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(54) **ROBOTIZED LAPAROSCOPIC SYSTEM**

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(57) **ABSTRACT**

A robotized laparoscopic system capable of executing commands of an operating surgeon is provided. The laparoscopic system includes a cylindrical tube inserted into the opening. A small-sized camera is attached to one end of the tube to capture the images of the surgical site. A bending portion is adapted to bend the tip of the tube in any direction. A driving unit controls a bending direction and a bending angle of the bending portion. A movement device moves the tube forward or backward in a longitudinal direction. A control unit independently controls the driving unit and the movement device. An input unit receives commands from the surgeon. A conversion unit converts the command input from the surgeon into digital signals and transmits the digital signals to the control unit. A support unit supports weight of the movement device by being connected to an operating or the floor.

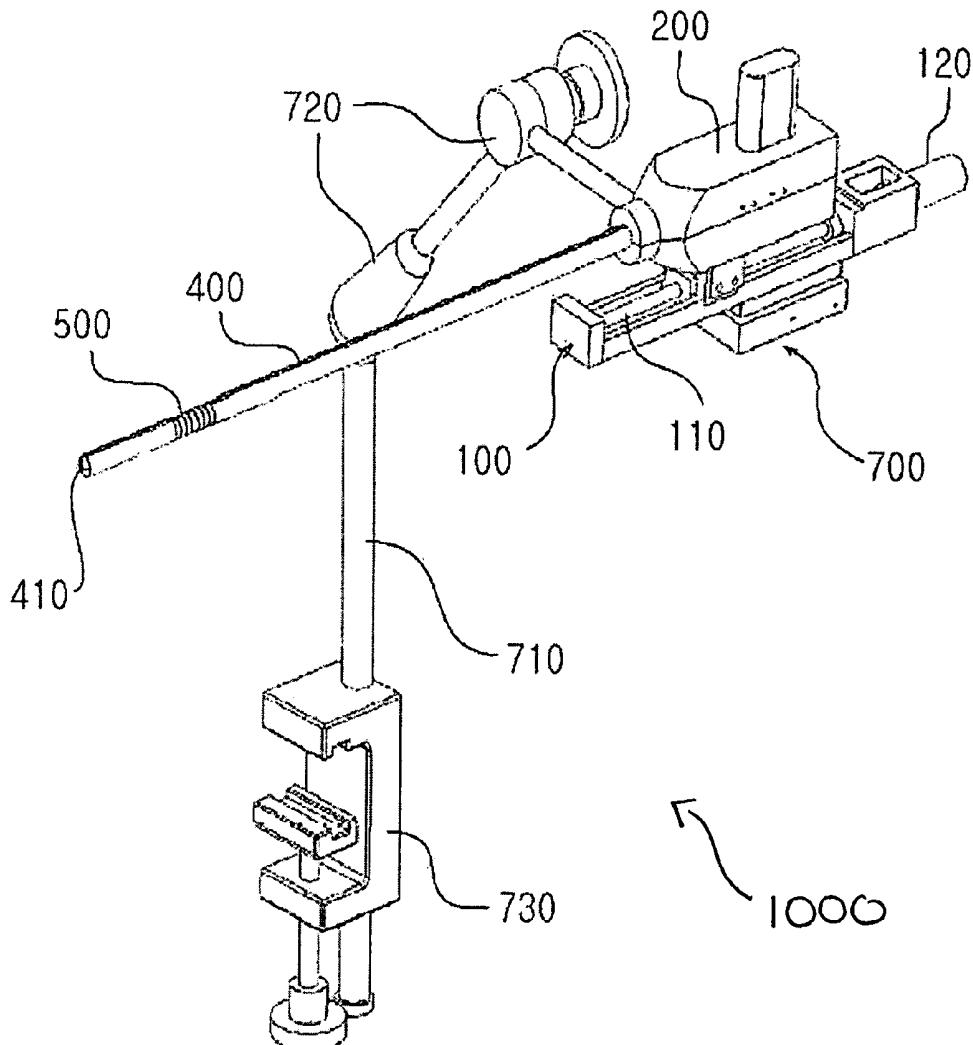


FIG. 1

Prior Art

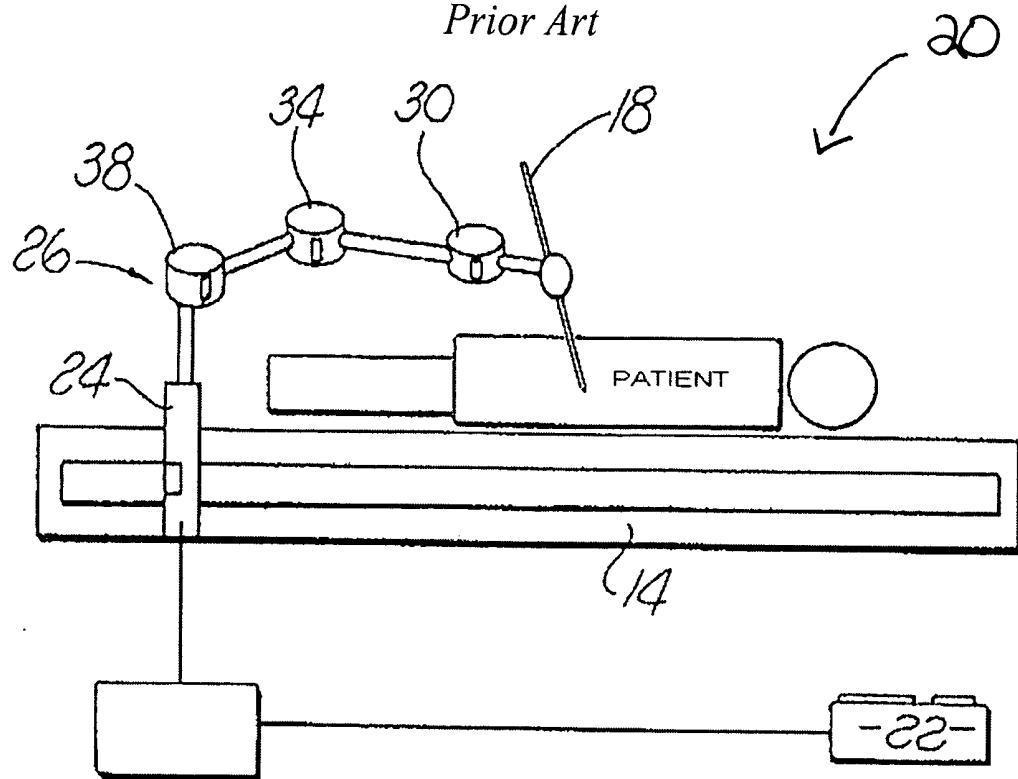


FIG. 2

Prior Art

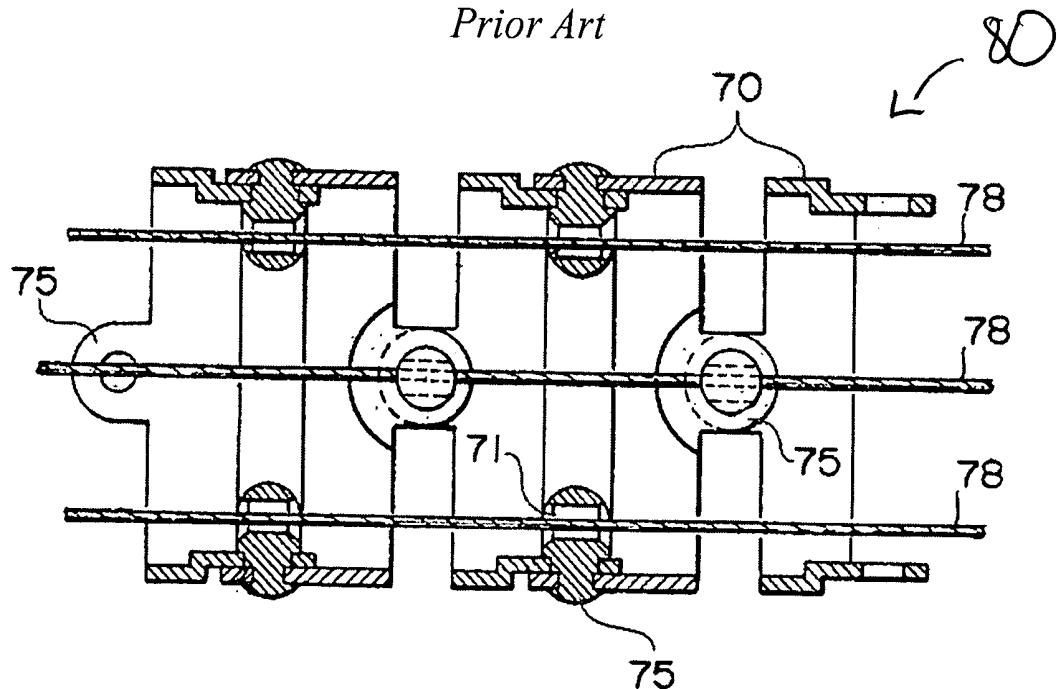


FIG. 3

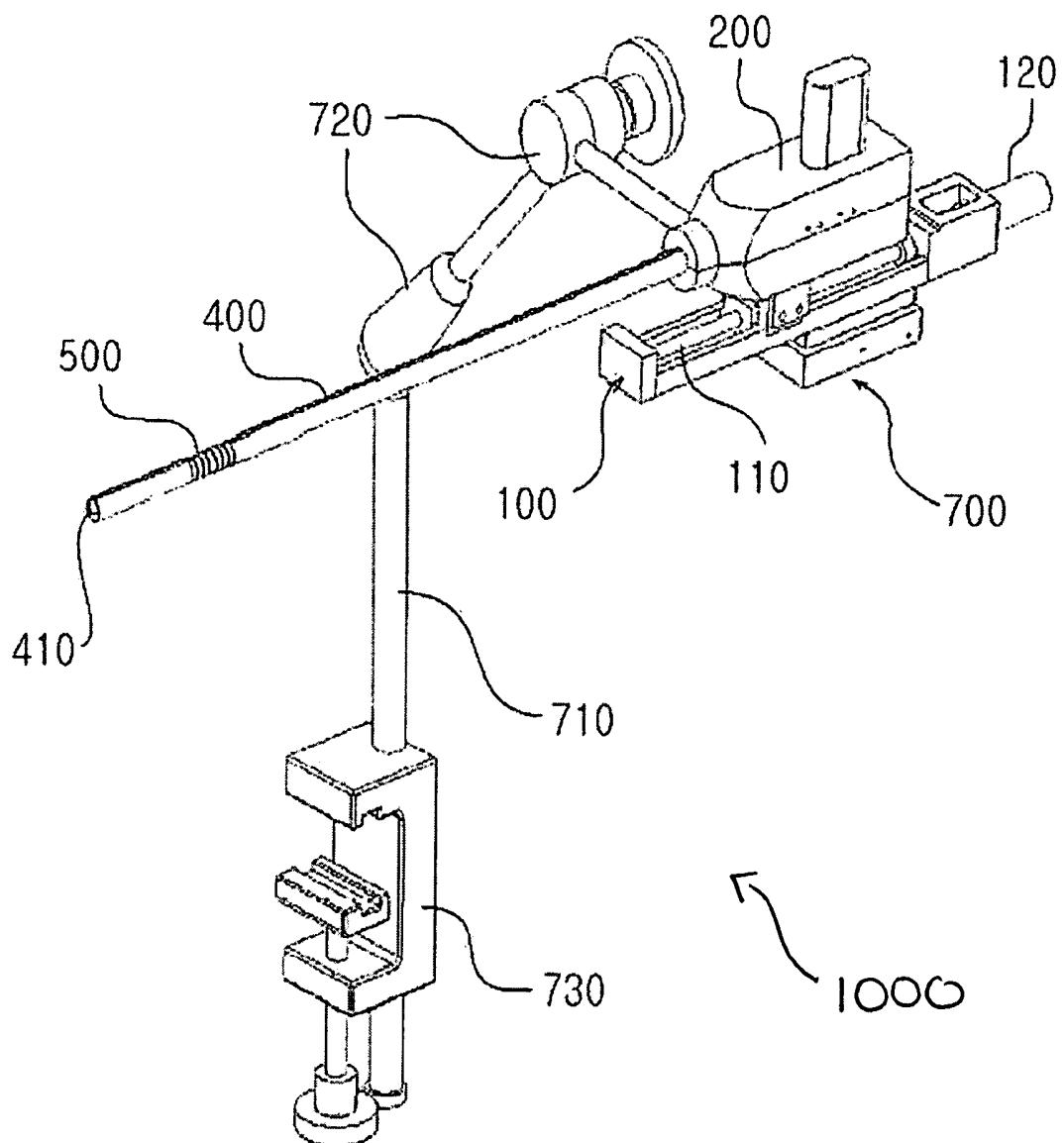


FIG. 4

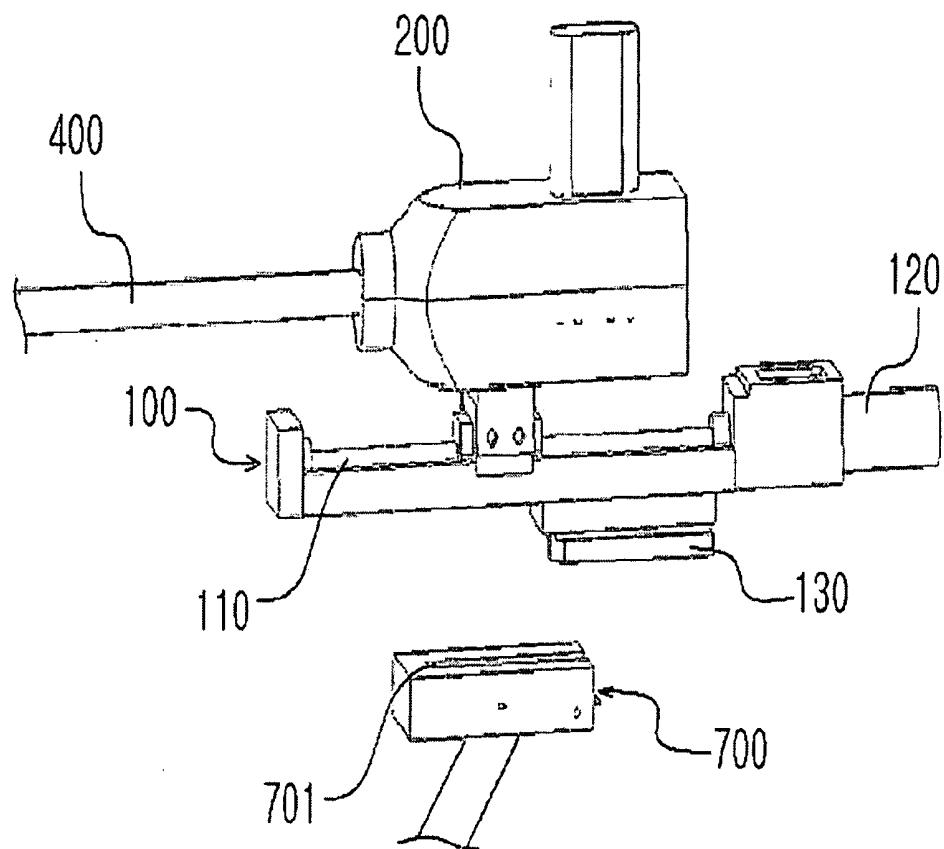


FIG. 5

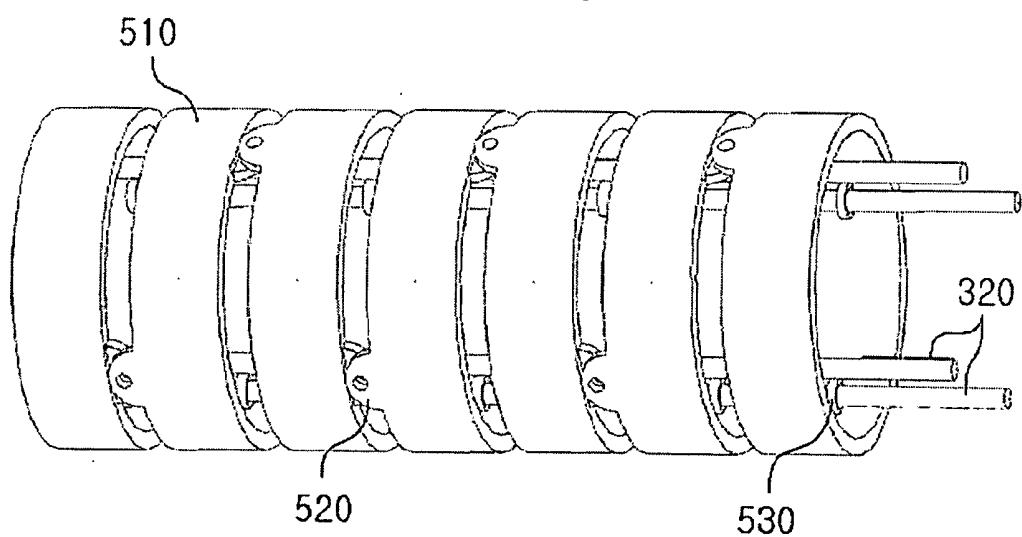


FIG. 6

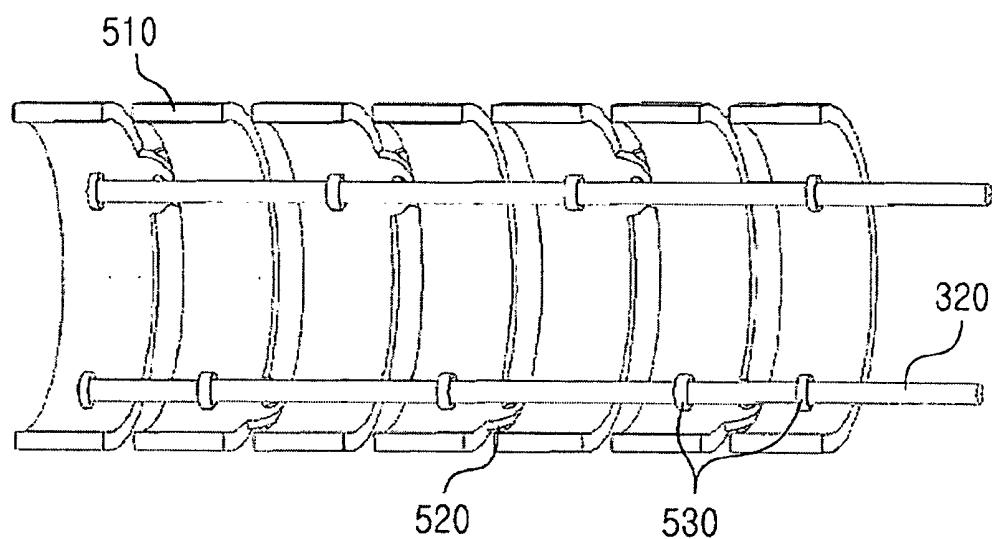


FIG. 7

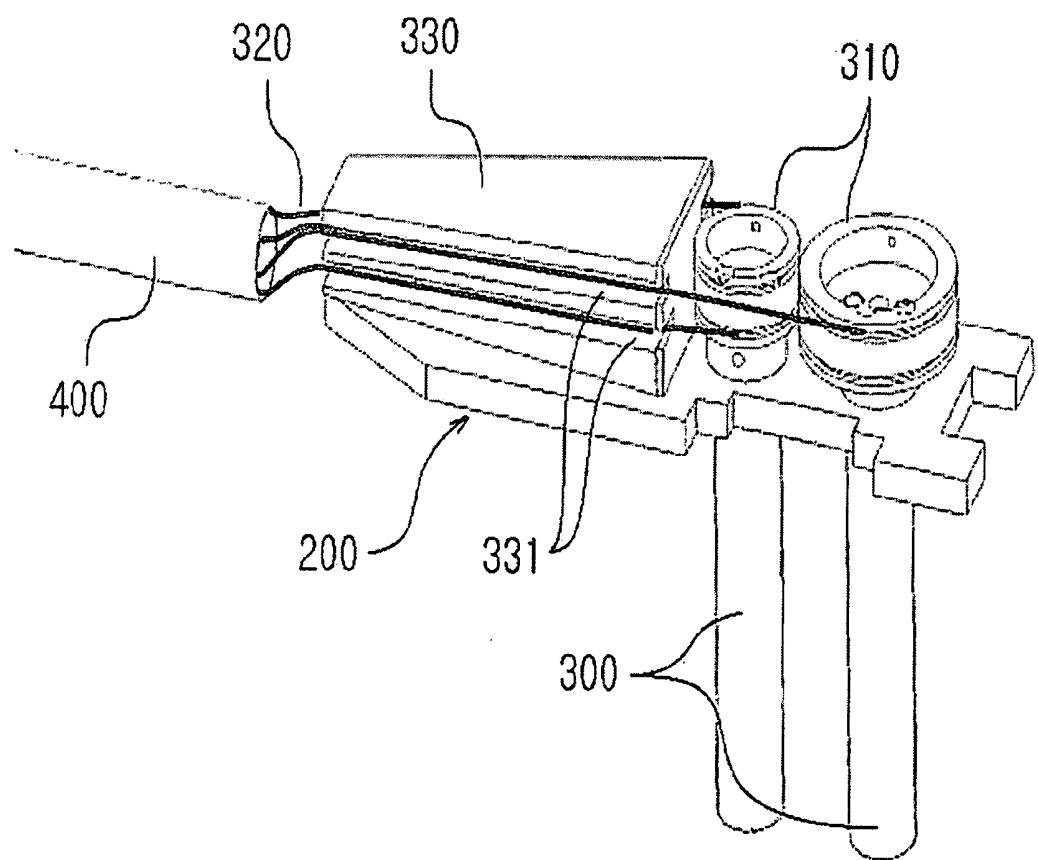


FIG. 8

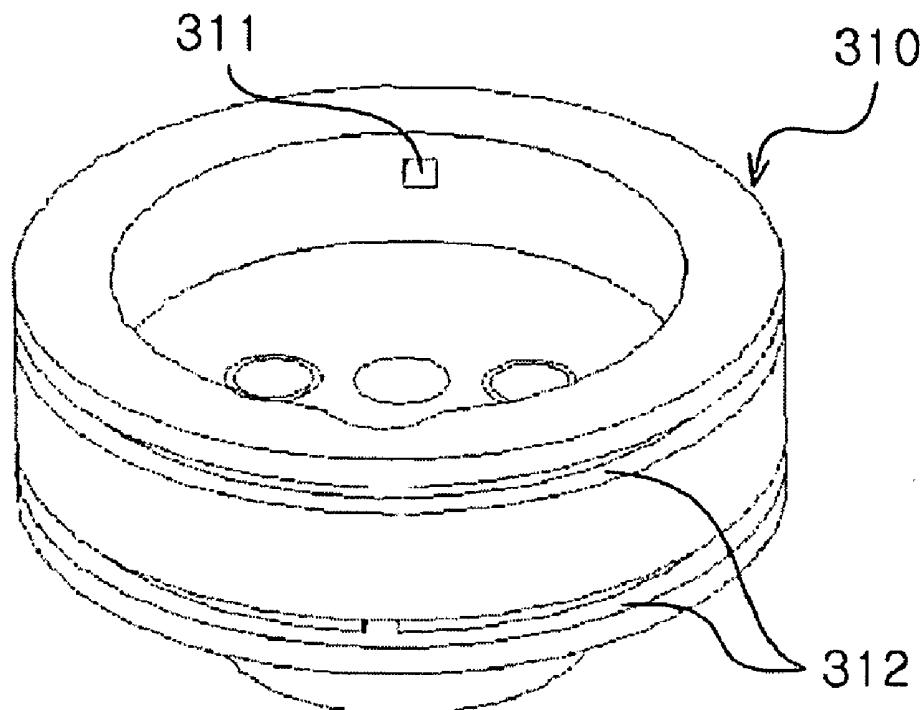


FIG. 9

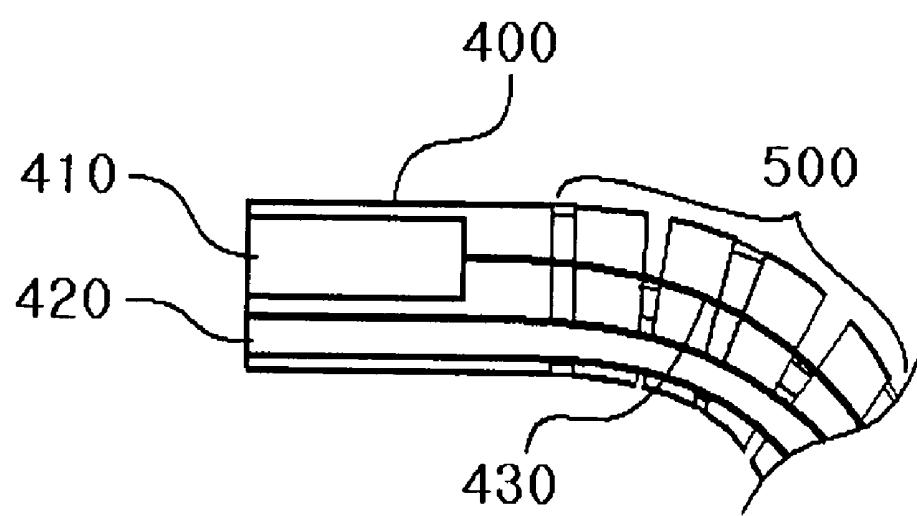


FIG. 10

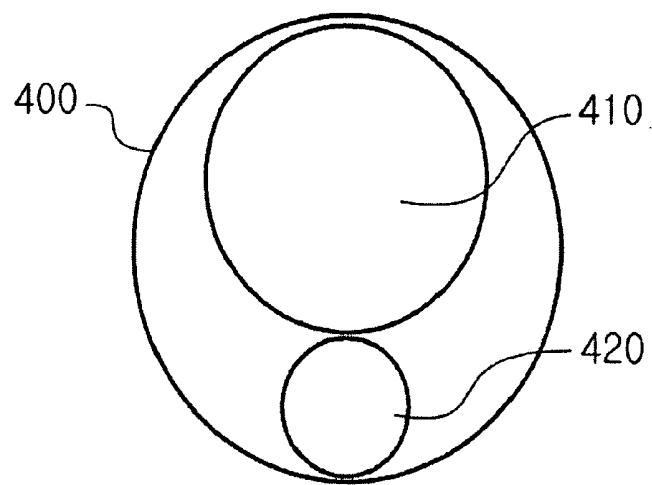


FIG. 11

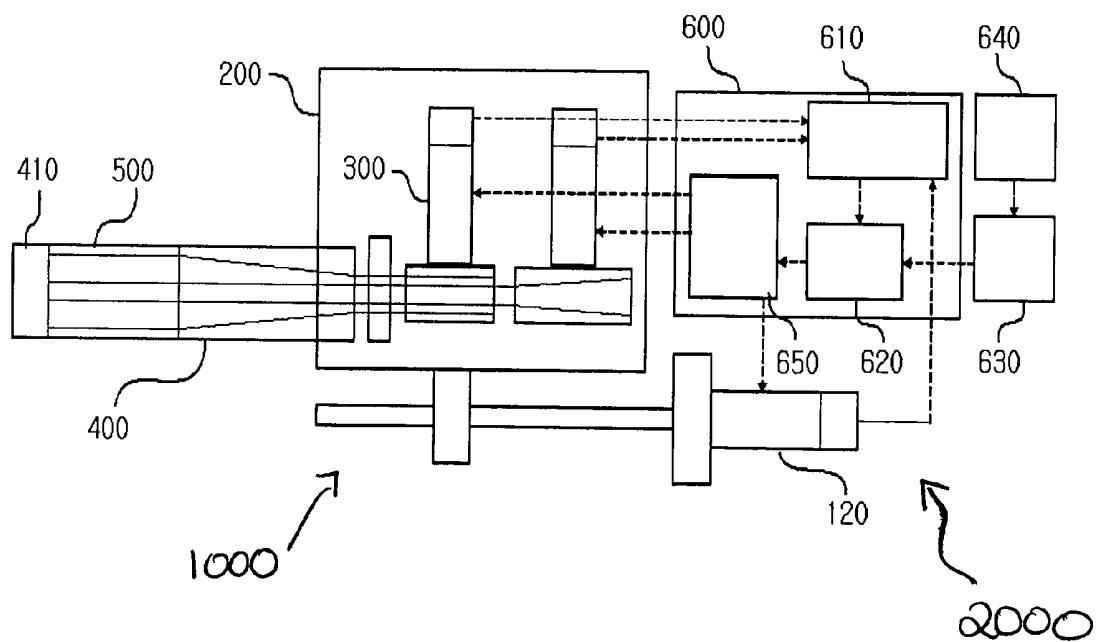
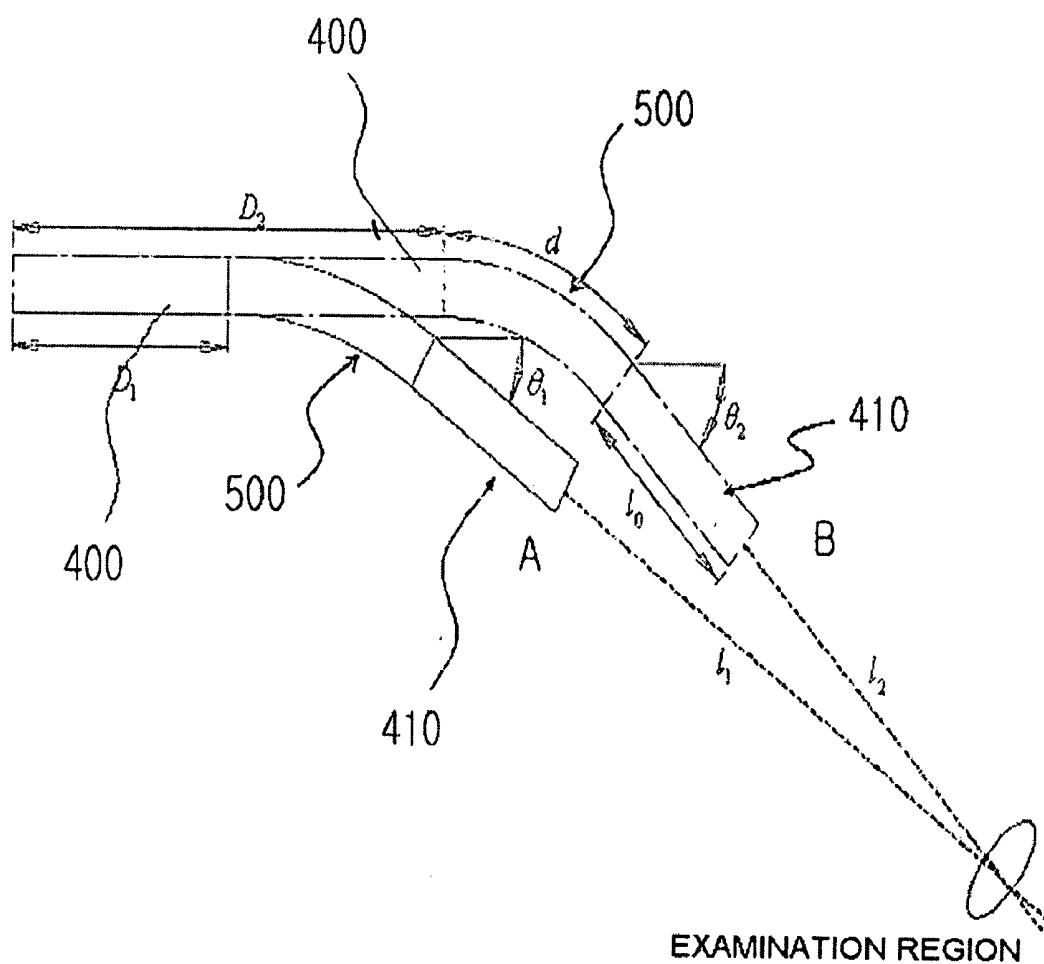


FIG. 12



ROBOTIZED LAPAROSCOPIC SYSTEM

PRIORITY CLAIM

[0001] This application claims under 35 U.S.C. § 119 the benefit of the filing date of Apr. 22, 2004 of Korean Application No. 2004-27949, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0002] 1. Technical Field

[0003] The invention generally relates to a laparoscopic system and, more particularly, to a robotized laparoscopic system capable of executing a surgeon's commands.

