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(12) **United States Patent**
Miyazaki et al.

(10) **Patent No.: US 10,944,949 B2**
(45) **Date of Patent: Mar. 9, 2021**

(54) **BODY CAVITY OBSERVATION SYSTEM, LAPAROSCOPE SYSTEM, TROCAR APPARATUS, AND OPERATION METHOD OF BODY CAVITY OBSERVATION SYSTEM**

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(72) Inventors: **Kazuto Miyazaki**, Tachikawa (JP); **Takaharu Fujii**, Tokorozawa (JP); **Takashi Saotome**, Ome (JP)

(73) Assignee: **KYOCERA Corporation**, Kyoto (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/408,494**

(22) Filed: **May 10, 2019**

(65) **Prior Publication Data**

US 2019/0268581 A1 Aug. 29, 2019

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2017/040482, filed on Nov. 9, 2017.

(30) **Foreign Application Priority Data**

Nov. 10, 2016 (JP) JP2016-220049

(51) **Int. Cl.**

H04N 9/73	(2006.01)
A61B 1/313	(2006.01)
A61B 1/00	(2006.01)
A61B 1/05	(2006.01)
A61B 17/34	(2006.01)
H04N 5/225	(2006.01)

(52) **U.S. Cl.**

CPC ***H04N 9/735*** (2013.01); ***A61B 1/00*** (2013.01); ***A61B 1/00009*** (2013.01); ***A61B 1/051*** (2013.01); ***A61B 1/3132*** (2013.01); ***A61B 17/34*** (2013.01); ***A61B 17/3423*** (2013.01); ***H04N 5/2257*** (2013.01); *H04N 2005/2255* (2013.01)

(58) **Field of Classification Search**

CPC H04N 9/735; H04N 5/2257

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,197,399	B2 *	6/2012	Bayer	A61B 1/05 600/113
9,044,185	B2 *	6/2015	Bayer	G06T 7/70
9,364,248	B2 *	6/2016	Yacoubian	A61B 17/00234
9,706,908	B2 *	7/2017	Sidar	A61B 1/00177
9,949,623	B2 *	4/2018	Lang	A61B 1/00006

(Continued)

FOREIGN PATENT DOCUMENTS

JP	2009195558 A	9/2009
JP	5266065 B2	8/2013

(Continued)

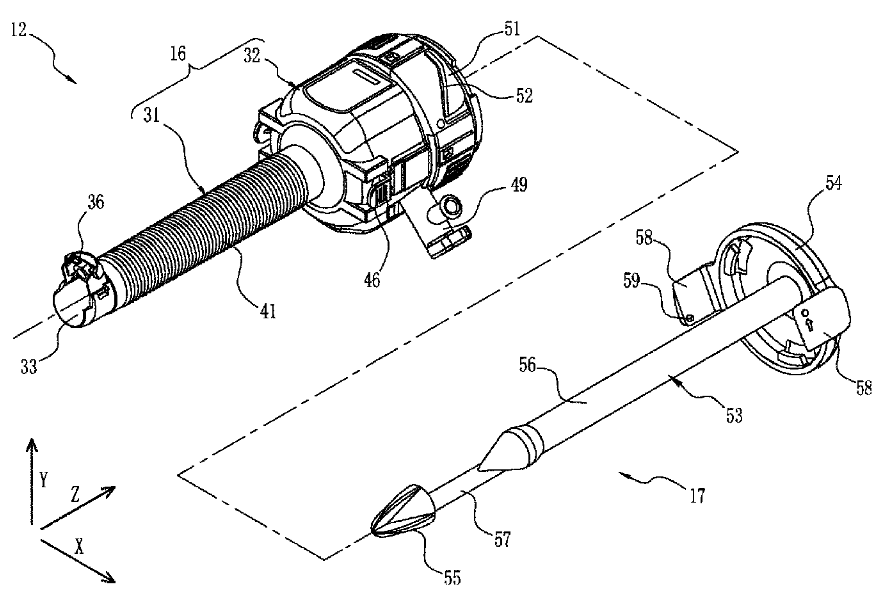
Primary Examiner — Irfan Habib

(74) *Attorney, Agent, or Firm* — Viering, Jentschura & Partner MBB

(57) **ABSTRACT**

A trocar with camera has a camera section. The camera section obtains a trocar image that includes an image of a white part on a surface of a puncture member by performing imaging when the puncture member of a trocar shaft is exposed at a deployed position. A white balance setting section for trocar image sets a white balance for the trocar image based on the image of the white part in the trocar image.

7 Claims, 43 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

10,123,684	B2 *	11/2018	Sidar	A61B 1/042
10,258,222	B2 *	4/2019	Levin	A61B 1/05
10,271,713	B2 *	4/2019	Ofir	A61B 1/051
10,398,287	B1 *	9/2019	Genova	A61B 1/00135
10,463,399	B2 *	11/2019	Savvouras	A61B 1/015
10,516,865	B2 *	12/2019	Sidar	G06T 5/40
10,517,464	B2 *	12/2019	Salman	A61B 1/00177
10,524,645	B2 *	1/2020	Davidson	A61B 1/045
10,595,714	B2 *	3/2020	Aizenfeld	A61B 1/015
2008/0033450	A1 *	2/2008	Bayer	A61B 17/3417 606/108
2008/0161646	A1 *	7/2008	Gomez	A61B 1/2676 600/169
2015/0272694	A1 *	10/2015	Charles	A61B 90/37 600/202

