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(54) **MICRO ROBOTIC IMAGING DEVICE FOR LAPAROSCOPIC SURGERY**

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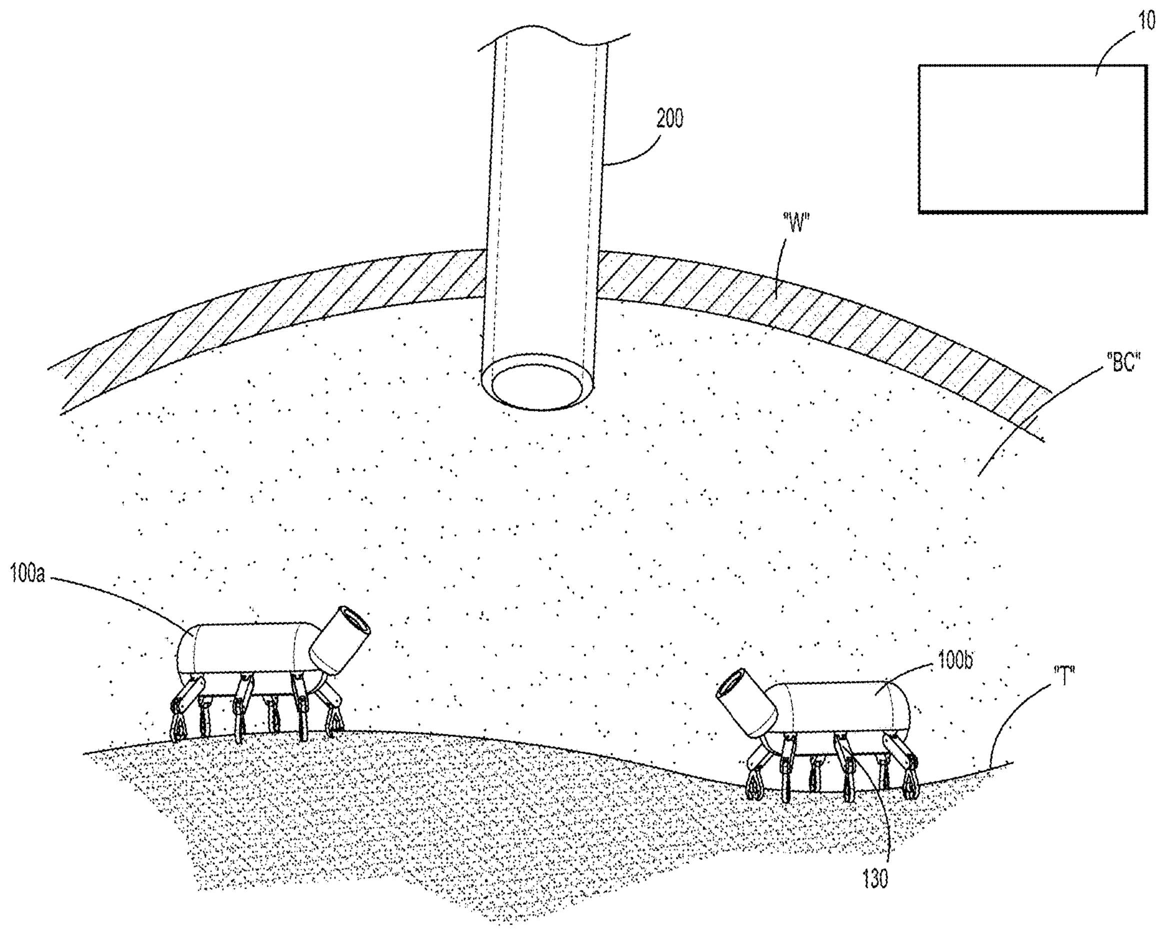
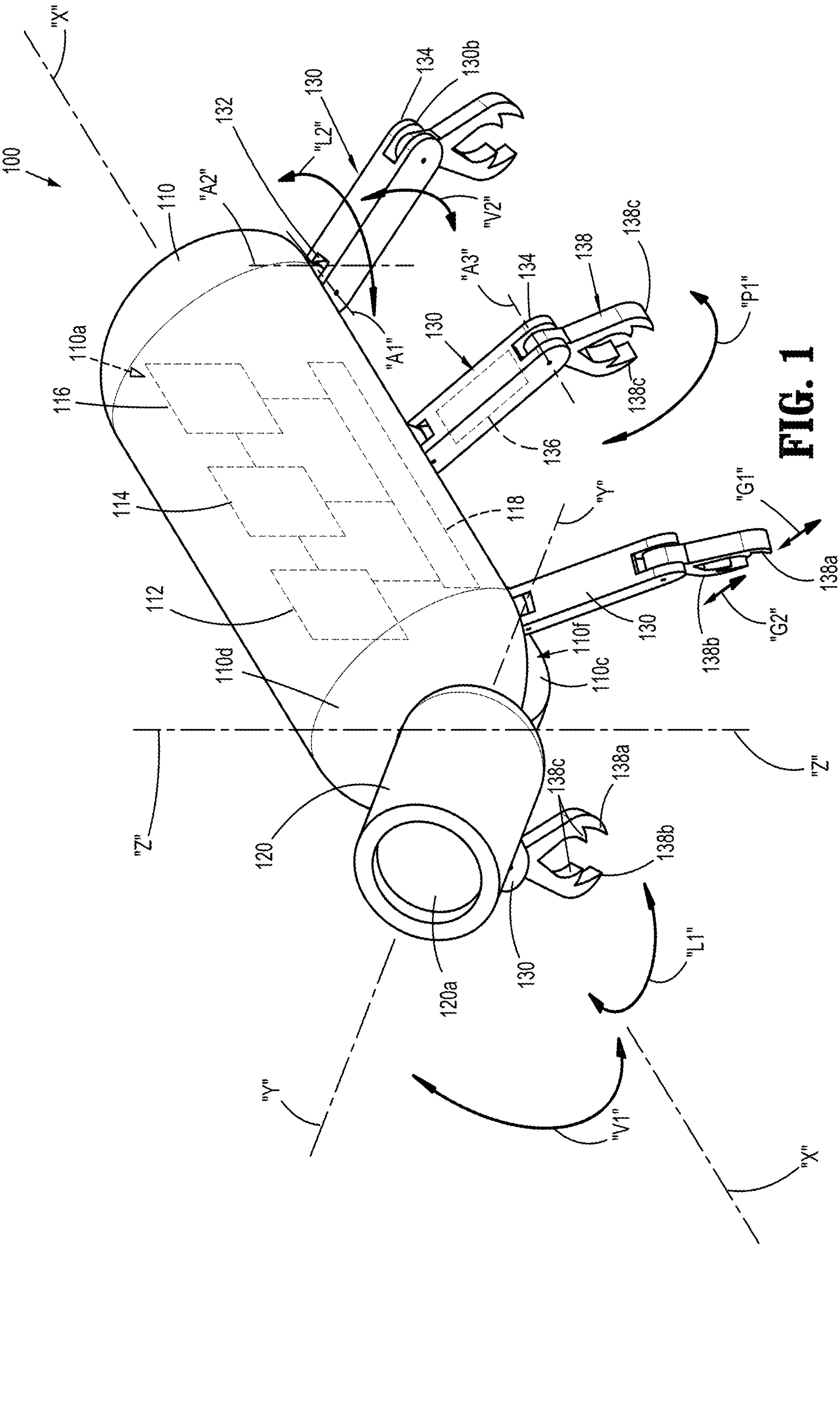
CPC ***A61B 1/00156*** (2013.01); ***A61B 1/045*** (2013.01); ***A61B 1/00016*** (2013.01); ***A61B 1/041*** (2013.01)