[0004] 2. Related Art

[0005] A laparoscopic system visualizes a surgical site through a tube inserted through an opening in the abdominal walls. Various surgical instruments such as surgical scalpels, surgical needles, etc. are generally used with a laparoscope. A surgeon in charge of surgery normally operates surgical instruments, whereas an assistant helping a surgeon operates a laparoscope during the surgery. An assistant operates the laparoscope according to commands from a surgeon and communications between a surgeon and an assistant are very important to achieve a successful laparoscopic surgery. However, many factors such as difference in the level of expertise frequently undermine accurate and effective communications, i.e., issuing and following commands, between a surgeon and an assistant, and the inaccurate communications may adversely affect outcome of a surgery.

[0006] U.S. Pat. No. 5,815,640 discloses an automated endoscope system for optimal positioning as illustrated in FIG. 1. This system 20 is constructed to mount a robotic arm 26 that replaces an assistant who maneuvers a conventional rigid endoscope 18. The robotic arm 26 includes a plurality of actuators 24, 30, 34 and 38 and is operated by a foot pedal 22 above an operating table 14. Accordingly, a surgeon can control a movement of the endoscope 18 by directly manipulating the foot pedal 22. However, the system creates distractions to a surgeon because of a large motion of the robotic arm 26 actuated by multiple joints. Further, a plurality of actuators 24, 30, 34 and 38 are needed to generate a required motion, which increases manufacturing costs and size of the system.

[0007] In addition, the endoscope 18 is inserted into an abdominal cavity through a trocar, which is a sharp-pointed surgical instrument fitted with a cannula. The robotic arm 26 pivotally moves, which is created by the insertion of a trocar, to change viewing angle to the abdominal cavity. However, in case of thyroidectomy or sternotomy, formation of a pivot is impossible and this system 20 may not apply to these surgeries. Further, an additional device needs to be installed.

[0008] U.S. Pat. No. 4,108,211 discloses four-way bendable tube structure, as shown in FIG. 2. The tube structure 80 is articulate and includes a plurality of links 70 connected by joints 75 and wire guides 71. Two pairs of wires 78 passing through the tube structure 80. The joints 75 formed at both ends are alternatively connected to allow continuously connected links 70 to turn in opposite directions. The wires 78 run from actuators to the most distal link among the links 70. If the actuators are activated, pulling the wires 78

causes a change in tension of the wires and results in bending of the links 70. Therefore, if the wires 78 wound by the actuators are controlled, the direction in which the links 70 are bent is easily adjustable. Accordingly, such an articulated structure can be effective when it is used with a laparoscope, in particular where dexterous movement is required in a narrow place.