FOREIGN PATENT DOCUMENTS

JP	2016016053	A	2/2016
WO	2007070831	A2	6/2007

* cited by examiner

FIG. 1

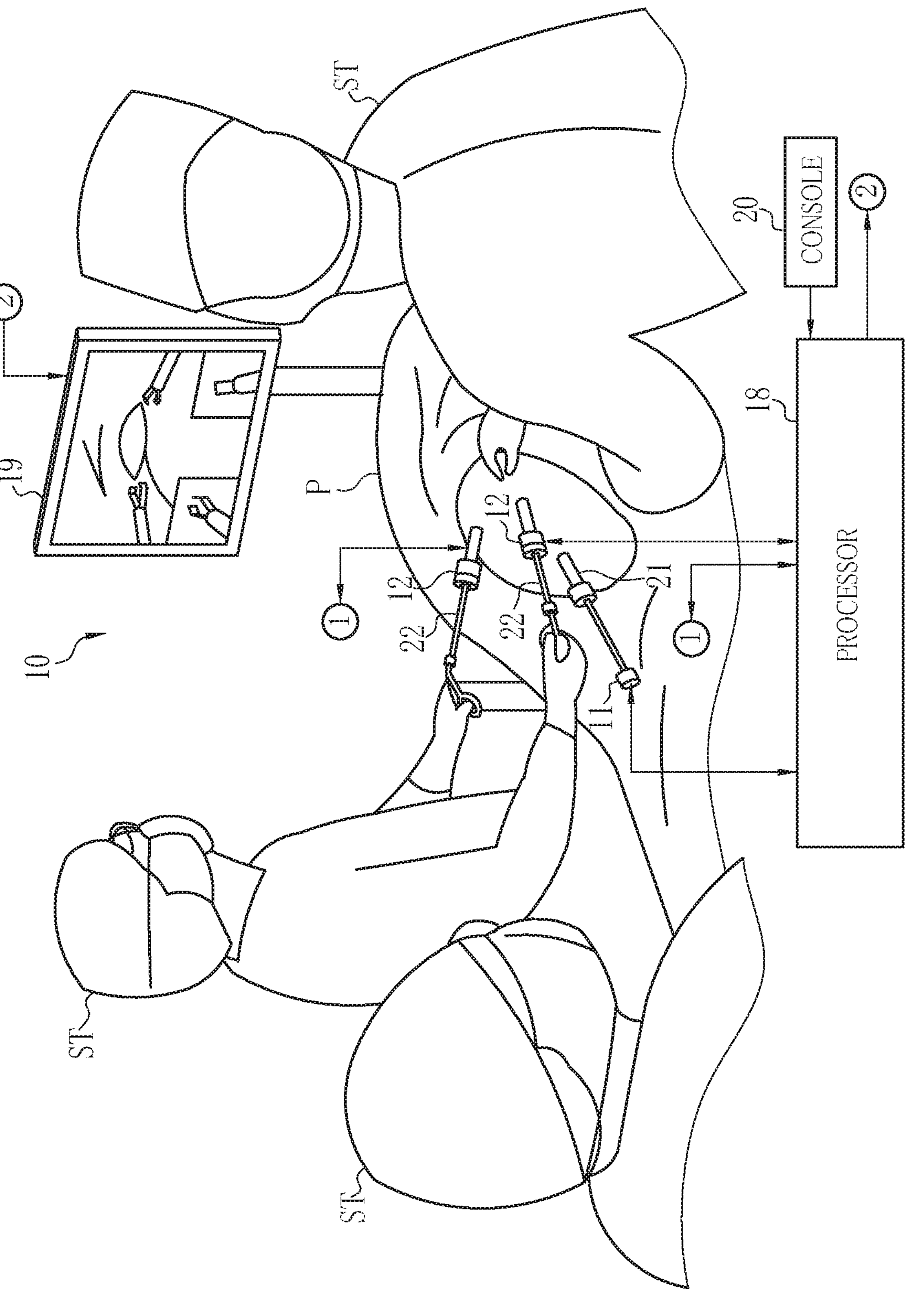


FIG. 2

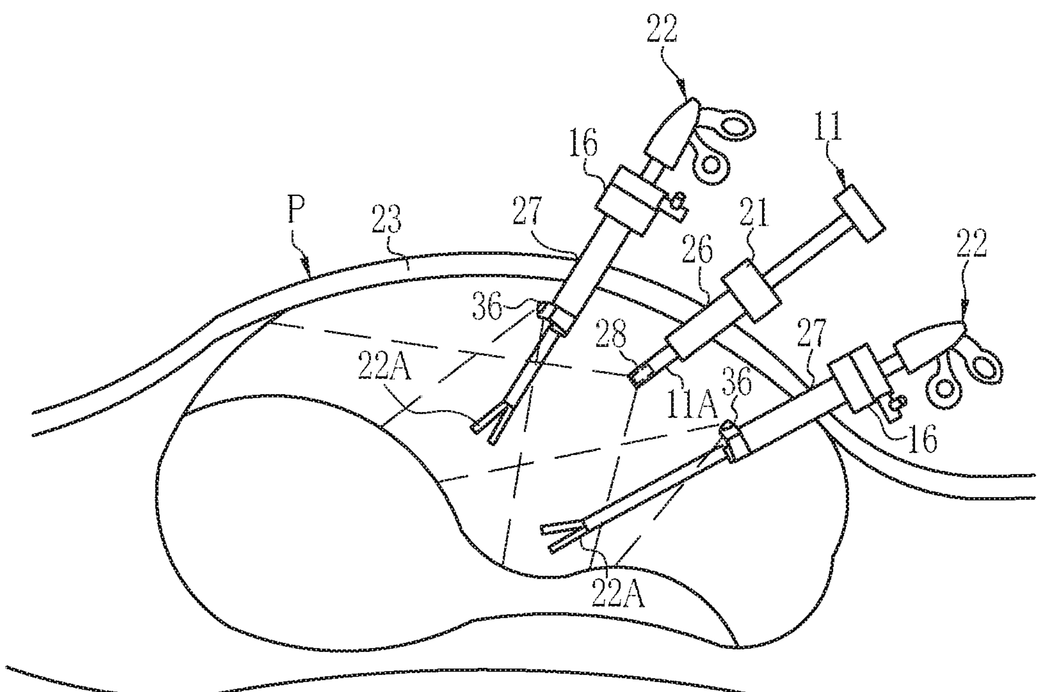


FIG. 3

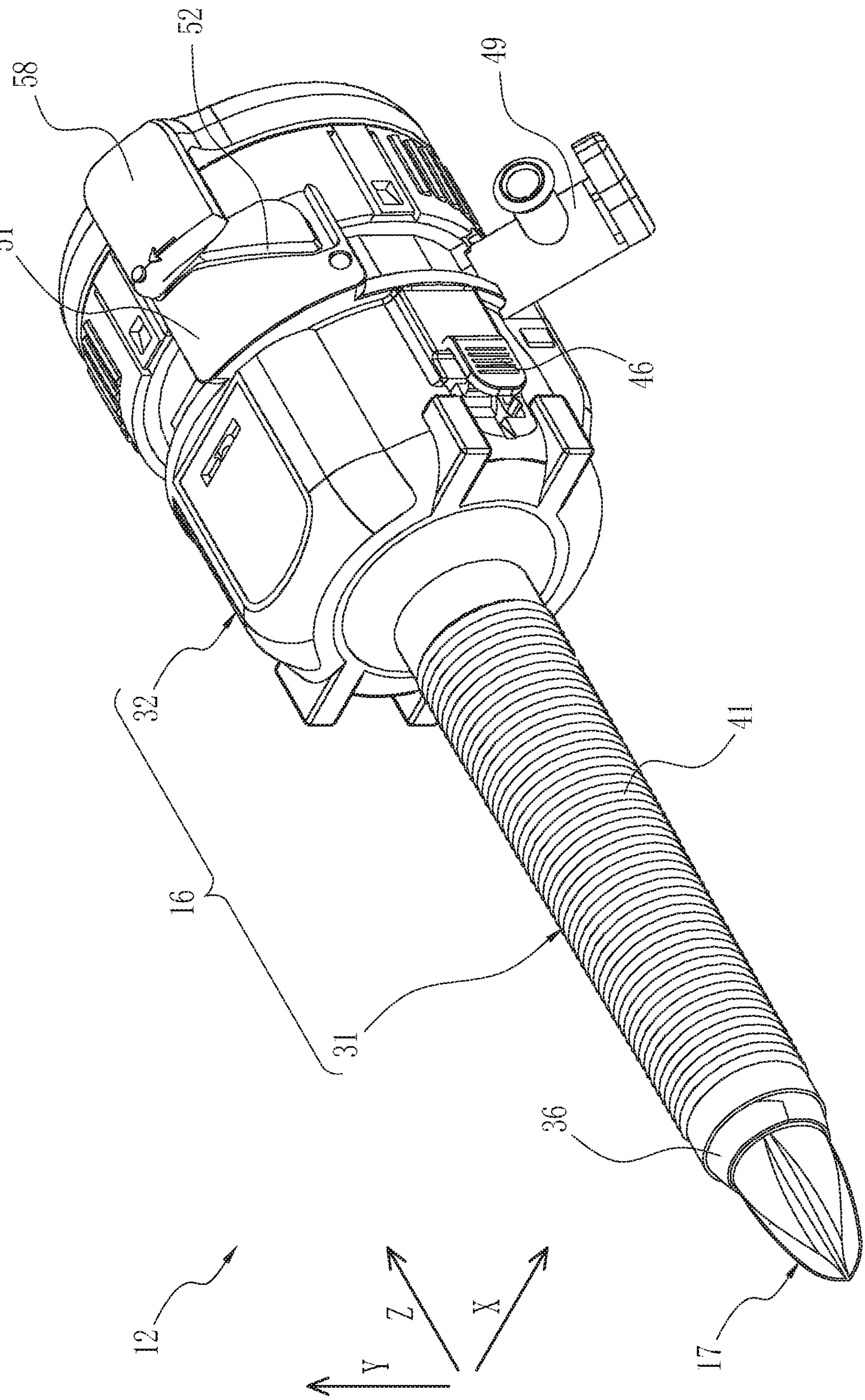


FIG. 4

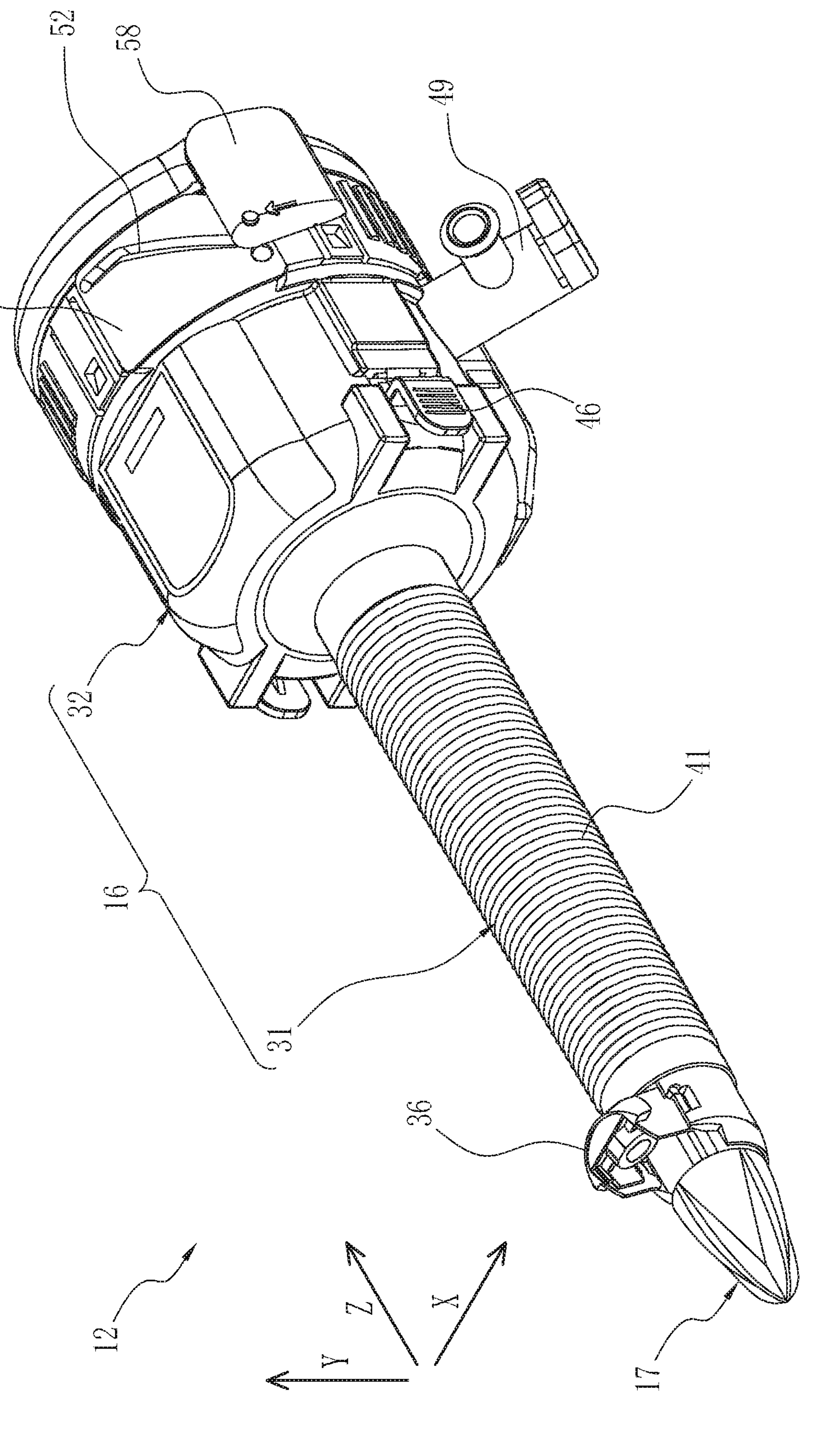


FIG. 5

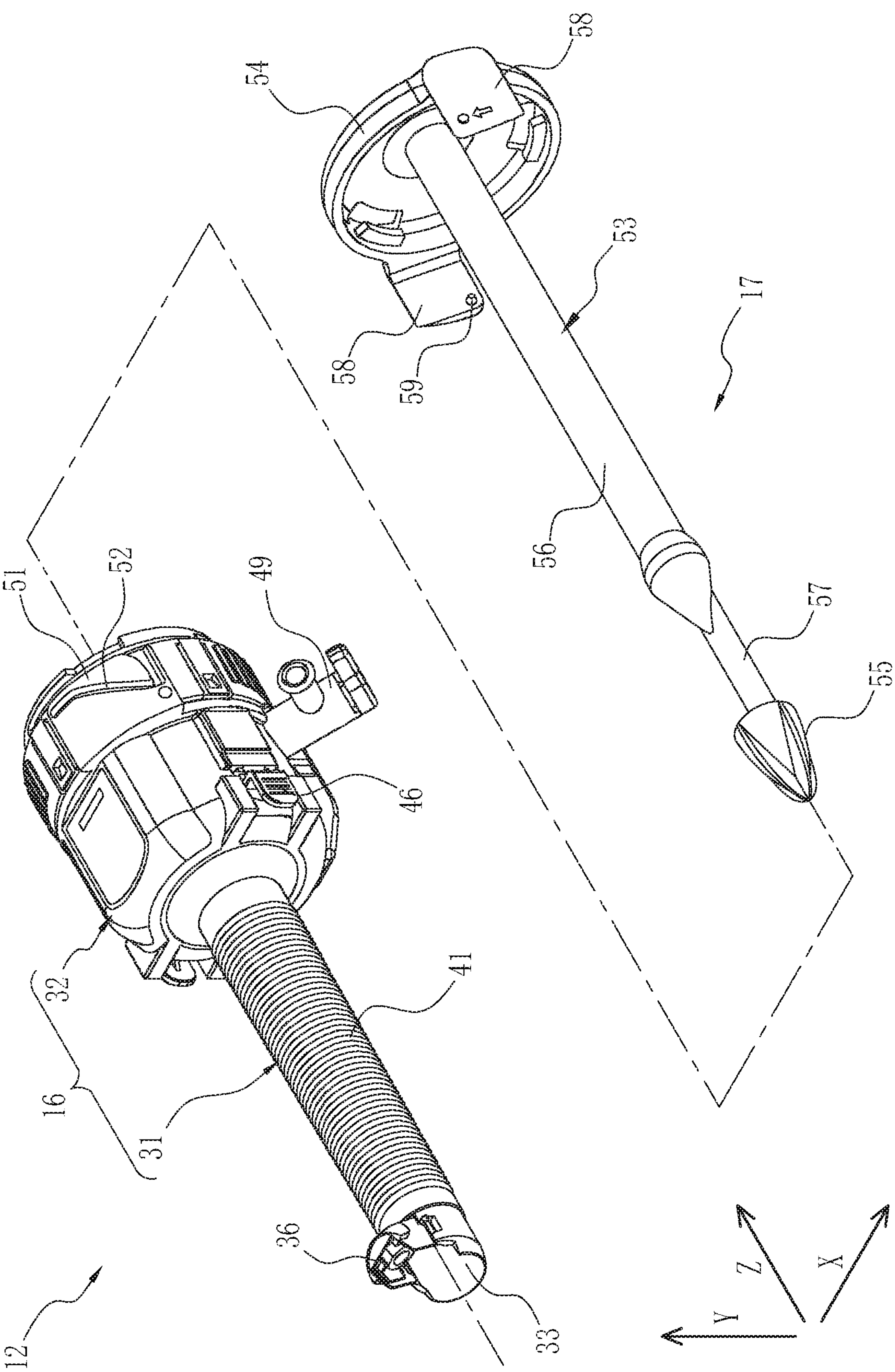
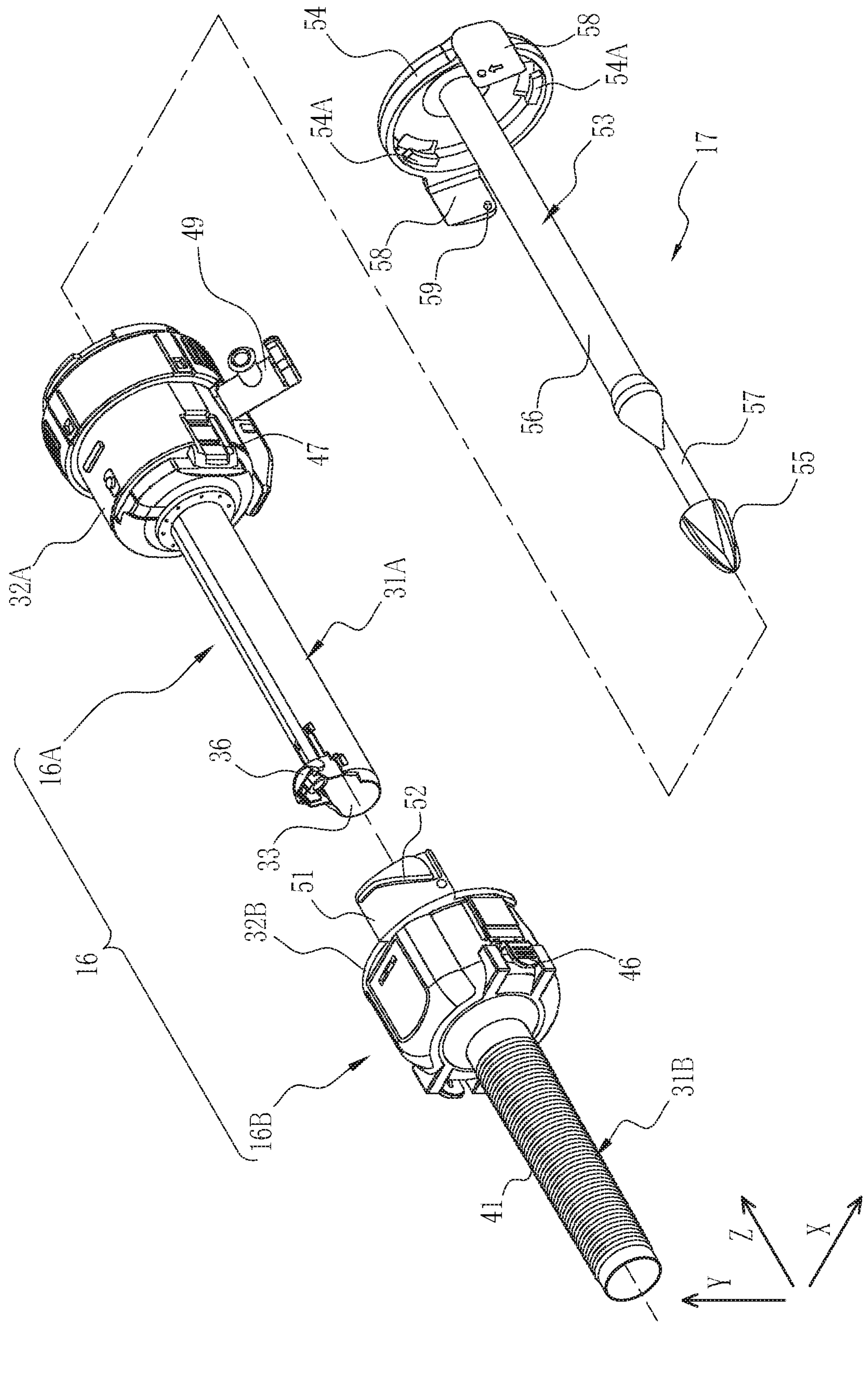


FIG. 6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32B