(57) **ABSTRACT**

A micro robotic imaging device includes a housing, a camera coupled to the housing, and legs coupled to the housing. The legs are movable relative to one another to move the camera within a patient's body for capturing imagery of the patient's body.

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110
110a
110c
110d
110f
112
114
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118
120
120a
130
130b
132
134
136
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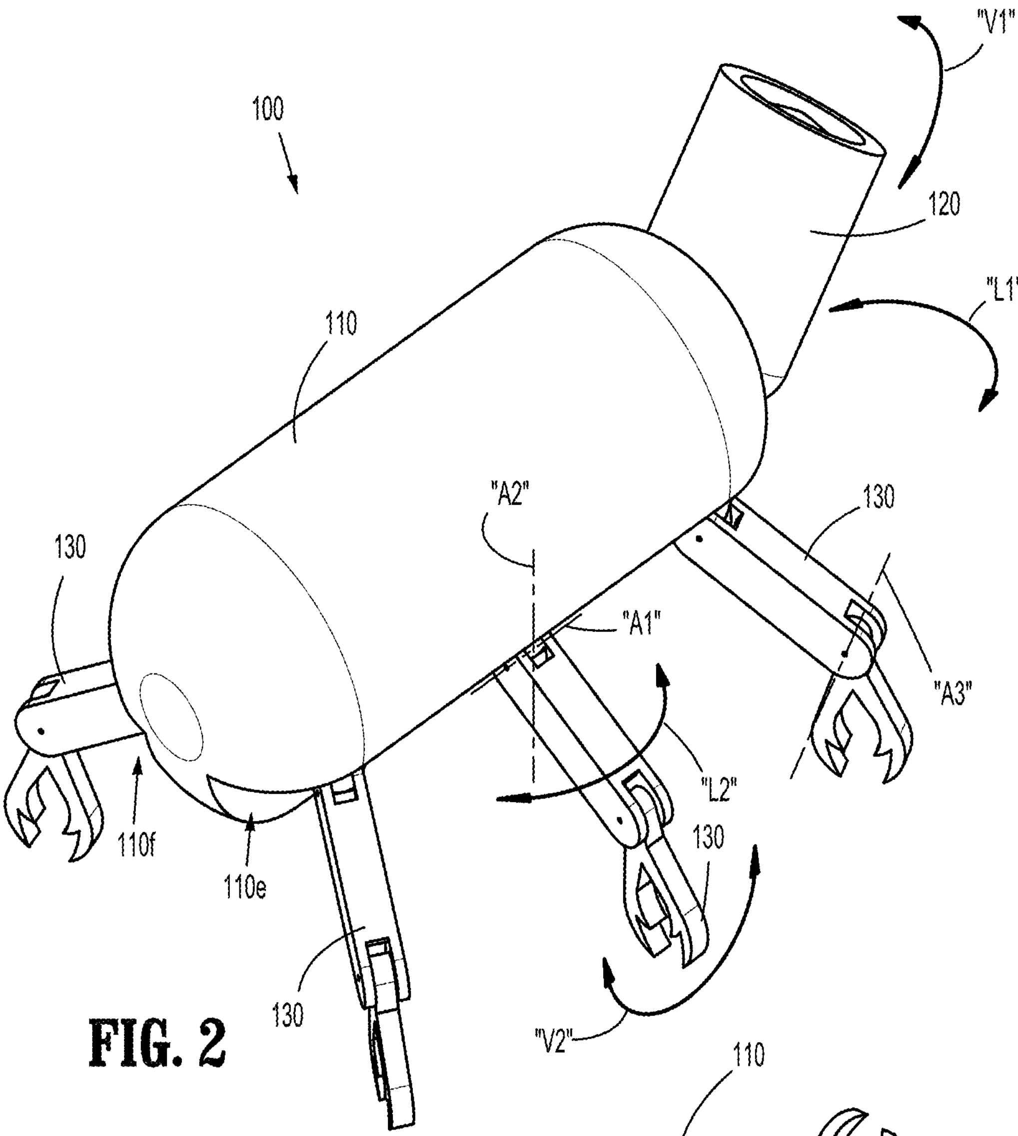
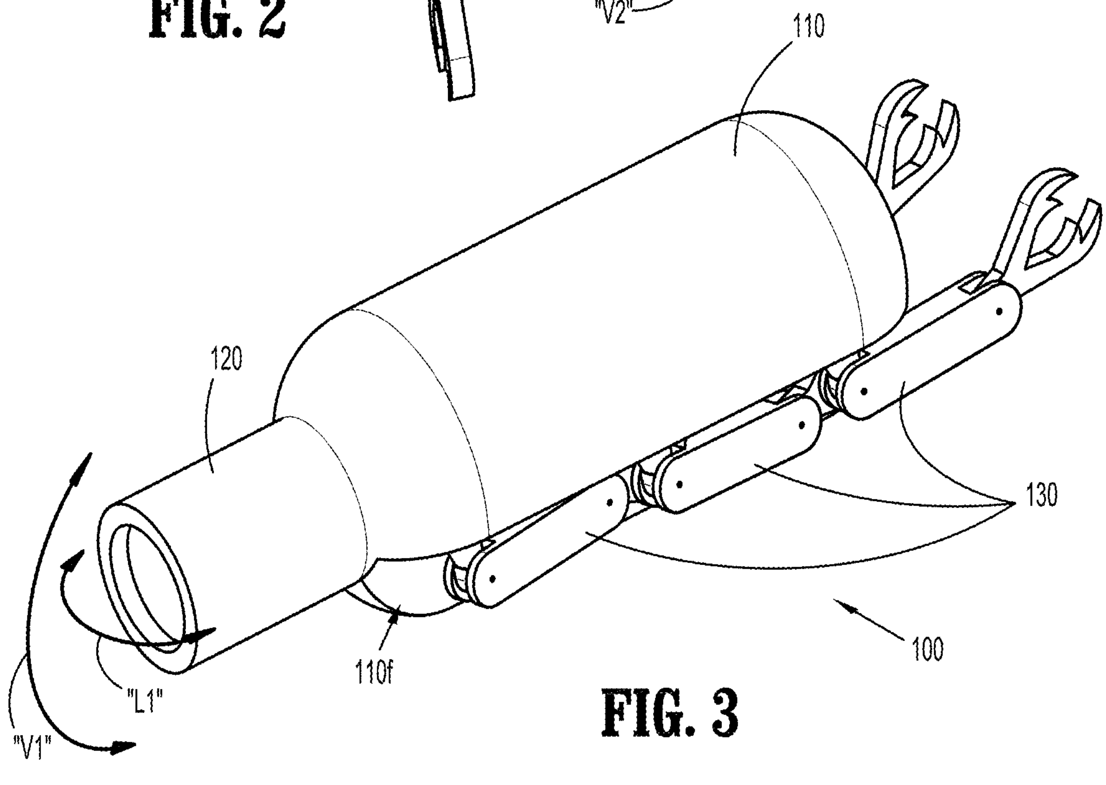
138b
138c
"X"
"Y"
"Z"
"A1"
"A2"
"A3"
"L1"
"L2"
"V1"
"V2"
"P1"
"G1"
"G2"

