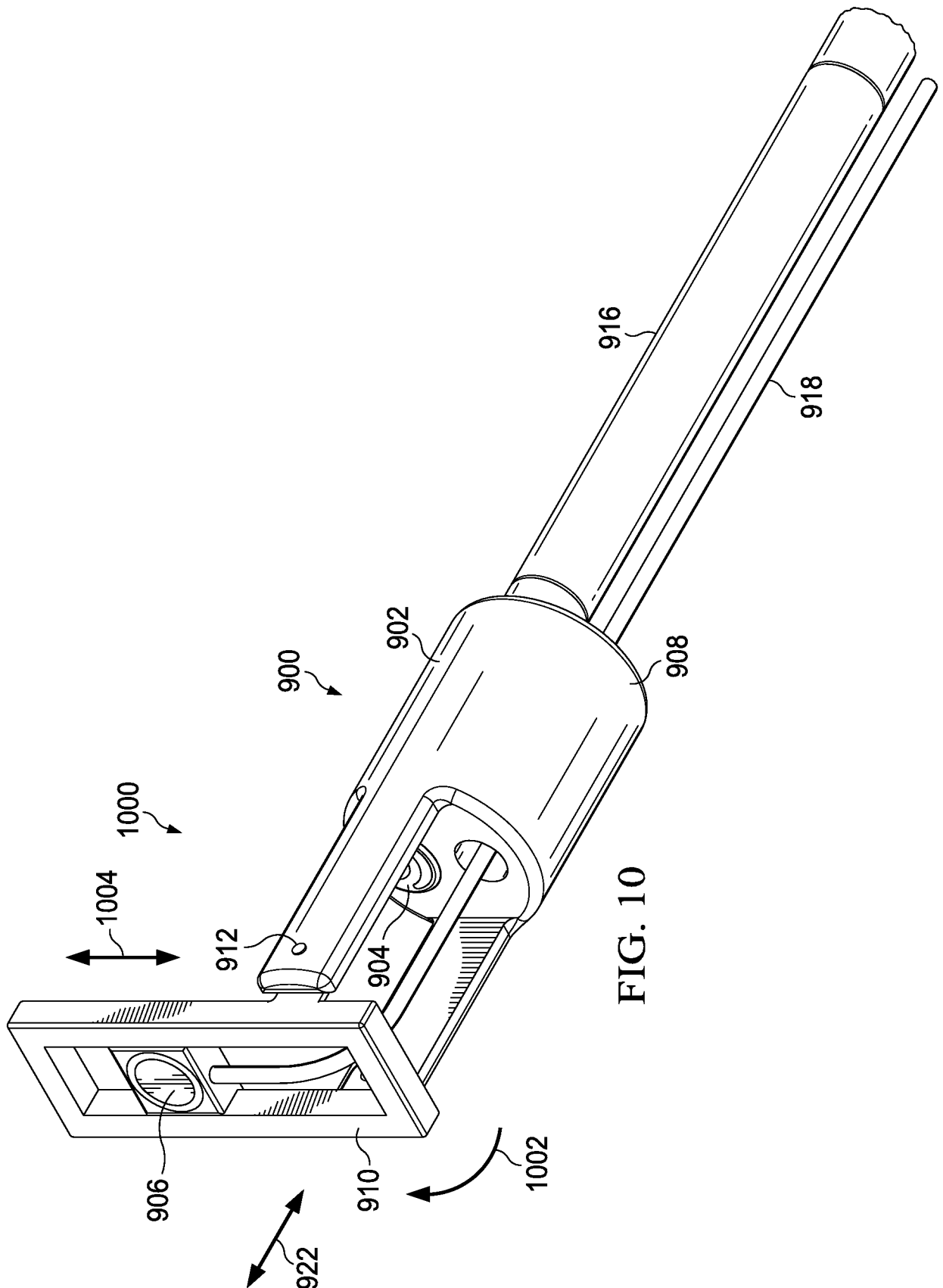


FIG. 8

9/13





11/13

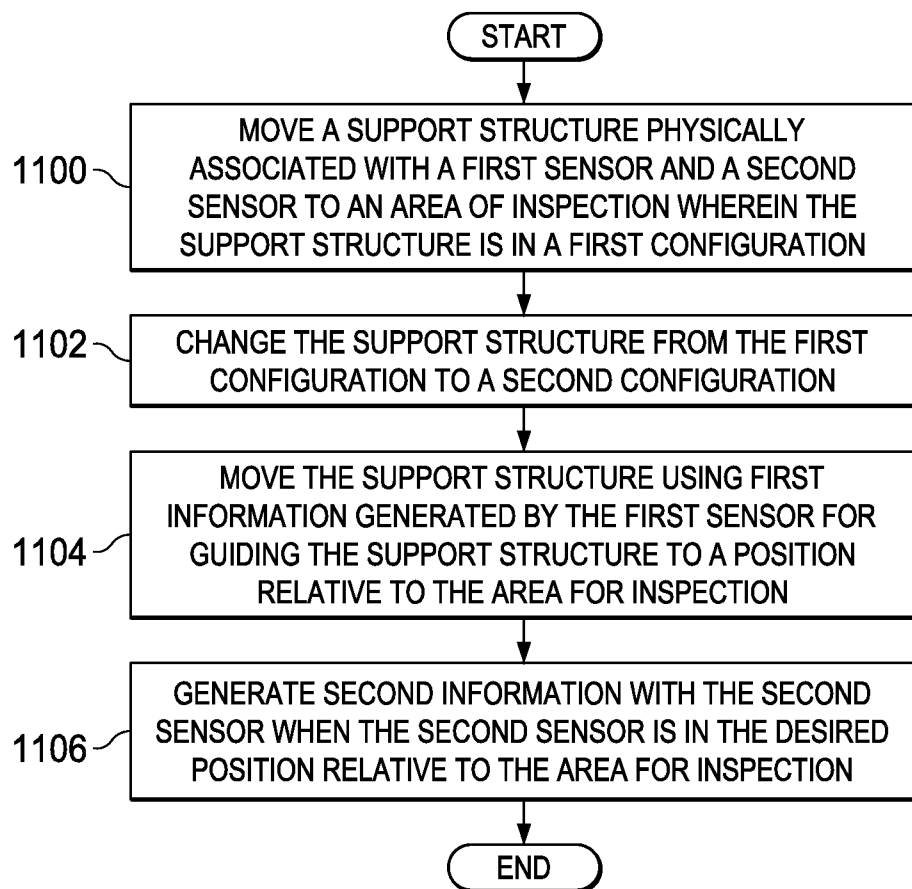
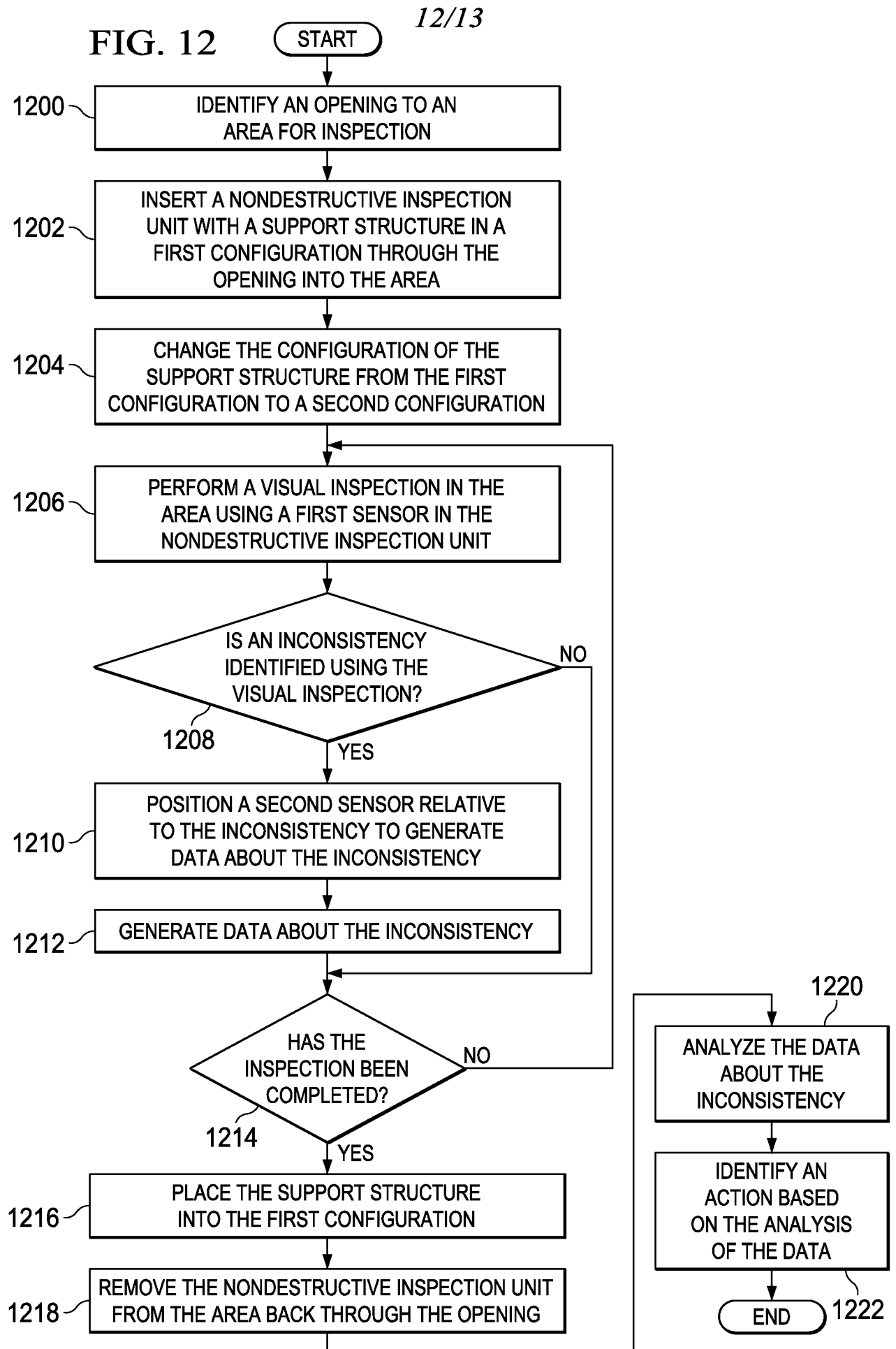
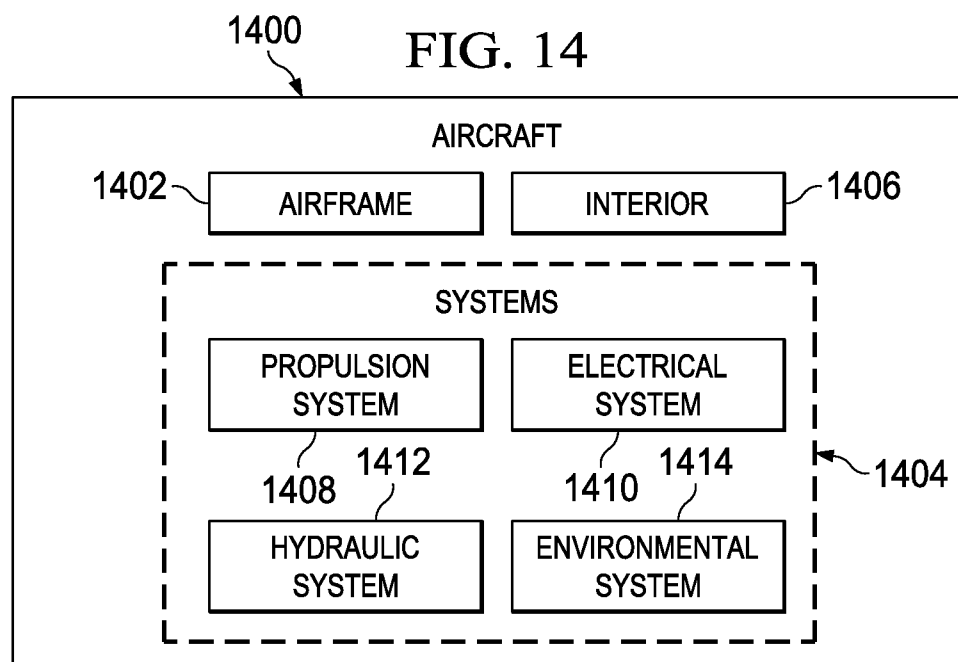
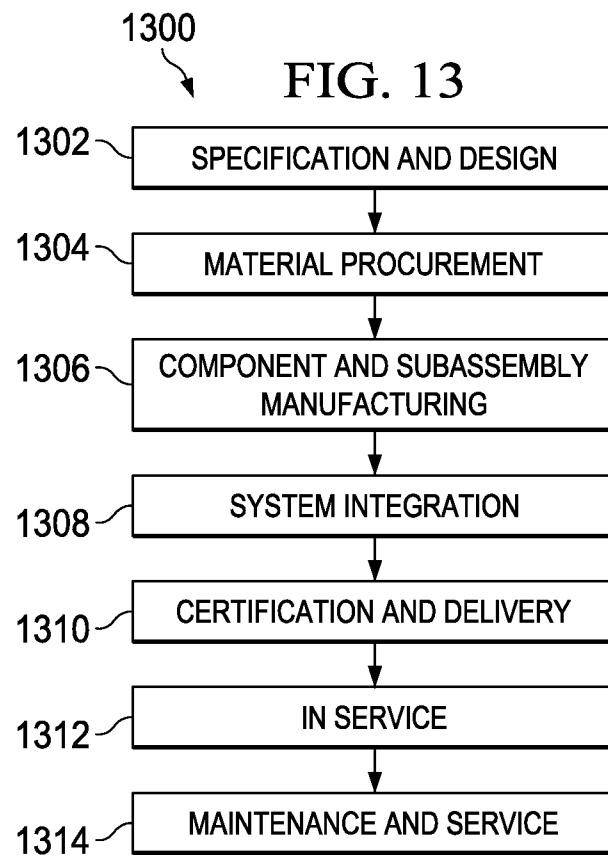


FIG. 11



13/13



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/031571

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N27/90 G01N29/22 G01N29/265 G01N21/88
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 139 822 A (URICH ROBERT H ET AL) 13 February 1979 (1979-02-13) the whole document -----	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

24 July 2014

Date of mailing of the international search report

04/08/2014

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European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Roetsch, Patrice

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2014/031571

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4139822	A	13-02-1979	NONE