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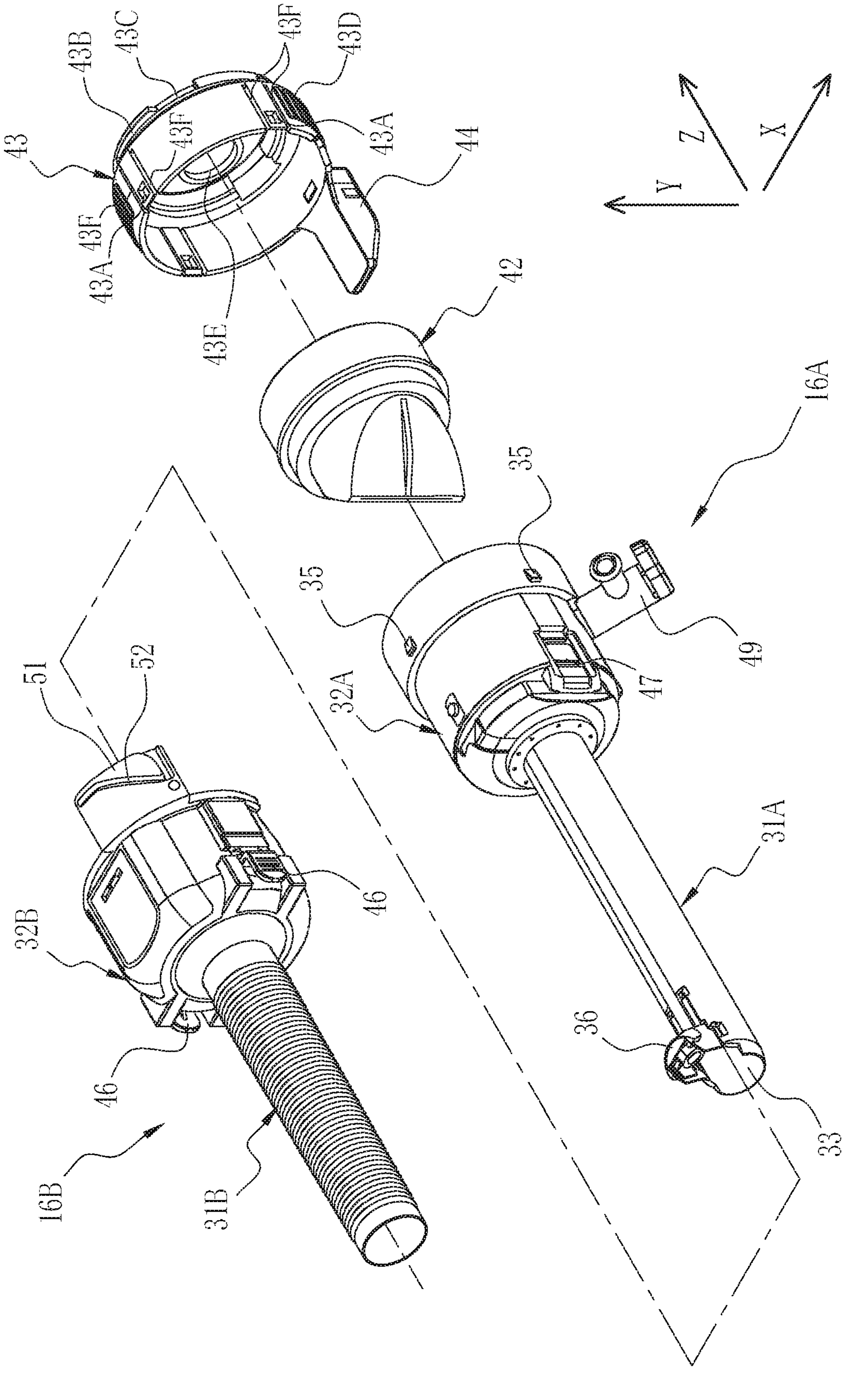
46
16B
31B
41
Z
X
Y

FIG. 7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31B
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FIG. 8

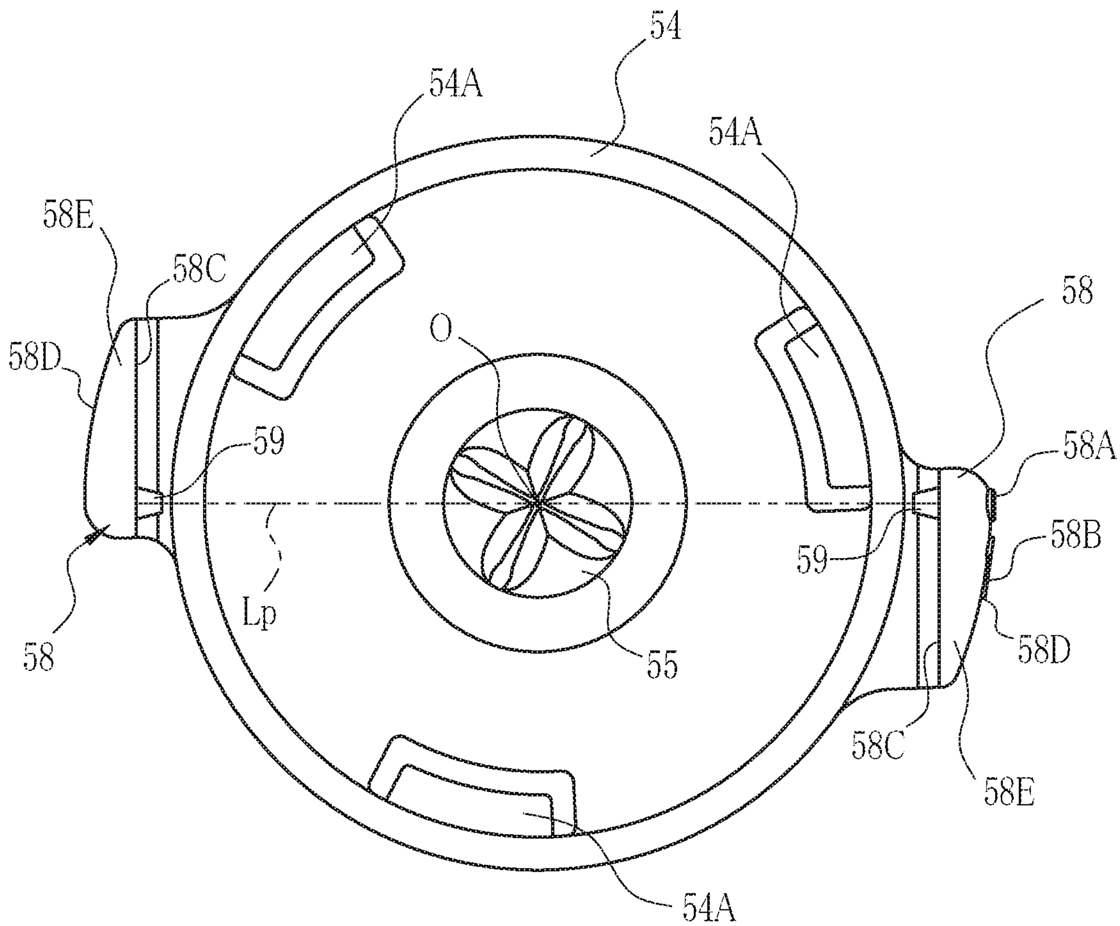

FIG. 9A

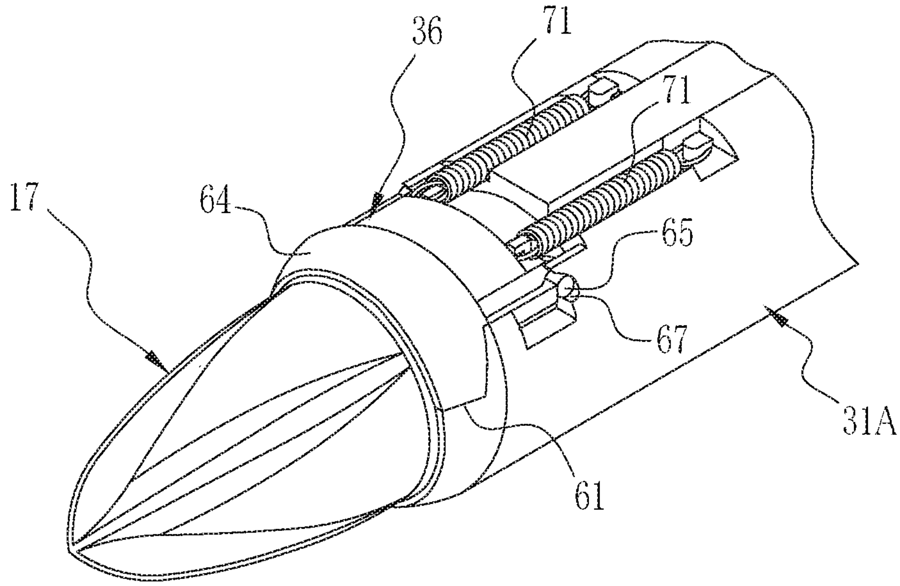
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FIG. 9B