FIG. 1



"V1"
100
120
"L1"
110
"A2"
130
130
"A1"
"A3"
"L2"
110f
110e
130
130
"V2"

FIG. 2



110
120
130
100
110f
"L1"
"V1"

FIG. 3

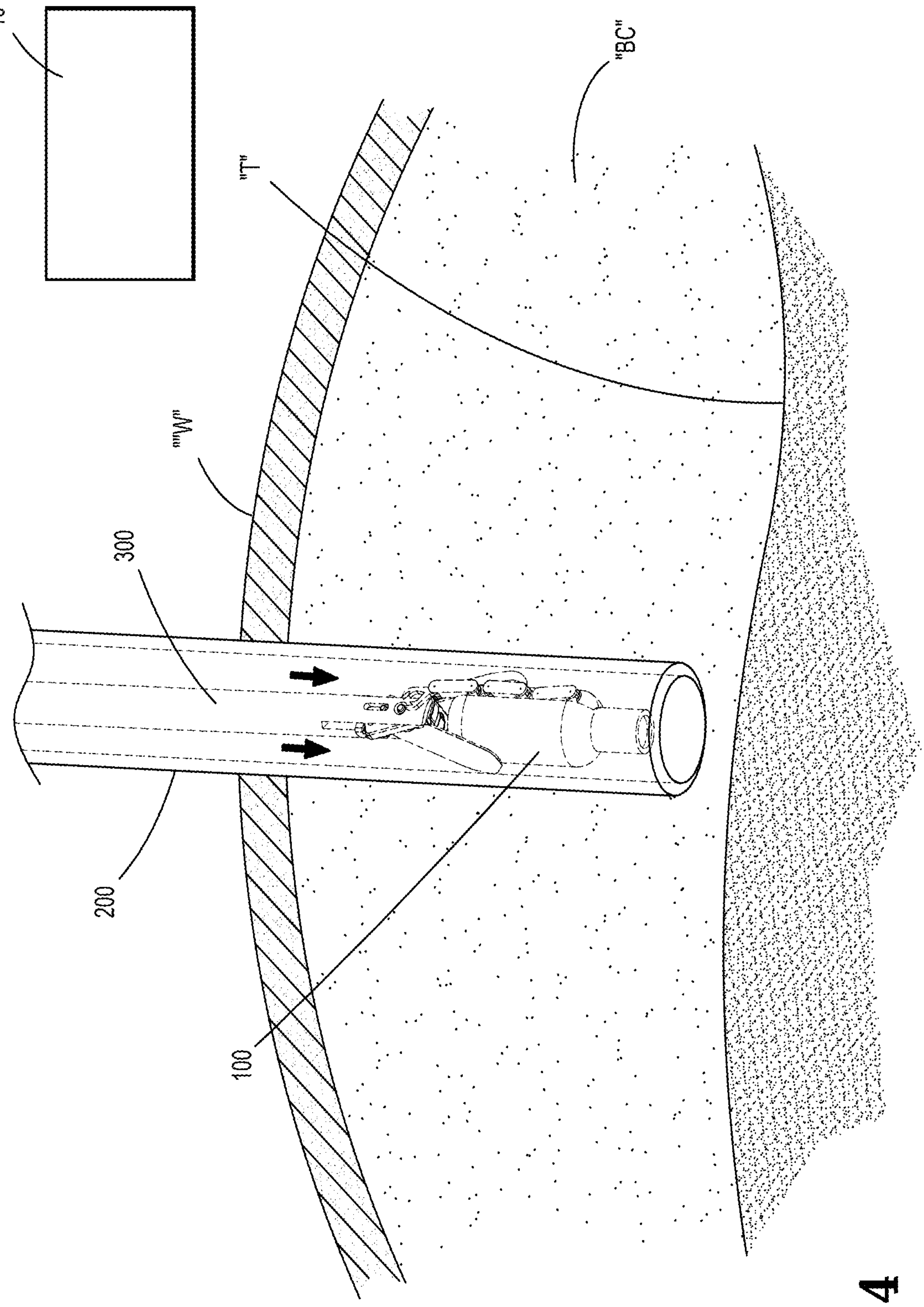


FIG. 4

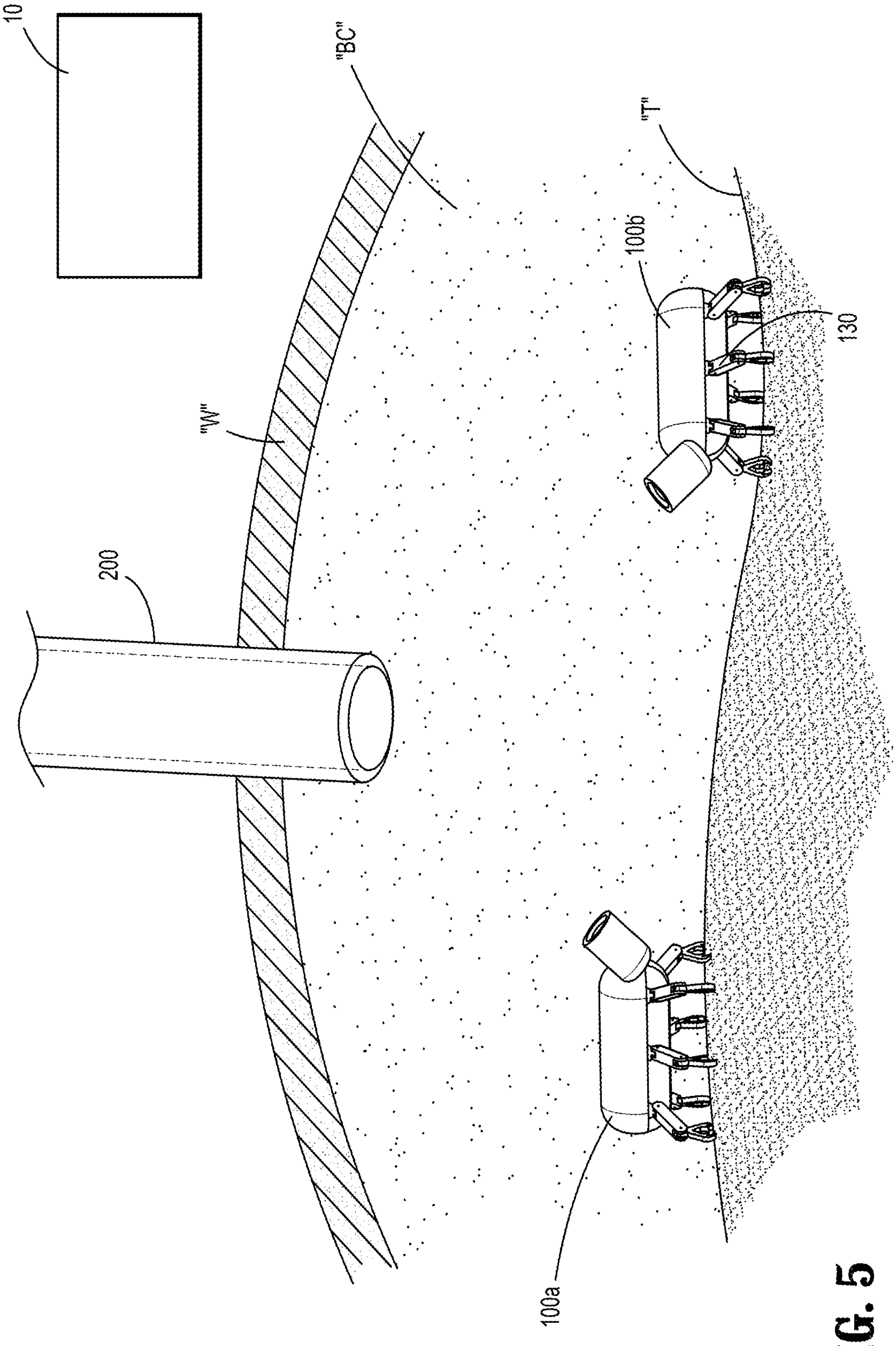


FIG. 5