[0009] In addition, U.S. Pat. Nos. 4,273,111, 4,503,842, 6,551,237, 6,569,086 and 6,669,629 discloses conventional systems that are applicable to an endoscope. However, the systems disclosed in the above-mentioned patents cannot apply to a laparoscopy. Because they are designed to inspect human organs through tortuous intestines, an accurate and detailed control of motions is not possible. Furthermore, a surgeon needs to use a specific input device or the help of an assistant to operate the systems. Accordingly, there is a need of a system that overcomes the foregoing drawbacks of the conventional system.

SUMMARY

[0010] One aspect of the invention is a robotized laparoscopic system capable of executing the operating surgeon's commands and steadily displaying a surgical site by automatically maneuvering or in response to a surgeon's commands. The laparoscopic system includes a cylindrical penetration tube, a camera, a driving unit and a control unit. The cylindrical penetration tube can be inserted into an opening through a trocar. The camera is attached at a tip of the penetration tube for displaying images of the surgical site. A bending portion is disposed adjacent to the tip for bending the penetration tube in any direction. The driving unit controls bending direction and angle of the bending portion. The laparoscopic system further includes a movement device, a control unit, a conversion unit and an input unit. The movement device moves the penetration tube forward or backward in a longitudinal direction. The control unit independently controls the driving unit and the movement device. The input unit receives commands from a surgeon, and the conversion unit converts command input from a surgeon into digital signals and transmitting them to the control unit.

[0011] Other systems, methods, features and advantages of the invention will be, or will become, apparent to one with skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features and advantages be included within this description, be within the scope of the invention, and be protected by the following claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The invention can be better understood with reference to the following drawings and description. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. Moreover, in the figures, like referenced numerals designate corresponding parts throughout the different views.

[0013] FIG. 1 shows a conventional automated endoscope system;

[0014] FIG. 2 shows a conventional articulated tube structure;

[0015] **FIG. 3** is a perspective view showing one embodiment of a robotized laparoscopic system;

[0016] **FIG. 4** shows an embodiment of support detached from an embodiment of a bending actuator housing in the laparoscopic system of **FIG. 3**;

[0017] **FIG. 5** shows an embodiment of a bending portion of the laparoscopic system of **FIG. 3**;

[0018] **FIG. 6** is a sectional view of the bending portion of **FIG. 5**;

[0019] **FIG. 7** is an embodiment of a driving unit of the laparoscopic system of **FIG. 3**;

[0020] **FIG. 8** is an enlarged view showing an embodiment of a circular bobbin used with the driving unit of **FIG. 7**;

[0021] **FIG. 9** is a sectional view showing an embodiment of a penetration tube of the laparoscopic system of **FIG. 3**;

[0022] **FIG. 10** is a front view showing the penetration tube of **FIG. 9**;

[0023] **FIG. 11** shows the brief construction of the laparoscopic system of **FIG. 3**; and

[0024] **FIG. 12** shows an operating status to implement enlarged and reduced images using the laparoscopic system of **FIG. 3**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] **FIG. 3** shows one embodiment of a robotized laparoscopic system, which is capable of executing a surgeon's commands. A laparoscopic system **1000** includes a guide unit **100**, a bending actuator housing **200** and a penetration tube **400**. The guide unit **100** supports the bending actuator housing **200** and other portions and is coupled to a support unit **700**. The support unit **700** is fixed on an operating table or floor. The support unit **700** includes a fixture **730** that is able to be easily fastened and clamped to the operating table and a support rod **710** that supports the guide unit **100** to maintain its height from the operating table at a certain level. A plurality of joints **720** are coupled to the support rod **710** and spaced apart from each other at a predetermined distance to adjust the position and orientation of the guide unit **100**.

[0026] **FIG. 4** illustrates in detail the guide unit **100** coupled to the support unit **700**. A protrusion **130** is inserted into a groove **701** of the support unit **700**, which enables the guide unit **100** and the support unit **700** to be easily attached to or detached from each other. A guide rail **110** and a linear motor **120** are mounted on the guide unit **100** to linearly reciprocate the bending actuator housing **200**. The housing **200** is mounted on the guide rail **110**, and linearly reciprocates by the linear motor **120** along the guide rail **110**. Thus, the guide unit **100**, the housing **200** and the motor **120** define a movement device for the tube **400**.

[0027] One end of the bending actuator housing **200** is coupled to the penetration tube **400**. Referring again to **FIG. 3**, a small-sized camera **410** is installed for visualizing the images of a surgical site at one end of the penetration tube **400**. A bending portion **500** adjacent to the tip of the penetration tube **400** is provided. In this embodiment, the

camera **410** is coupled to the tip of the penetration tube **400**. The camera **410** is proximately placed to a surgical site, so that an intermediate image transfer device is not needed and resolution of images of the surgical site increases. Alternatively or additionally, the camera **410** may be installed in the center of the penetration tube **400** or in the bending actuator housing **200**. In that case, structures for transmitting images such as a bundle of optical fibers are connected from the tip of the penetration tube **400** to the camera **410** to transmit images acquired at the tip of the penetration tube **400** to the camera **410**.

[0028] **FIGS. 5-6** show an enlarged view of the bending portion **500** shown in **FIG. 3**. The bending portion **500** includes a plurality of annular link members **510**. Each link member **510** has a pair of joints **520** at its both ends. Two joints **520** cross from each other at an angle of 90 degrees, so that they have rotating radii perpendicular to each other. Due to the link members **510**, bending direction of the bending portion **500** is not limited to any specific direction.

[0029] **FIG. 6** shows a sectional view of the bending portion **500**. A plurality of wire guides **530** is formed on the inner surface of the link members **510** in four directions of the link members **510**, and wires **320** are inserted into the wire guides **530**. The wire guides **530** on the inner surfaces of the link members **510** are formed to be co-linear when the bending portion **500** is straightened. The wire guides **530** of the last link member **510** are coupled to the wires **320**. Therefore, if one of the four wires **320** coupled to the last joint member **510** is released at a certain length, the other wire opposite to the released wire **320** is drawn at the same length. Accordingly, intervals between the joint members **510** on one side decrease and intervals between the joint members **510** on the other side increase due to the wires **320**, thereby bending the bending portion **500**.

[0030] **FIG. 7** shows a driving unit of the laparoscopic system **1** shown in **FIG. 3**. As shown in **FIG. 7**, two motors **300** and two circular bobbins **310** are installed within the bending actuator housing **200**. The rotational axes of the circular bobbins **310** are connected to the motors **300**, respectively. Four wires **320** connecting link members **510** are wound around the two bobbins **310**, so that two wires **320** are wound around upper and lower portions of one bobbin. When each of the wires **320** is extended to the penetration tube **400** having a small diameter, the wires **320** may become tangled. For this reason, a guide member **330** having a plurality of guide grooves **331** is installed. The wires **320** wound around the circular bobbins **310** are extended to an inlet of the penetration tube **400** without getting tangled. On the guide member **330**, the guide grooves **331** are formed to allow the wires **320** to be separately inserted therein.