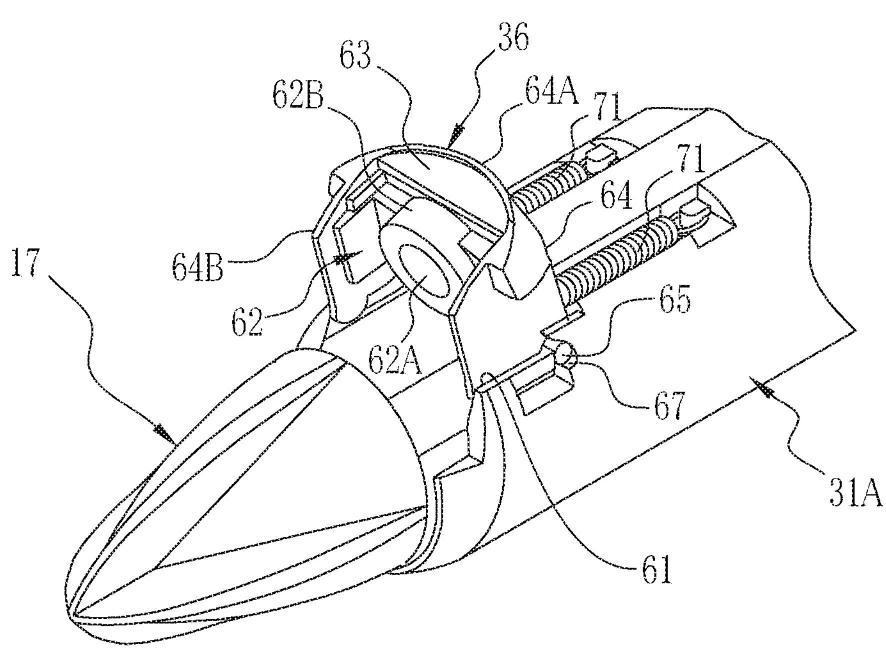
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FIG. 10

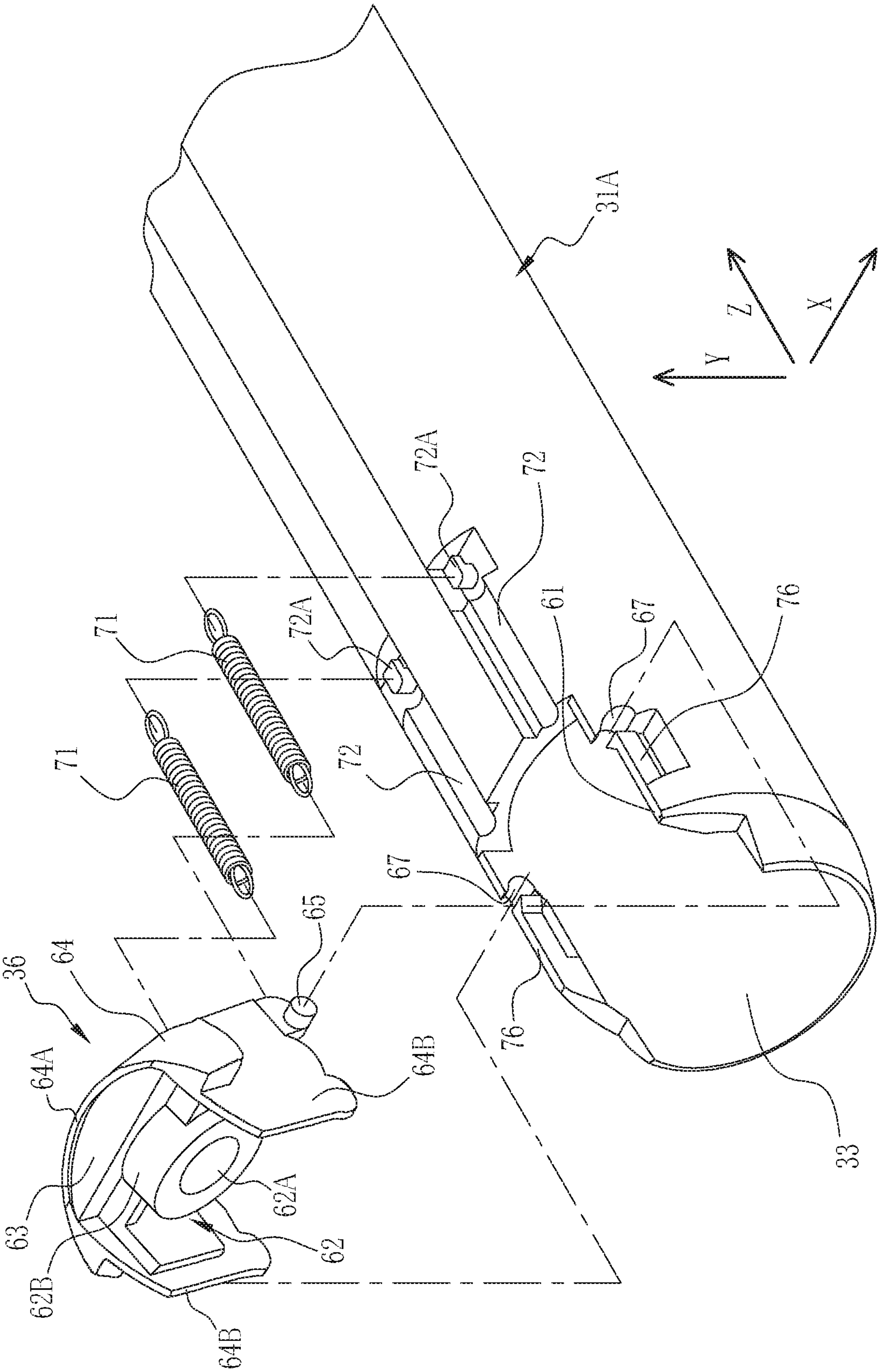
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FIG. 11