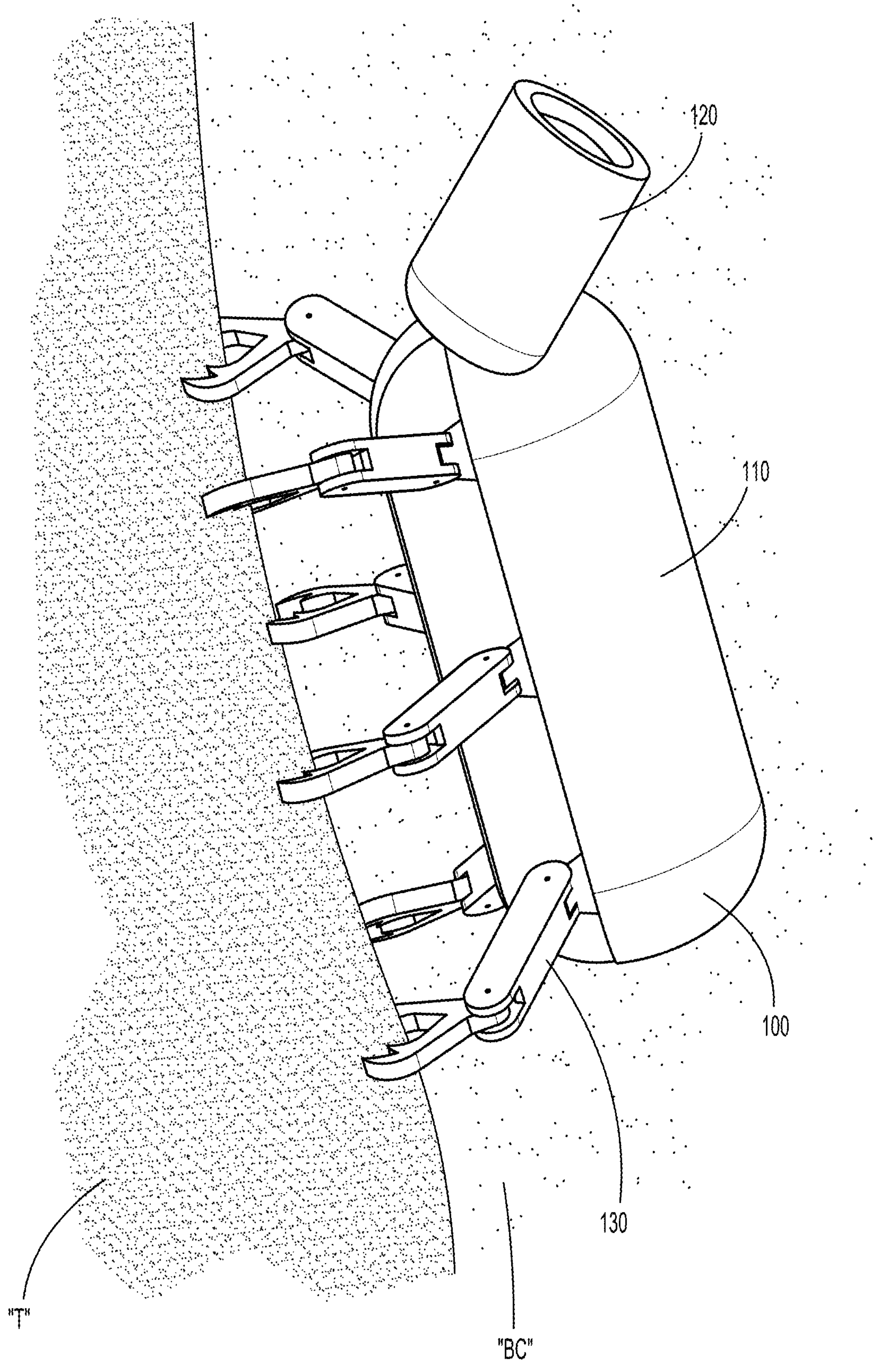


FIG. 6

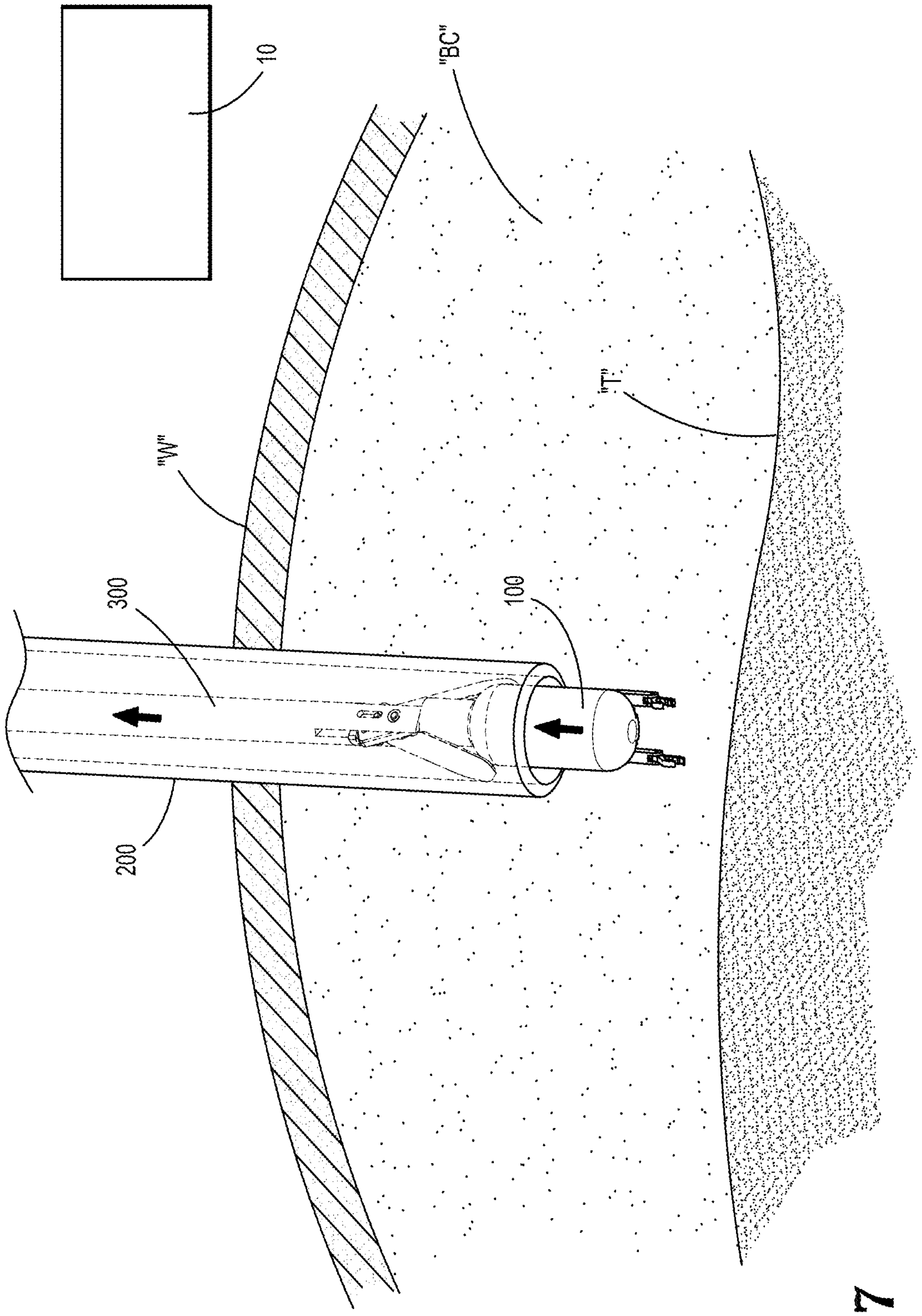


FIG. 7

MICRO ROBOTIC IMAGING DEVICE FOR LAPAROSCOPIC SURGERY

CROSS REFERENCE TO RELATED APPLICATION

[0001] The present application claims the benefit of and priority to U.S. Provisional Application Ser. No. 62/690,611, filed on Jun. 27, 2018 the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to laparoscopic surgery and, more particularly, to robotic imaging for effectuating laparoscopic surgery.