[0031] **FIG. 8** is an enlarged view of a circular bobbin **310**. Holes **311** are formed on the circular bobbin **310** to allow the wires **320** to be fastened thereto. Grooves **312** formed on the bobbin **310** restrict the movement of the wires **320**. A pair of wires **320** wound around the circular bobbin **310** are wires **320** that are to be inserted into opposite wire guides **530** of the bending portion **500** and are wound around the circular bobbin **310** in opposite directions. Therefore, if the circular bobbin **310** is rotated in any one direction, one wire **320** is wound and the other wire **320**, forming a pair with the wire **320**, is released. At this time, the last link

member 510 of the bending portion 500 is coupled to the wires 320, so that a side of the bending portion 500 is contracted or extended with the rotation of the circular bobbin 310. If the operating directions of the two motors 300 are suitably adjusted, the bending direction of the bending portion 500 can be arbitrarily controlled. However, at the joints 520 of the bending portion 500, slight spaces exist to facilitate the driving of the bending portion 500, and revolutions of the motors 300 is not always proportional to the bending angle of the bending portion 500 due to the spaces. Therefore, an elastic member is coupled to the inner or outer side of the bending portion 500 in the longitudinal direction of the bending portion 500. This enables the rotary angle of the motors 300 and the bending angle of the bending portion 500 to be proportional to each other.

[0032] FIGS. 9-10 show a bending portion of the penetration tube 400 in detail. At the tip of the penetration tube 400, the small-sized camera 410 and a light transmission unit 420 are installed. The small-sized camera 410 is connected to an external output device or power device through an electric wire 430, and the light transmission unit 420 is connected to an external light source device. The bending portion 500 is placed on the end tip of the penetration tube 400, so that the angle of the small-sized camera 410 is be adjusted by operating the motors 300.

[0033] FIG. 10 shows a front view of the penetration tube 400 shown in FIG. 9. The end tip of the light transmission unit 420 is installed below the small-sized camera 410, but the position of the light transmission unit 420 is not limited to this embodiment. Depending on the size of the light transmission unit 420 and the small-sized camera 410, the position and the number of light transmission units 420 to be installed can be adjusted. While a surgeon performs surgery using surgical images captured by the small-sized camera 410, he or she needs to rotate the captured images relative to the longitudinal axis of the penetration tube 400. An auxiliary driving device (not shown) may be installed on the penetration tube 400. The auxiliary driving device is capable of rotating the small-sized camera 410 relative to the longitudinal axis of the penetration tube 400.

[0034] FIG. 11 is a block diagram of an entire system 2000 including the laparoscopic system 1000 of FIG. 3. The system 2000 includes a control unit 600, an input unit 640 and a conversion unit 630. As described above, the wires 320 coupled to the bending portion 500 are wound around the circular bobbins 310. The bending actuator housing 200 coupled to the penetration tube 400 can move along the guide rail 110 of the guide unit 100. Therefore, the view of a surgical site is determined by the operation of the motors 300 that rotate the circular bobbins 310, and the enlargement/reduction ratio of the view is determined by the operation of the linear motor 120 that moves the penetration tube 400 forward or backward.

[0035] A conventional rigid laparoscope is manipulated by an assistant on behalf of the operating surgeon and provides a surgeon with a different view from that of an assistant. To the contrary, the system 2000 including the laparoscopic system 1000 is directly operated by a surgeon performing an operation. A surgeon input commands to the input unit 640 and the control unit 600 operates the motors 300 and the linear motor 120 based on a command input. A conversion unit 630 is interposed between the input unit 640 and the

control unit 600 and converts a surgeon's commands into corresponding movement commands of each motor. Then, the conversion unit 630 transmits these control signals to the control unit 600.

[0036] The control unit 600 further includes a counter 610 and a computation unit 620. The counter 610 measures revolutions of the motors 300 and the movement distance of the linear motor 120. The computation unit 620 calculates the motor input corresponding to the position difference between the surgeon's command input position and the current tip position of the penetration tube 400. The control unit 630 also includes a motor driving unit 650 for operating the motors 300 and the linear motor 120. These units help a surgeon to more precisely adjust the position of the small-sized camera 410 while performing an operation. In this embodiment, a microphone device for receiving commands from the surgeon is used as the input unit 640. Alternatively or additionally, the input unit 640 may include a position measurement device for measuring the location of a surgeon's head, a foot pedal switch or a joystick.

[0037] FIG. 12 shows an operating status of the laparoscopic system 1000. Generally, the camera 410 installed at the penetration tube normally has no enlargement and reduction functions due to its small size. Instead of the camera 410, the laparoscopic system 1000 generates the enlargement and reduction functions of the camera by moving the penetration tube 400 forward or backward. However, if the penetration tube 400 is moved forward or backward while being bent, the viewing angle by the small-sized camera 410 changes and therefore, a separate control method is required. As shown in FIG. 12, if the penetration tube 400 moves forward from position A and the direction of the small-sized camera 410 is not adjusted, the view captured by the small-sized camera 410 may change. Therefore, in order to correct the difference in position of an image due to the forward movement of the penetration tube 400, the bending portion 500 should be bent at the same time as the penetration tube 400 moves forward, for example, to the position B.

[0038] The following Equations [1] and [2] can be derived on the basis of the relationship between positions A and B.

$$\frac{d}{\theta_1} (1 - \cos\theta_1) + (l_0 + l_1) \sin\theta_1 = \frac{d}{\theta_2} (1 - \cos\theta_2) + (l_0 + l_2) \sin\theta_2 \quad [1]$$

$$\frac{d}{\theta_1} \sin\theta_1 + (l_0 + l_1) \cos\theta_1 + D_1 = \frac{d}{\theta_2} \sin\theta_2 + (l_0 + l_2) \cos\theta_2 + D_2 \quad [2]$$

[0039] where D_1 is position of the penetration tube 400 relative to the guide unit 100 at position A and D_2 is the position of the penetration tube 400 relative to the guide unit 100 at position B;

[0040] d is the length of the bending portion 500;

[0041] I_0 is the length between the lens of the small-sized camera 410 and the bending portion 500; I_1 is the distance between the lens of the small-sized camera 410 and the surgical site of interest and D_1 is the distance between the lens of the small-sized camera 410 and the surgical site of interest.

[0042] In order to perform enlargement and reduction, the position of the linear motor 120 and the bending angle of the

bending portion **500** must be calculated. Specifically, to perform either enlargement or reduction, when the desired distance varies from I_1 to I_2 , variations occurring in the movement from D_1 to D_2 and variations occurring in the movement from θ_1 to θ_2 must be obtained. The D_2 can be obtained by solving Equation [1], and D_2 can be obtained using the θ_2 and Equation [2].