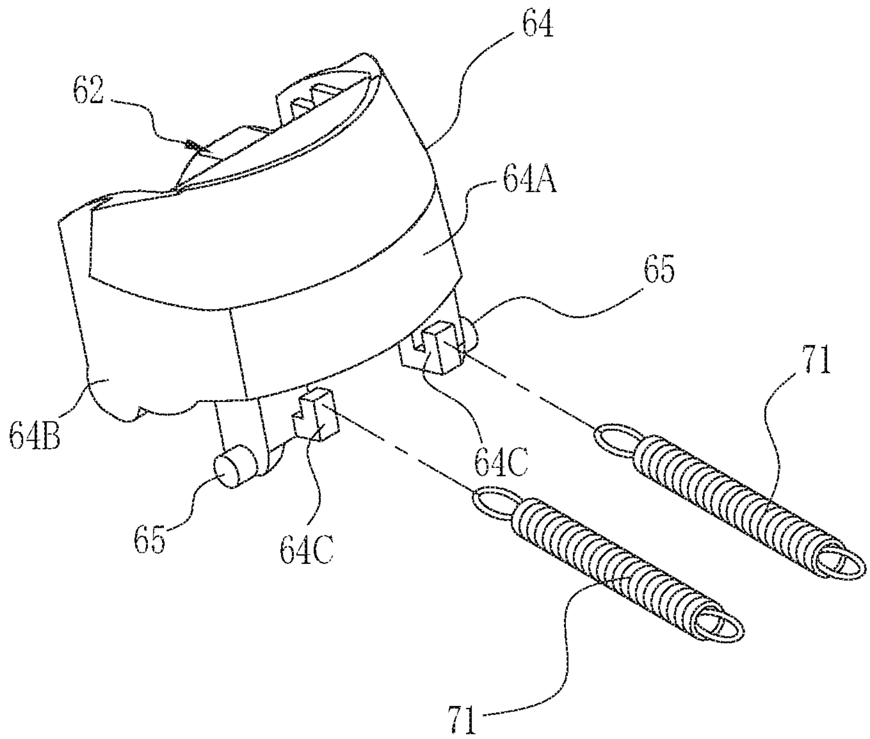


FIG. 12A

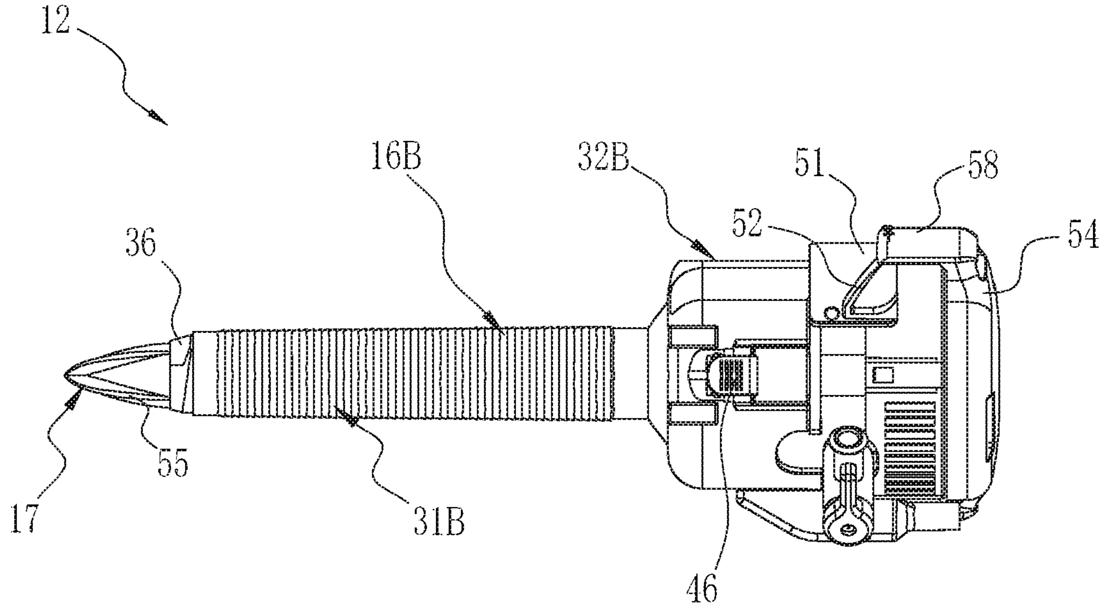


FIG. 12B

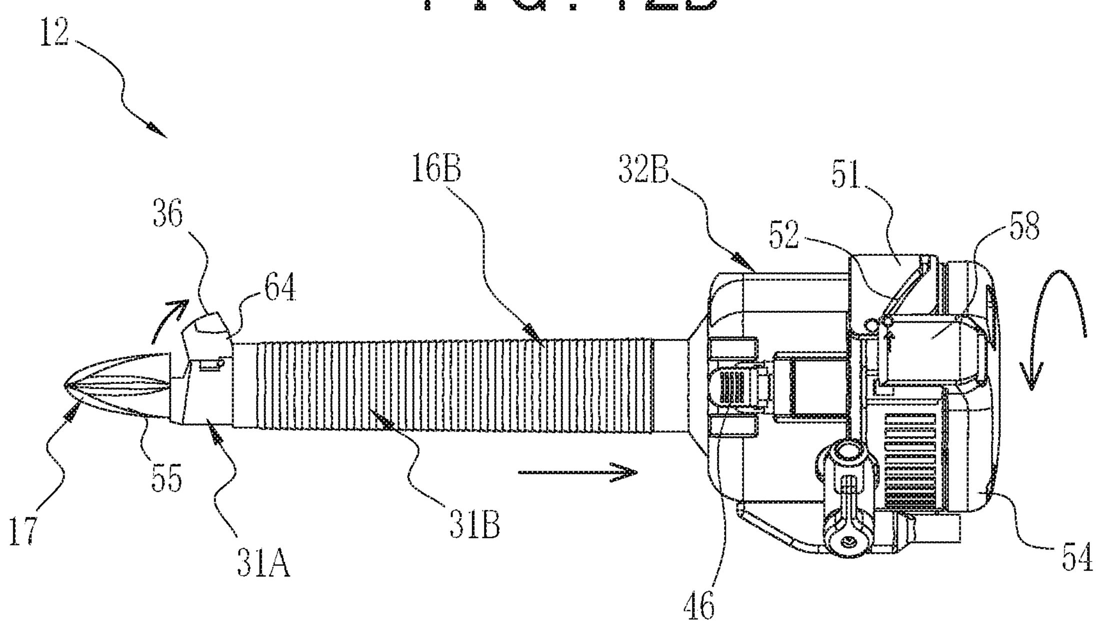


FIG. 13A

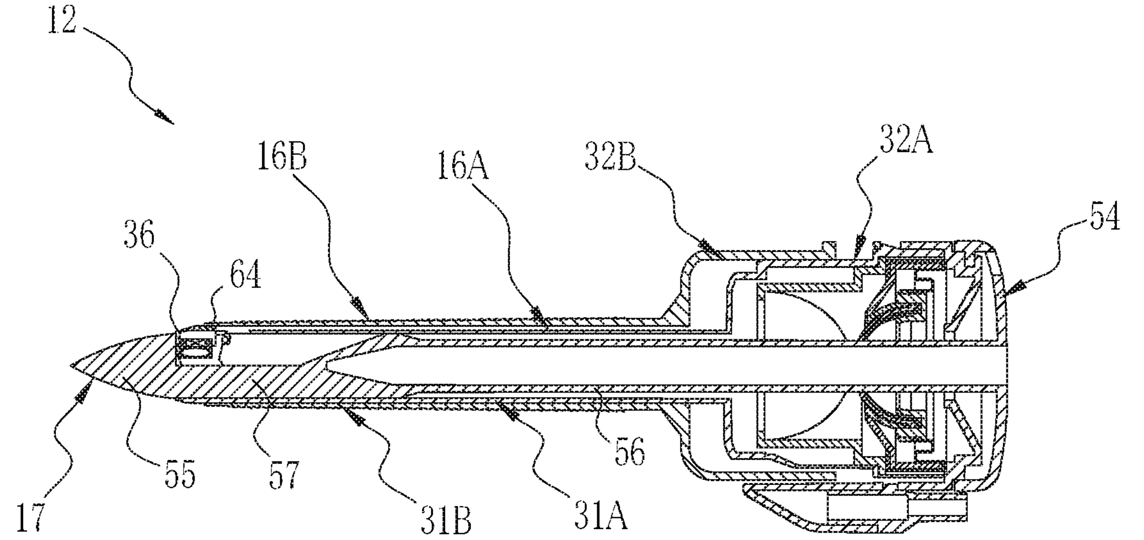


FIG. 13B

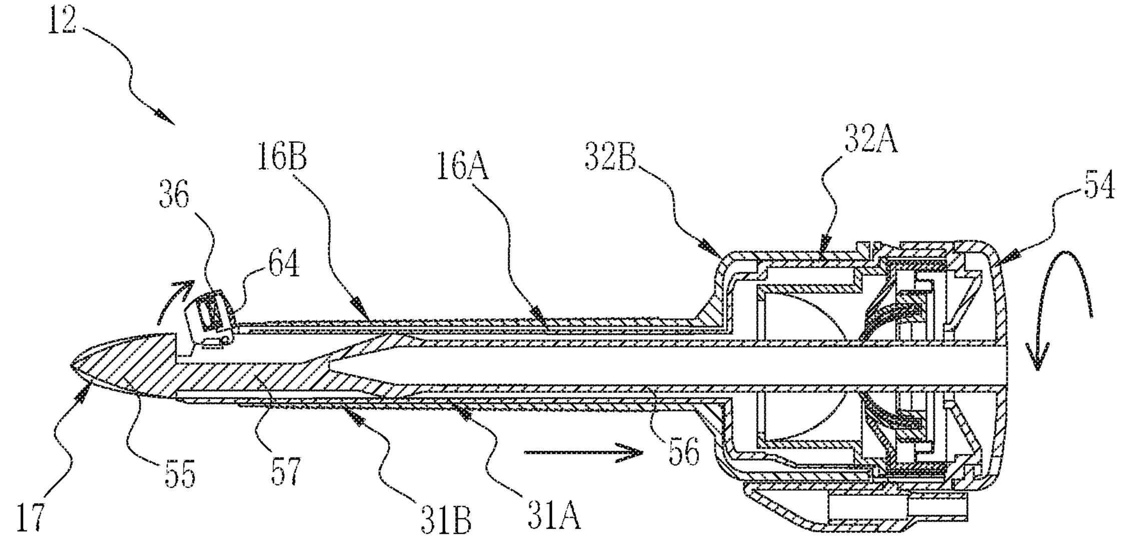


FIG. 14

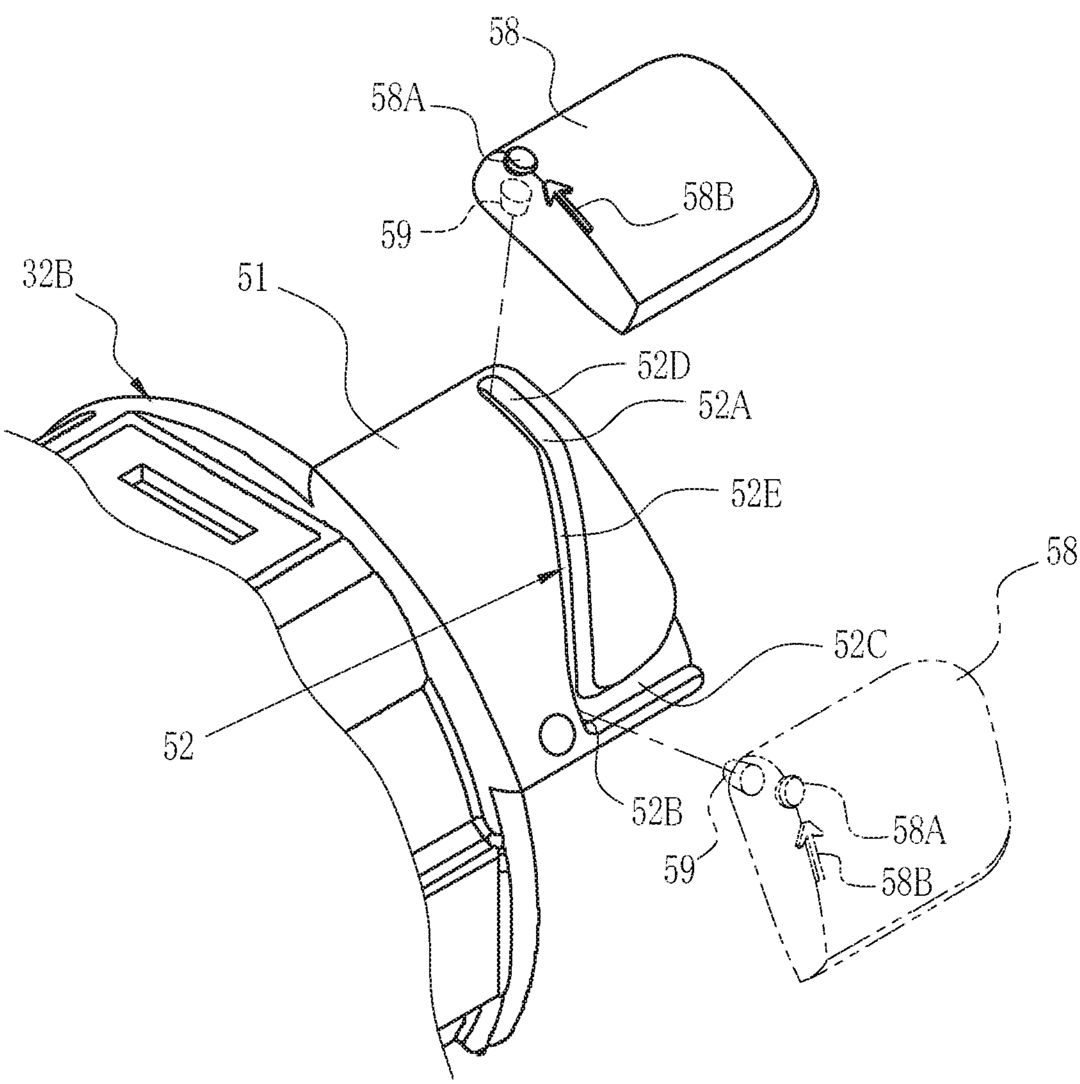