BACKGROUND

[0003] Laparoscopic surgery is a minimally invasive surgical technique performed in the abdomen through multiple small incisions. One of the surgical tools used in laparoscopic surgery is an imaging device such as a laparoscope. A laparoscope conventionally includes a camera that produces a video image of the target area, such as tissue within the body cavity of a patient, for display on a video monitor. The laparoscope can be inserted through a transcutaneous trocar in a small incision to provide visualization while performing surgery in the abdominal cavity. Typically, either a robotic arm or an assistant are dedicated to positioning the laparoscope so that surgeon can see the target area within the body cavity of the patient. Cameras for these imaging devices are often 2D or 3D, but provide a very shallow depth of field, requiring frequent re-positioning of these cameras to obtain all the necessary images of the target area.

SUMMARY

[0004] Accordingly, a continuing need exits to provide imaging devices that provide a broad depth of field and limit positioning challenges occasioned by the robotic arm or the assistant for obtaining such imaging.

[0005] According to one aspect, the present disclosure is directed to a micro robotic imaging device. The micro robotic imaging device includes a housing, a camera coupled to the housing, and legs coupled to the housing. The legs are movable relative to one another to move the camera within a patient's body for capturing imagery of the patient's body.

[0006] In some embodiments, the legs, the camera, or combinations thereof may be in wireless communication with a remote console. The remote console may be configured to operate the legs, the camera, or combinations thereof.

[0007] In certain embodiments, the camera may be movable relative to the housing.

[0008] In embodiments, the legs may be movable relative to the housing between a retracted position and an extended position. When the legs are disposed in the retracted position, the micro robotic imaging device may be configured to pass through a surgical cannula for selectively positioning the micro robotic imaging device within the patient's body. When the legs are disposed in the extended position, the legs may be movable relative to the housing to enable the micro robotic imaging device to crawl.

[0009] In some embodiments, a first leg of the legs may include a foot configured to grasp tissue. The foot may be movable relative to the first leg. The foot may include a first arm and a second arm.

[0010] According to another aspect, the present disclosure is directed to a micro robotic imaging system for capturing imagery of a patient's body cavity. The micro robotic imaging system includes a remote console and a micro robotic imaging device in communication with the remote console. The micro robotic imaging device includes a housing, a camera coupled to the housing, and legs movably coupled to the housing to enable the micro robotic imaging device to crawl through the patient's body cavity.

[0011] In certain embodiments, the remote console and the micro robotic imaging device may be wirelessly coupled. The remote console may be actuatable to operate the micro robotic imaging device.

[0012] The micro robotic imaging system may further include a surgical cannula, wherein the micro robotic imaging device may be configured to pass through the surgical cannula. The legs may be movable between a retracted position and an extended position such that in the retracted position, the micro robotic imaging device can pass through the surgical cannula, and in the extended position, the micro robotic imaging device cannot pass through the surgical cannula.

[0013] The micro robotic imaging system may further include a grasper configured to pass the micro robotic imaging device through the surgical cannula and selectively position the micro robotic imaging device within the patient's body cavity.

[0014] In accordance with yet another aspect of the present disclosure, a method of in vivo imaging of a patient's body with a micro robotic imaging system is provided. The method includes advancing a micro robotic imaging device into the patient's body, remotely controlling the micro robotic imaging device so that the micro robotic imaging device crawls through the patient's body, and capturing imagery of the patient's body with the micro robotic imaging device.

[0015] The method may include moving legs of the micro robotic imaging device so that the micro robotic imaging device crawls along tissue within the patient's body.

[0016] The method may include moving a camera of the micro robotic imaging device to capture the imagery of the patient's body.

[0017] The method may include moving the legs of the micro robotic imaging device to enable the micro robotic imaging device to fit through a surgical cannula for selective passage into or out of the patient's body. The surgical cannula may have a diameter through which the micro robotic imaging device passes. The diameter may be about 5 mm to about 15 mm.

[0018] Other aspects, features, and advantages will be apparent from the description, the drawings, and the claims that follow.

BRIEF DESCRIPTION OF DRAWINGS

[0019] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the disclosure and, together with a general description of the disclosure given above and the detailed description given below, serve to explain the principles of the disclosure, wherein:

[0020] FIG. **1** is a front, perspective view of a micro robotic imaging device in an extended position in accordance with the present disclosure;

[0021] FIG. **2** is a rear, perspective view of the micro robotic imaging device of FIG. **1**;

[0022] FIG. **3** is a side, perspective view of the micro robotic imaging device of FIGS. **1** and **2** in a retracted position; and

[0023] FIGS. **4-7** are progressive views illustrating the micro robotic imaging device of FIGS. **1-3** being utilized in a laparoscopic surgical procedure.

DETAILED DESCRIPTION

[0024] Embodiments of the presently disclosed micro robotic imaging devices are described in detail with reference to the drawings, in which like reference numerals designate identical or corresponding elements in each of the several views. As commonly known, the term "clinician" refers to a doctor, a nurse, or any other care provider and may include support personnel. Additionally, the term "proximal" refers to the portion of structure that is closer to the clinician and the term "distal" refers to the portion of structure that is farther from the clinician. In addition, directional terms such as front, rear, upper, lower, top, bottom, and the like are used simply for convenience of description and are not intended to limit the disclosure attached hereto.

[0025] In the following description, well-known functions or constructions are not described in detail to avoid obscuring the present disclosure in unnecessary detail.