[0043] Equations [1] and [2] are calculated by the control unit **600** and/or the conversion unit **630**. If an enlargement or reduction command has been issued by the surgeon, the control unit **600** and the conversion unit **630** automatically calculate θ_2 and D_2 to calculate the amount of the movement of the motors **300** and the linear motor **120**, thus operating both the motors **300** and the linear motor **120** based on the calculation of the amount of the movement.

[0044] A robotized laparoscopic system is capable of executing the operating surgeon's during surgery even where the formation of a pivot is impossible. The laparoscopic system can reduce distractions between a surgeon and the robotized laparoscopic system by minimizing movements of the system outside the abdominal cavity while providing internal images of equivalent quality as a conventional system. The laparoscopic system is compact and light-weight, which allows a surgeon to perform laparoscopy without the help of an assistant. Further, operation costs can be reduced. In addition, a surgeon can perform an operation more precisely by directly maneuvering the camera using 3 degrees-of-freedom motion.

[0045] While various embodiments of the invention have been described, it will be apparent to those of ordinary skill in the art that many more embodiments and implementations are possible within the scope of the invention. Accordingly, the invention is not to be restricted except in light of the attached claims and their equivalents.

We claim:

1. A robotized laparoscopic system for a surgery, comprising:

- a cylindrical tube inserted into an opening of abdominal walls and having a tip on one end;
- a bending portion adjacent to the tip for bending the tube;
- a driving unit for controlling a bending direction and a bending angle of the bending portion;
- a movement device for moving the tube in a longitudinal direction; and,
- a control unit for controlling the driving unit and the movement device independently.

2. The laparoscopic system according to claim 1, wherein the camera is coupled to the tip of the tube to capture an image of a surgical site and a surgical instrument.

3. The laparoscopic system according to claim 2, further comprising an input unit for receiving commands.

4. The laparoscopic system according to claim 3, further comprising a conversion unit for converting the received commands into digital signals and transmitting the digital signals to the control unit.

5. The laparoscopic system according to claim 1, wherein the bending portion comprises:

a plurality of annular link members;

at least one rotary joint linking the plurality of annular link members and disposed at both ends of an annular link member.

6. The laparoscopic system according to claim 5, wherein the driving unit comprises:

a plurality of motors; and

wires having one end attached to a last link member of the bending portion and having the other end attached to each of the motors.

7. The laparoscopic system according to claim 6, wherein one of the plurality of motors winds the wires to draw the last link member.

8. The laparoscopic system according to claim 1, further comprising an elastic member attached to the outside and/or inside of the bending portion in a longitudinal direction.

9. The laparoscopic system according to claim 1, wherein the control unit comprises:

a counter for measuring revolutions of the motors;

a computation unit for calculating the position difference between a received command input position and a current tip position of the tube; and

a motor driving unit for operating each motor.

10. The laparoscopic system according to claim 1, wherein the movement device comprises:

a guide unit having a guide rail formed thereon;

a bending actuator housing mounted on the guide rail and coupled to the tube; and,

a linear motor for linearly reciprocating the bending actuator housing along the guide rail.

11. The laparoscopic system according to claim 10, wherein the bending actuator housing further comprises a longitudinal reference axis and a motor rotating a camera coupled to the tube.

12. The laparoscopic system according to claim 1, further comprising a support unit coupled to the guide unit.

13. The laparoscopic system according to claim 12, wherein the support unit comprises:

a fixation to be fastened to an operating table or floor;

a support rod including a plurality of joints to control a position of the guide unit; and

a coupling to be easily attached to or detached from the guide unit.

14. The laparoscopic system according to claim 1, wherein the control unit calculates a displacement D_2-D_1 of the movement device and a rotation angle D_2-D_1 of the bending portion using the following Equations, to compensate for the change in viewing angle by either enlargement or reduction command.

$$\frac{d}{\theta_1}(1 - \cos\theta_1) + (l_0 + l_1)\sin\theta_1 = \frac{d}{\theta_2}(1 - \cos\theta_2) + (l_0 + l_2)\sin\theta_2$$

$$\frac{d}{\theta_1}\sin\theta_1 + (l_0 + l_1)\cos\theta_1 + D_1 = \frac{d}{\theta_2}\sin\theta_2 + (l_0 + l_2)\cos\theta_2 + D_2$$

where d is a length of the bending portion, I_0 is a distance between a front surface of the tube and the bending

portion, θ_1 is a bending angle of the bending portion before moving, I_1 is a distance between an end of the tube and a surgical site of interest before moving, D_1 is a position of the tube before moving, D_2 is a bending angle of the bending portion after moving, I_2 is a distance between the tip of the tube and the surgical site after moving, and D_2 is a position of the tube after moving.

15. The laparoscopic system according to claim 1, wherein the tube is a penetration tube.

16. The laparoscopic system according to claim 1, wherein the movement device moves the tube forward or backward.

17. The laparoscopic system according to claim 1, wherein the bending portion is configured to bend the tube in any direction required for the surgery.

18. A robotized laparoscopic system capable of executing commands of an operating surgeon, the laparoscopic system visualizing an image of a surgical instrument and a surgical site to allow a surgeon to precisely operate the surgical instrument inserted through an opening in the abdominal walls, comprising:

a cylindrical tube inserted into the opening;

a camera attached at the tip of the tube to capture an image of the surgical site and the surgical instrument;

a bending portion adjacent to the tip for bending the tube in any direction;

a driving unit for controlling a bending direction and a bending angle of the bending portion;

movement device for moving the tube forward or backward in a longitudinal direction;

a control unit for controlling the driving unit and the movement device independently;

an input unit for receiving commands issued by the surgeon; and

a conversion unit for converting the commands input from the surgeon into digital signals and transmitting the digital signals to the control unit.

19. The laparoscopic system according to claim 18, wherein the input unit includes a microphone.

20. The laparoscopic system according to claim 18, wherein the input unit includes a position measurement device for measuring a location.

* * * * *

专利名称(译)	机器人腹腔镜系统		
公开(公告)号	US20050240078A1	公开(公告)日	2005-10-27
申请号	US10/971249	申请日	2004-10-22
[标]申请(专利权)人(译)	KWON DONG小号 KO SEONGÿ KIM JONATHAN 李润旼 LEE WOO旼		
申请(专利权)人(译)	KWON DONG小号 KO SEONGÿ KIM JONATHAN 李润旼 LEE WOO旼		
当前申请(专利权)人(译)	KWON DONG小号 KO SEONGÿ KIM JONATHAN 李润旼 LEE WOO旼		
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优先权	1020040027949 2004-04-22 KR		
其他公开文献	US7435216		
外部链接	Espacenet USPTO		

摘要(译)

提供了一种能够执行手术医生的命令的自动化腹腔镜系统。腹腔镜系统包括插入开口中的圆柱形管。将小尺寸相机连接到管的一端以捕获手术部位的图像。弯曲部分适于在任何方向上弯曲管的尖端。驱动单元控制弯曲部分的弯曲方向和弯曲角度。移动装置使管沿纵向向前或向后移动。控制单元独立地控制驱动单元和移动装置。输入单元接收来自外科医生的命令。转换单元将来自外科医生的命令输入转换为数字信号，并将数字信号发送到控制单元。支撑单元通过连接到操作或地板来支撑移动装置的重量。