FIG. 15A

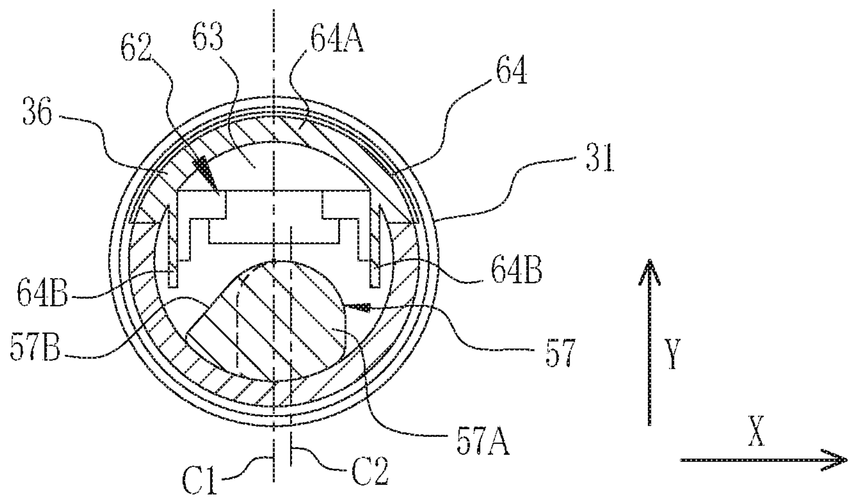


FIG. 15B

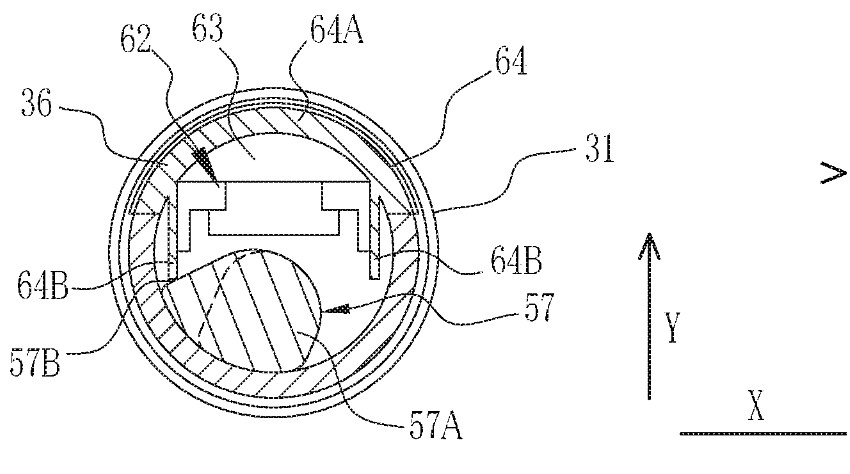


FIG. 15C

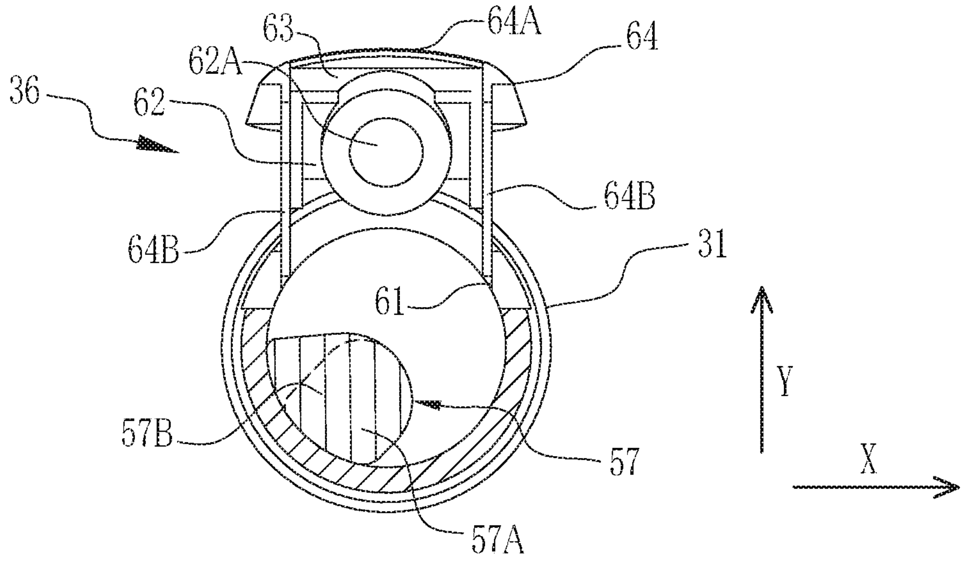


FIG. 16A

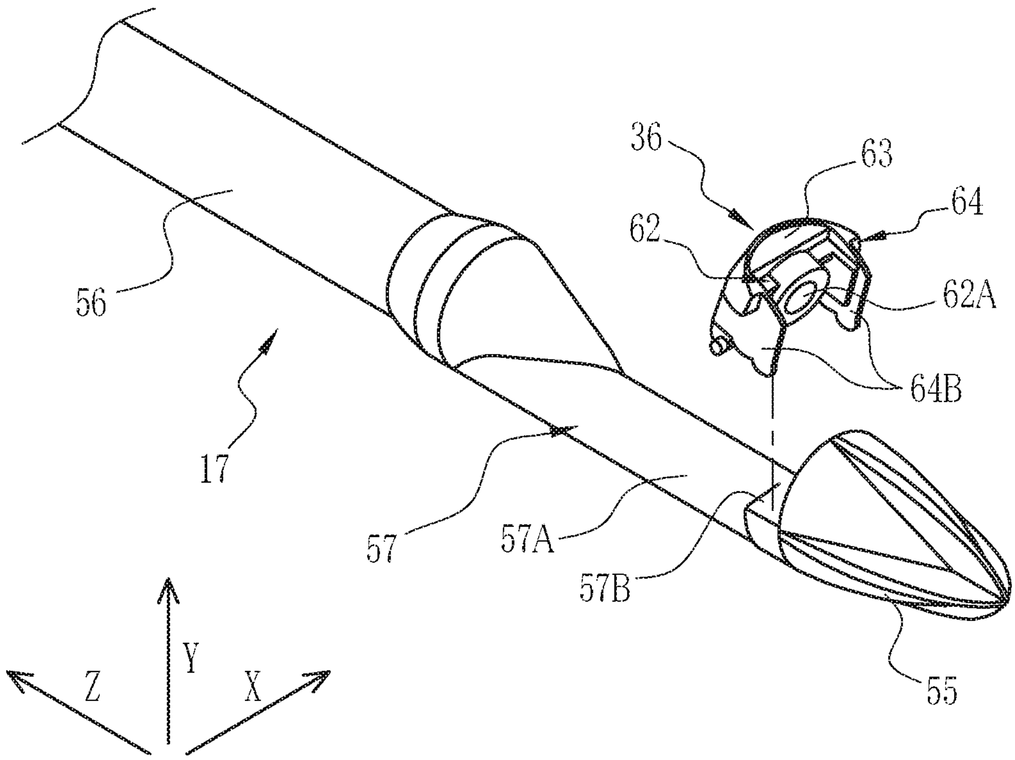
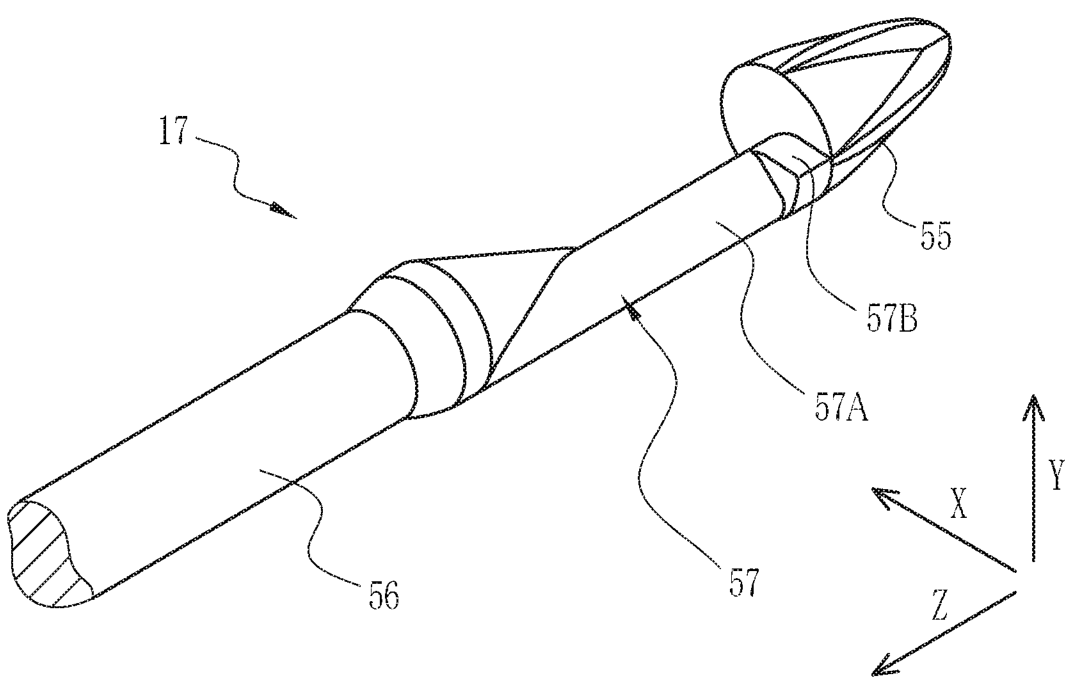
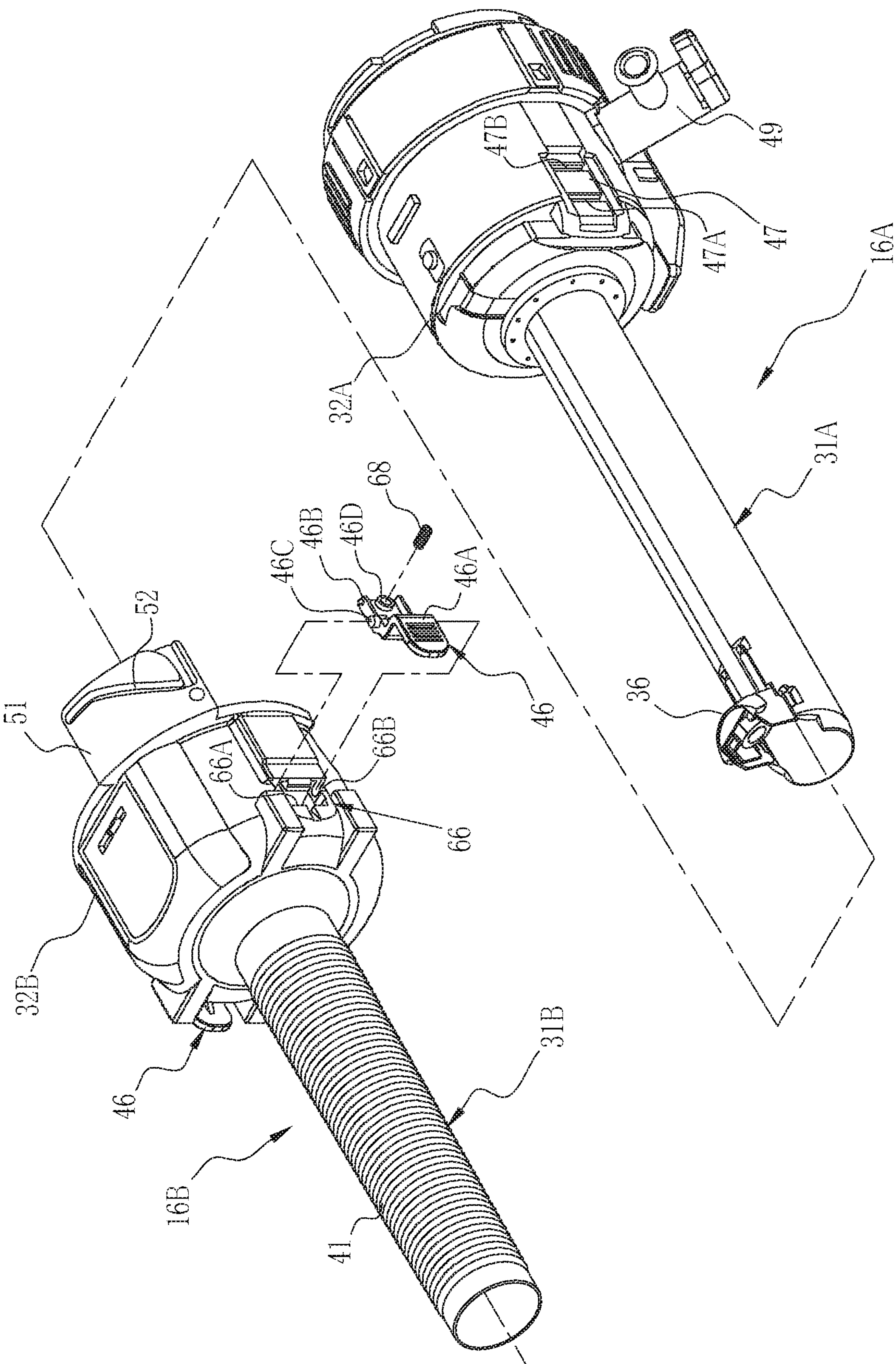