[0026] The presently disclosed micro robotic imaging devices are configured to work with robotic surgical systems. Such systems employ various robotic elements to assist the clinician and allow remote operation (or partial remote operation) of surgical instrumentation such as the presently disclosed micro robotic imaging devices, which can be in the form of a micro robotic wireless camera. The robotic surgical systems may be employed with one or more consoles **10** (FIG. **4**) that are next to the operating theater or located in a remote location, for communicating with, or operating, such surgical instrumentation wirelessly, for example. As can be appreciated, console **10** may include any number of mechanical and electrical components such as computers, controllers, displays, memory, data, software, etc. so that a highly skilled clinician may perform multiple operations in multiple locations without leaving his/her remote console which can be both economically advantageous and a benefit to the patient or a series of patients.

[0027] For a detailed description of exemplary medical work stations and/or components thereof, reference may be made to U.S. Patent Application Publication No. 2012/0116416, and PCT Application Publication No. WO2016/025132, the entire contents of each of which are incorporated by reference herein.

[0028] Turning now to FIGS. **1-3**, a micro robotic imaging device of the present disclosure is generally referred to as **100**. Micro robotic imaging device or MRID **100** includes a housing **110**, a camera **120** supported on housing **110**, and a plurality of legs **130** pivotally coupled to housing **110**. Housing **110** defines a cavity **110*a*** therein that supports any number of motors **112**, circuitry **114** (e.g., CPU, sensors, chips, transmitters, receivers, memory, wiring, speakers, microphones, etc.), power supplies **116** (e.g., batteries), and/or mechanical drives **118** (e.g., gears, cables, pulleys, bearings, screws, nuts, etc.) that cooperate to effectuate operation of camera **120** and/or legs **130**. Housing **110** further defines a longitudinal axis "X" therethrough and axes "Y" and "Z" on a distal end portion **110*d*** of housing **110**, where axes "X," "Y," and "Z" are disposed in perpendicular relation to one another so as to define a three dimensional Cartesian coordinate system. Housing **110** further includes a keel **110*c*** that extends along a bottom surface of housing **110** and defines storage channels **110*e*, 110*f*** (FIG. **2**) along opposite sides of keel **110*c***.

[0029] As indicated by vertical arrows "V1" and lateral arrows "L1," camera **120** of MRID **100** may be supported on housing **110** and polyaxially movable about longitudinal axis "X," and relative to axes "Y" and "Z" of housing **110**, to obtain imaging of a target site captured by camera **120**. Camera **120** can be configured to communicate with console **10** (e.g., by wired or wireless communication such as Bluetooth, Wi-Fi, etc.), for instance, to transmit data thereto, or receive data therefrom. Camera **120** is configured to communicate with circuitry **114**, such as one or more memory devices thereof (e.g., RAM, ROM, etc.), for example, to store data of imagery and/or audio (e.g., pictures, video, sound, etc.) thereon. Camera **120** includes one or more lens' **120*a*** that receive imagery and cooperate with circuitry **114** of housing **110** to store and/or transmit data of imagery.

[0030] Each leg **130** of MRID **100** has a first end **130*a*** that supports a housing joint **132** and a second end **130*b*** that supports a foot joint **134**. Housing joint **132** defines axes "A1" and "A2" and couples leg **130** to housing **110** such that leg **130** can polyaxially pivot about axes "A1" and "A2" and relative to housing **110** (e.g., laterally and/or vertically), as indicated by lateral arrows "L2" and vertical arrows "V2." Leg **130** supports a foot driver **136** that is operably coupled to motors **112**, circuitry **114**, power supplies **116** and/or mechanical drives **118** supported in housing **110**. Foot driver **136** is also operatively coupled to a foot **138** coupled to foot joint **134** of leg **130** that defines pivot axis "A3" for foot **138**. Foot driver **136** is actuatable to pivot foot **138** about pivot axis "A3" of foot joint **134**, as indicated by arrows "P1." Foot driver **136** can include one or more suitable mechanical components (e.g., gears, pulleys, cables, screws, etc.) and/or electrical components (e.g., motors, circuitry, etc.) to manipulate foot **138**.

[0031] Foot **138** of leg **130** includes a first arm **138*a*** and a second arm **138*b***, each of which include teeth **138*c*** that are configured to facilitate tissue gripping. As illustrated by arrows "G1" and "G2," foot driver **136** can be configured to actuate foot **138** such that first and/or second arms **138*a*, 138*b*** thereof pivot about pivot axis "A3" relative to one another between open and closed positions to selectively grasp tissue between first and second arms **138*a*, 138*b***. In the open position of foot **138**, first and second arms **138*a*, 138*b*** of foot **138** are spaced apart or unapproximated from one another, and in the closed position (not shown) of foot **138**, first and second arms **138*a*, 138*b*** thereof are approximated or in close proximity to one another (and may be in contact with one another).

[0032] As seen in FIGS. **2** and **3**, legs **130** of MRID **100** are movable between an extended position (FIG. **2**) and a retracted position (FIG. **3**). In the extended position (FIG. **2**), legs **130**, or portions thereof, are selectively movable, together and/or independent of one another, to enable MRID **100** to crawl and/or climb (ascend and/or descend) along a surface such as tissue "T" (see FIGS. **4** and **5**). In the retracted position (FIG. **3**), MRID **100** is positioned to be inserted into a body cavity "BC," and/or removed therefrom, through a cannula **200**, such as trocar (e.g., 5 mm-15 mm), by a surgical instrument **300**, such as a grasper. For a more detailed description an example trocar, reference can be made to U.S. Pat. No. 6,482,181 to Racenet et al., and for a more detailed description of an example grasper, reference can be made to U.S. Patent Application Publication No. 2017/0224367 to Kapadia, the entire contents of each of which are incorporated by reference herein.

[0033] With reference to FIGS. **1-6**, with cannula **200** inserted through, for example, an abdominal wall "W," and MRID **100** disposed in the retracted position thereof, grasper **300** can grasp MRID **100** and advance MRID **100** through cannula **200** and into body cavity "BC." Any number of MRID's **100**, such as MRID **100***a* and MRID **100***b*, may be advanced through cannula **200** and positioned into body cavity "BC" where each MRID **100** can be remotely positioned into the extended position thereof to enable crawling movement of MRID **110**. When in the extended position, each MRID **100** wirelessly communicates with console **10** (or with other MRIDs **100** and/or other surgical instruments like grasper **300**) so that each MRID may crawl to any suitable location within body cavity "BC" (e.g., adjacent to cannula **200** or spaced far from cannula **200**). In particular, MRID **100** can be tele-manipulated so that legs **130** of MRID **100** crawl along tissue "T" to achieve a desired position or be moved to change or achieve a different position. Such process or repositioning can be repeated as desired. Camera **120** of MRID **100** can also be positioned or repositioned as desired to obtain desired imagery or sound for effectuating a procedure (e.g., surgical, therapeutic, and/or diagnostic). When the procedure is completed, MRID **100** can be moved back toward cannula **200** so that grasper **300** can grab MRID **100** and remove MRID **100** through cannula **200** with MRID **100** positioned win the retracted position thereof.