FIG. 16B

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31A
32A
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47A
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36
68
46D
46B
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66A
66B
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32B
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31B
16B
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FIG. 17

FIG. 18A

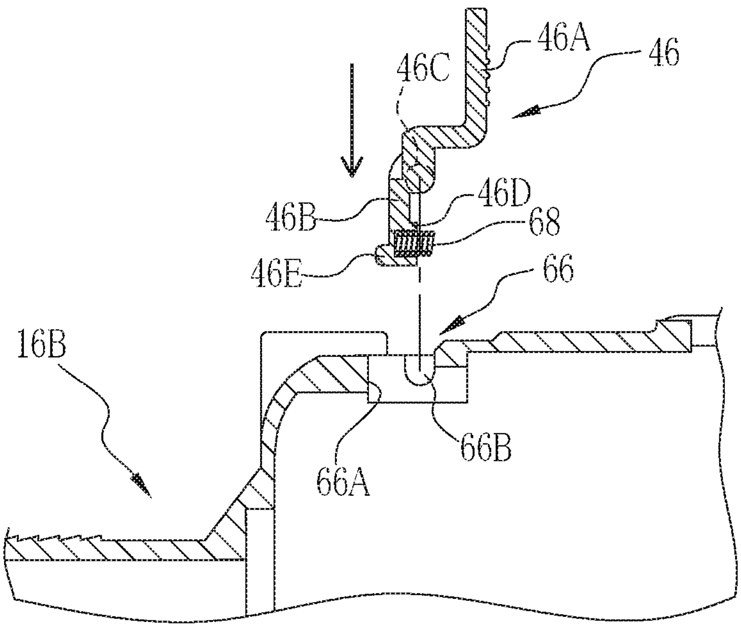


FIG. 18B

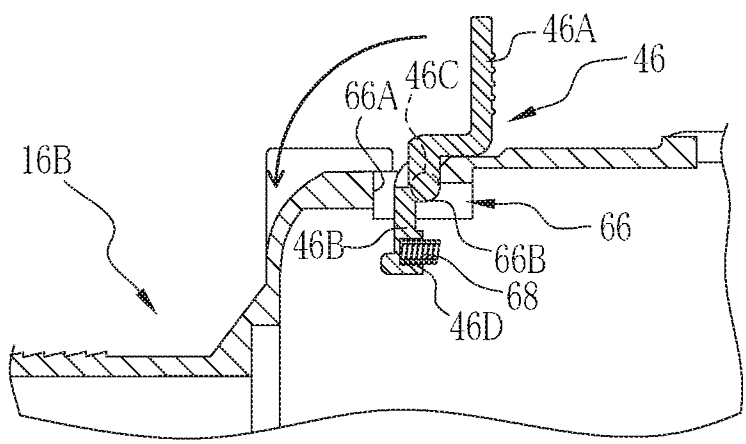