[0034] In some embodiments, one or more the presently disclosed feet may include a single arm having hooks or barbs similar to insect feet for grasping tissue like a grappling hook.

[0035] As can be appreciated, securement of any of the components of the presently disclosed apparatus can be effectuated using known securement techniques such welding, crimping, gluing, fastening, etc.

[0036] Persons skilled in the art will understand that the structures and methods specifically described herein and illustrated in the accompanying figures are non-limiting exemplary embodiments, and that the description, disclosure, and figures should be construed merely as exemplary of particular embodiments. It is to be understood, therefore, that the present disclosure is not limited to the precise embodiments described, and that various other changes and modifications may be effected by one skilled in the art without departing from the scope or spirit of the disclosure. Additionally, it is envisioned that the elements and features illustrated or described in connection with one exemplary embodiment may be combined with the elements and features of another without departing from the scope of the present disclosure, and that such modifications and variations are also intended to be included within the scope of the present disclosure. Indeed, any combination of any of the presently disclosed elements and features is within the scope of the present disclosure. Accordingly, the subject matter of the present disclosure is not to be limited by what has been particularly shown and described.

1. A micro robotic imaging device, comprising:
- a housing;
- a camera coupled to the housing; and
- legs coupled to the housing, the legs movable relative to one another to move the camera within a patient's body for capturing imagery of the patient's body.

2. The micro robotic imaging device of claim **1**, wherein the legs, the camera, or combinations thereof are in wireless communication with a remote console.

3. The micro robotic imaging device of claim **2**, wherein the remote console is configured to operate the legs, the camera, or combinations thereof.

4. The micro robotic imaging device of claim **1**, wherein the camera is movable relative to the housing.

5. The micro robotic imaging device of claim **1**, wherein the legs are movable relative to the housing between a retracted position and an extended position.

6. The micro robotic imaging device of claim **5**, wherein when the legs are disposed in the retracted position, the micro robotic imaging device is configured to pass through a surgical cannula for selectively positioning the micro robotic imaging device within the patient's body.

7. The micro robotic imaging device of claim **5**, wherein when the legs are disposed in the extended position, the legs are movable relative to the housing to enable the micro robotic imaging device to crawl.

8. The micro robotic imaging device of claim **1**, wherein a first leg of the legs includes a foot configured to grasp tissue.

9. The micro robotic imaging device of claim **8**, wherein the foot is movable relative to the first leg.

10. The micro robotic imaging device of claim **9**, wherein the foot includes a first arm and a second arm.

11. A micro robotic imaging system for capturing imagery of a patient's body cavity, the micro robotic imaging system comprising:
- a remote console; and
- a micro robotic imaging device in communication with the remote console, the micro robotic imaging device including:
  - a housing;
  - a camera coupled to the housing; and
  - legs movably coupled to the housing to enable the micro robotic imaging device to crawl through the patient's body cavity.

12. The micro robotic imaging system of claim **11**, wherein the remote console and the micro robotic imaging device are wirelessly coupled.

13. The micro robotic imaging system of claim **12**, wherein the remote console is actuatable to operate the micro robotic imaging device.

14. The micro robotic imaging system of claim **11**, further comprising a surgical cannula, wherein the micro robotic imaging device is configured to pass through the surgical cannula.

15. The micro robotic imaging system of claim **14**, wherein the legs are movable between a retracted position and an extended position, wherein in the retracted position, the micro robotic imaging device can pass through the surgical cannula, and wherein in the extended position, the micro robotic imaging device cannot pass through the surgical cannula.

16. The micro robotic imaging system of claim **15**, further comprising a grasper configured to pass the micro robotic imaging device through the surgical cannula and selectively position the micro robotic imaging device within the patient's body cavity.

17. A method of in vivo imaging of a patient's body with a micro robotic imaging system, the method comprising:

advancing a micro robotic imaging device into the patient's body;

remotely controlling the micro robotic imaging device so that the micro robotic imaging device crawls through the patient's body; and

capturing imagery of the patient's body with the micro robotic imaging device.

18. The method of claim **17**, further comprising moving legs of the micro robotic imaging device so that the micro robotic imaging device crawls along tissue within the patient's body.

19. The method of claim **17**, further comprising moving a camera of the micro robotic imaging device to capture the imagery of the patient's body.

20. The method of claim **18**, further comprising moving the legs of the micro robotic imaging device to enable the micro robotic imaging device to fit through a surgical cannula for selective passage into or out of the patient's body, the surgical cannula having a diameter through which the micro robotic imaging device passes, the diameter being about 5 mm to about 15 mm.

* * * * *

专利名称(译)	腹腔镜手术微型机器人成像装置		
公开(公告)号	[US20200000323A1](https://)	公开(公告)日	2020-01-02
申请号	US16/404250	申请日	2019-05-06
[标]申请(专利权)人(译)	柯惠有限合伙公司		
申请(专利权)人(译)	COVIDIEN LP		
当前申请(专利权)人(译)	COVIDIEN LP		
发明人	COWLEY, MATTHEW S.		
IPC分类号	A61B1/00 A61B1/04 A61B1/045		
CPC分类号	A61B1/041 A61B1/045 A61B1/00156 A61B1/00016 A61B1/00183		
优先权	62/690611 2018-06-27 US		
外部链接	Espacenet USPTO		

摘要(译)

微型机器人成像设备包括壳体，联接至壳体的照相机以及联接至壳体的支腿。 支腿可相对移动，以使相机在患者体内移动，以捕获患者身体的图像。