FIG. 18C

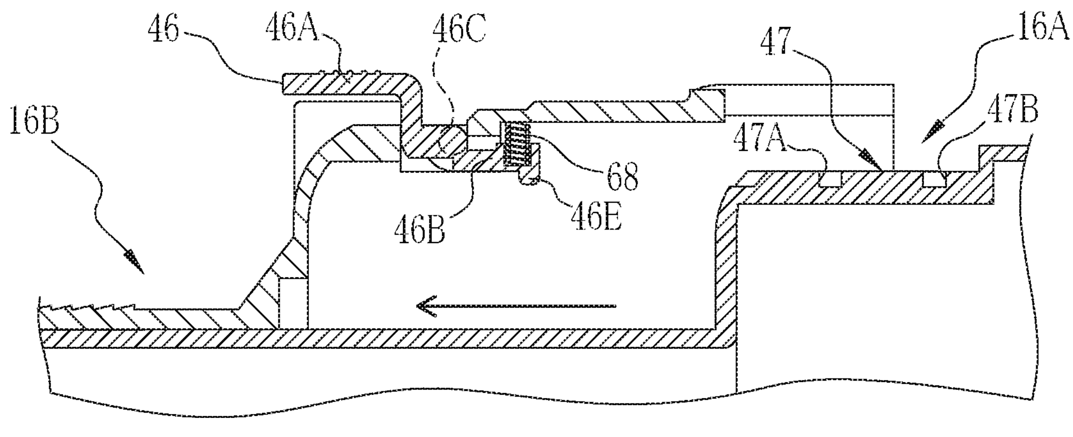


FIG. 19A

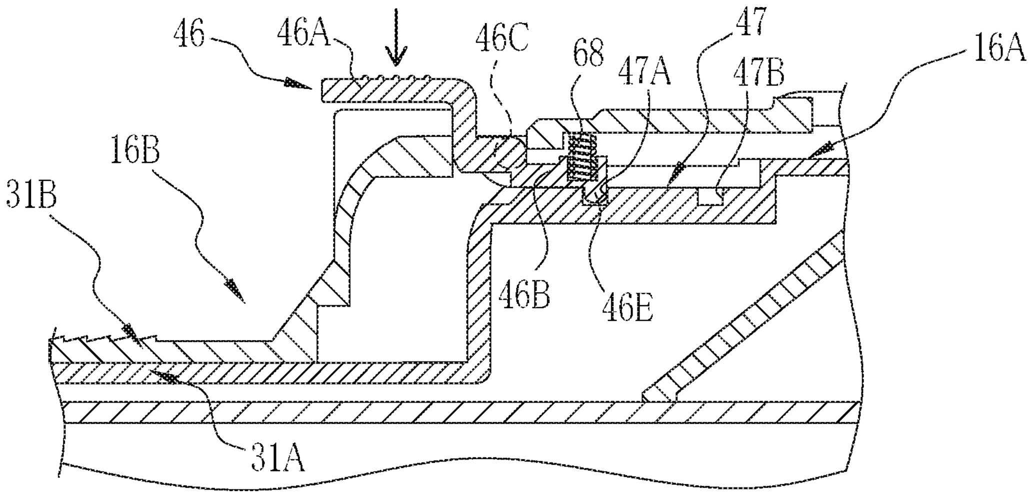


FIG. 19B

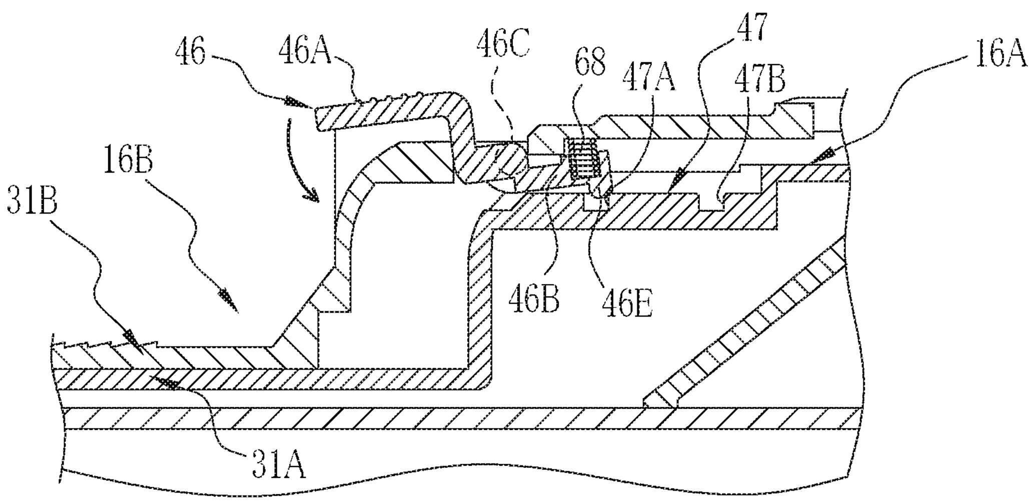


FIG. 19C

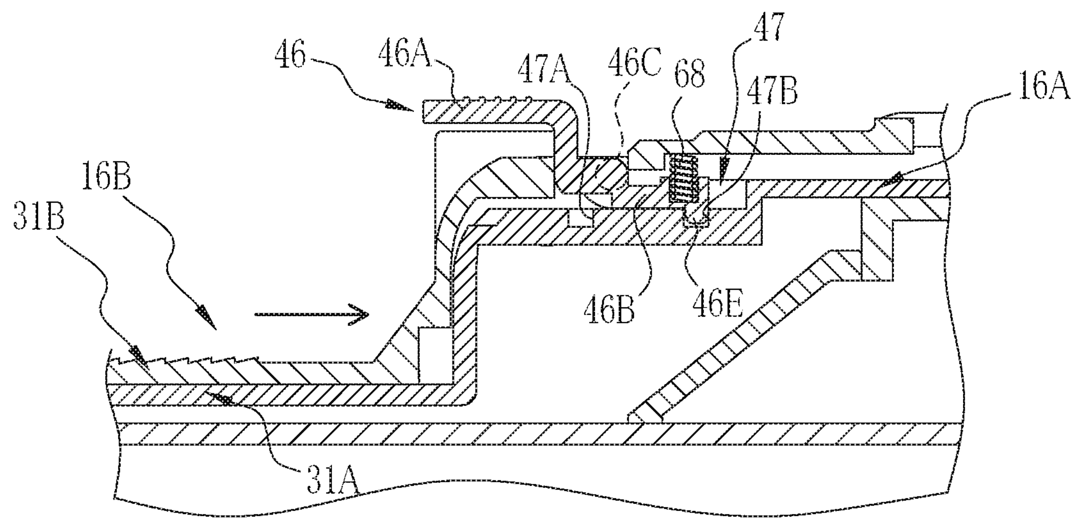


FIG. 20A

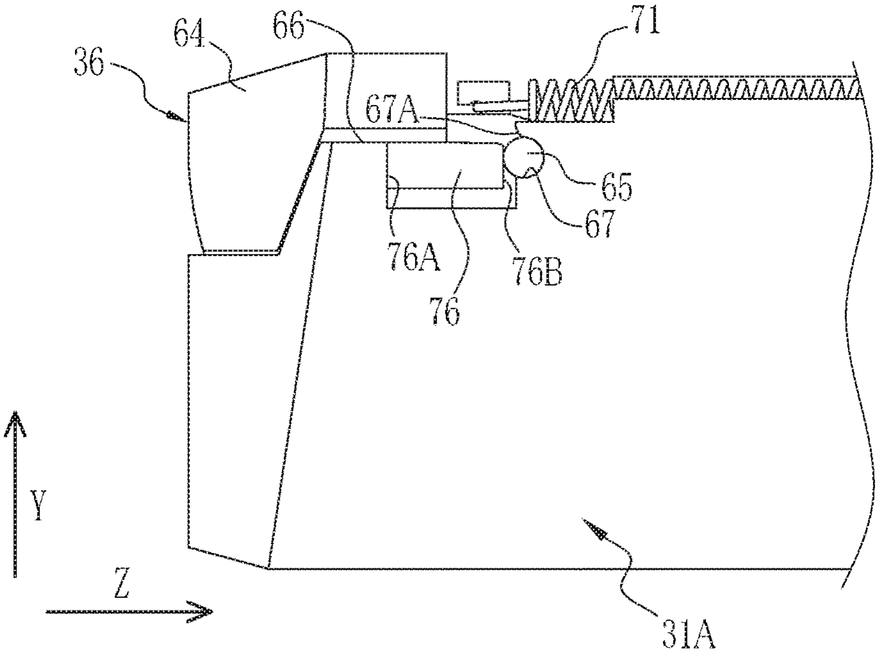


FIG. 20B

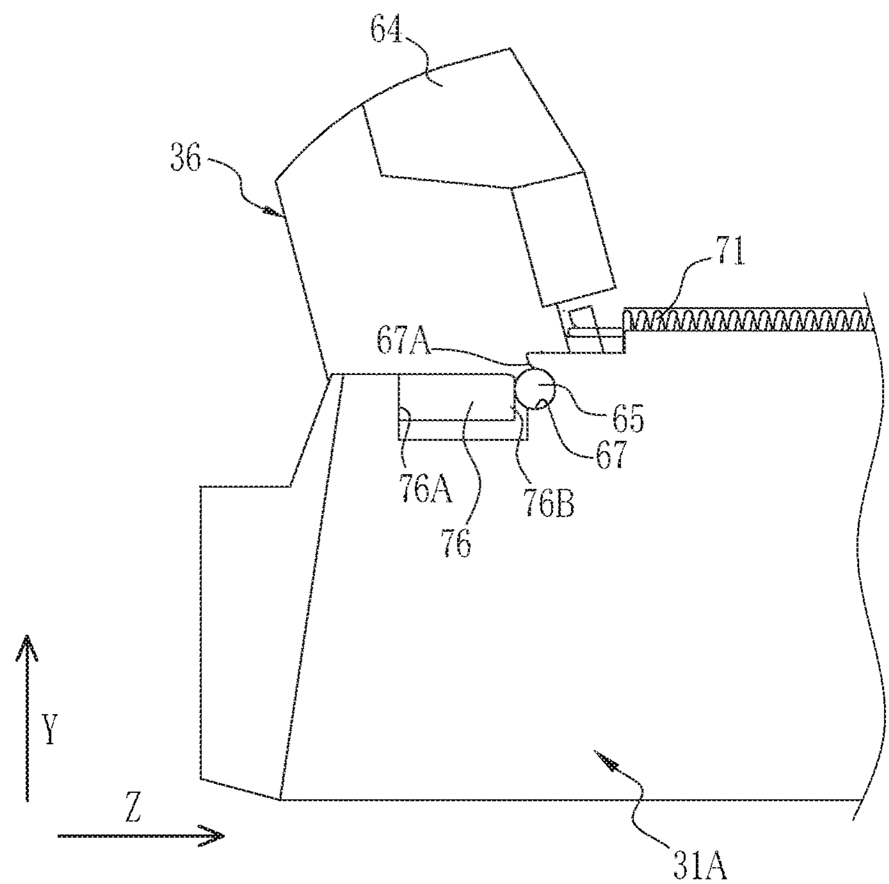


FIG. 21A

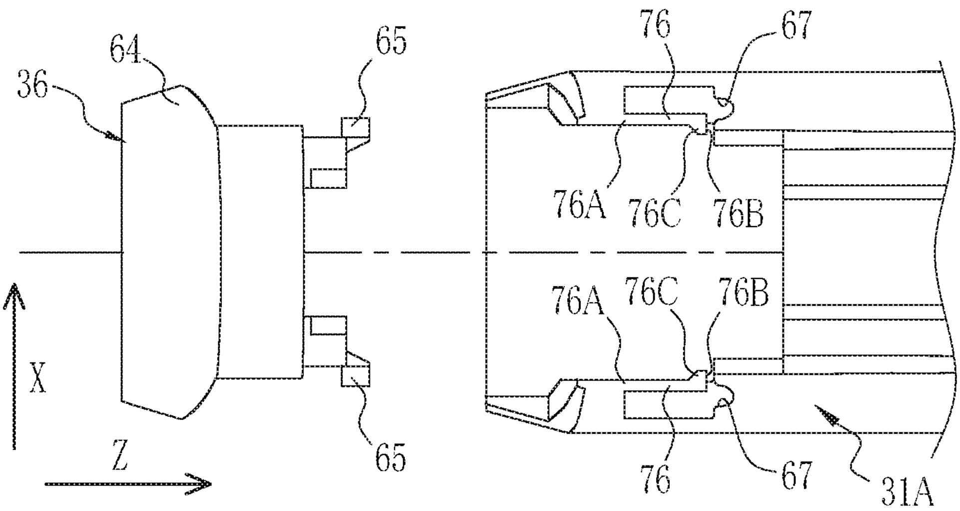


FIG. 21B

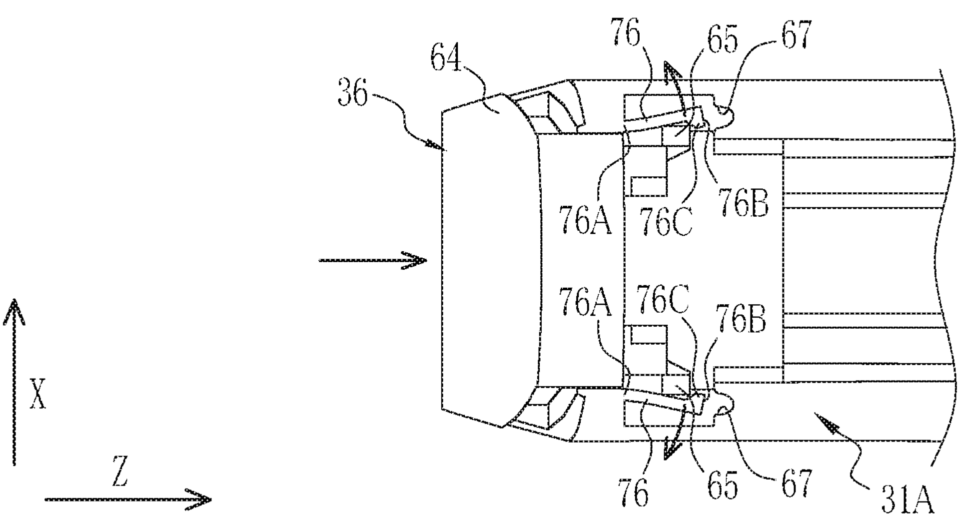


FIG.21C

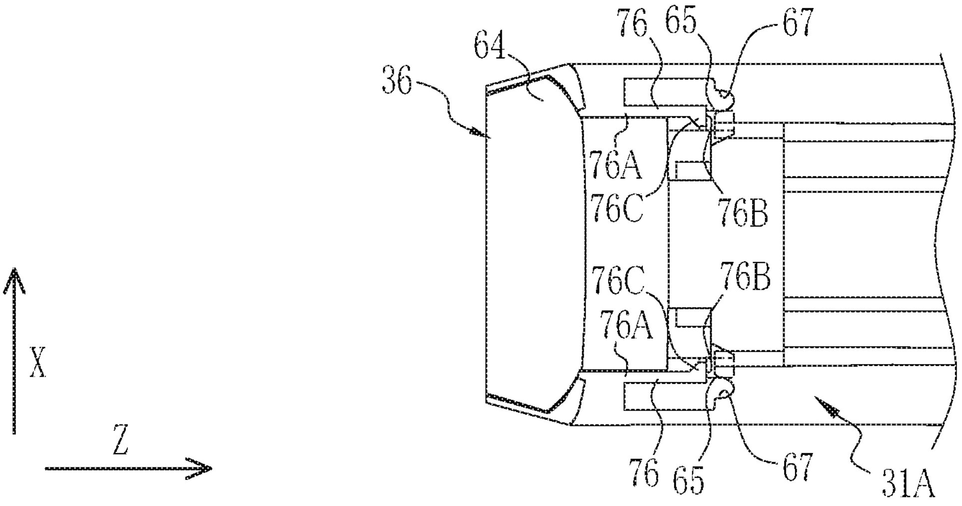


FIG. 22

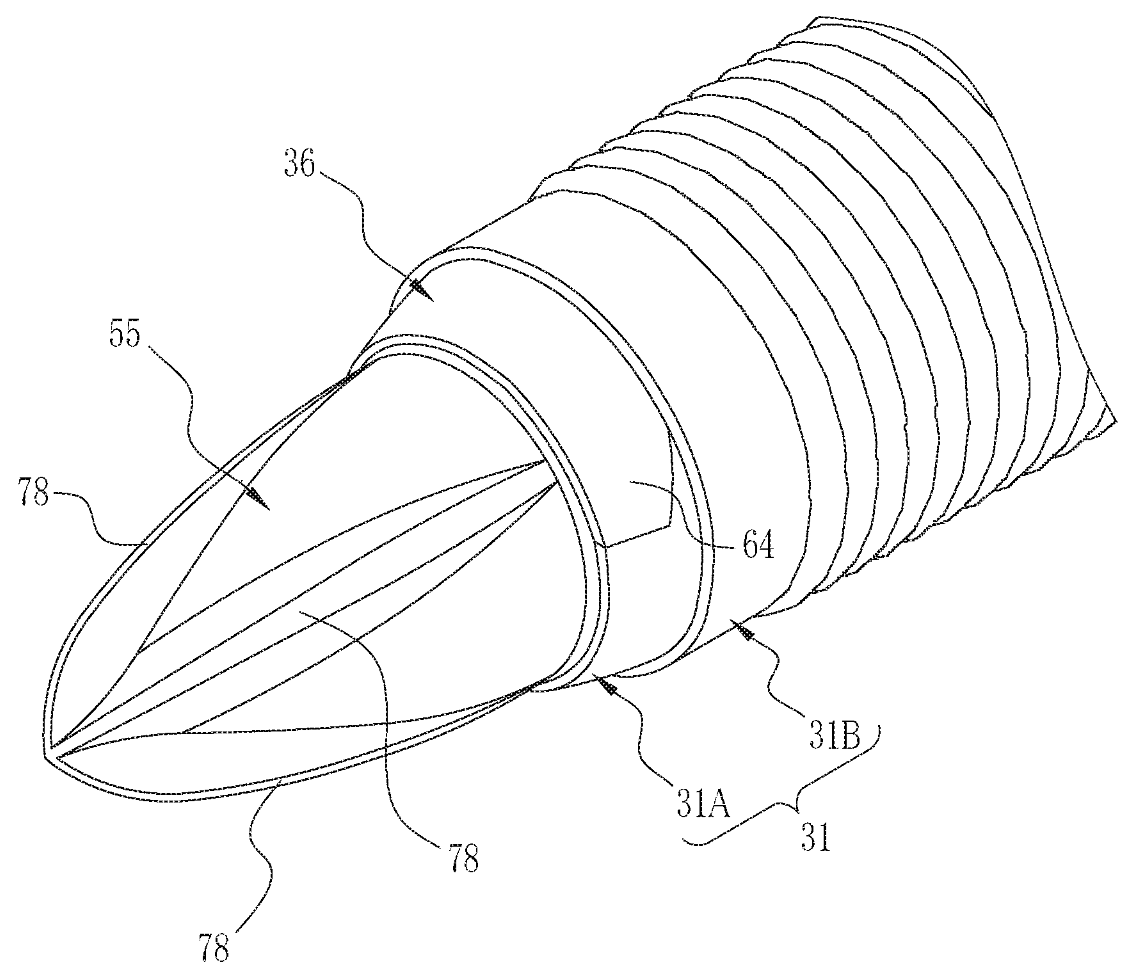
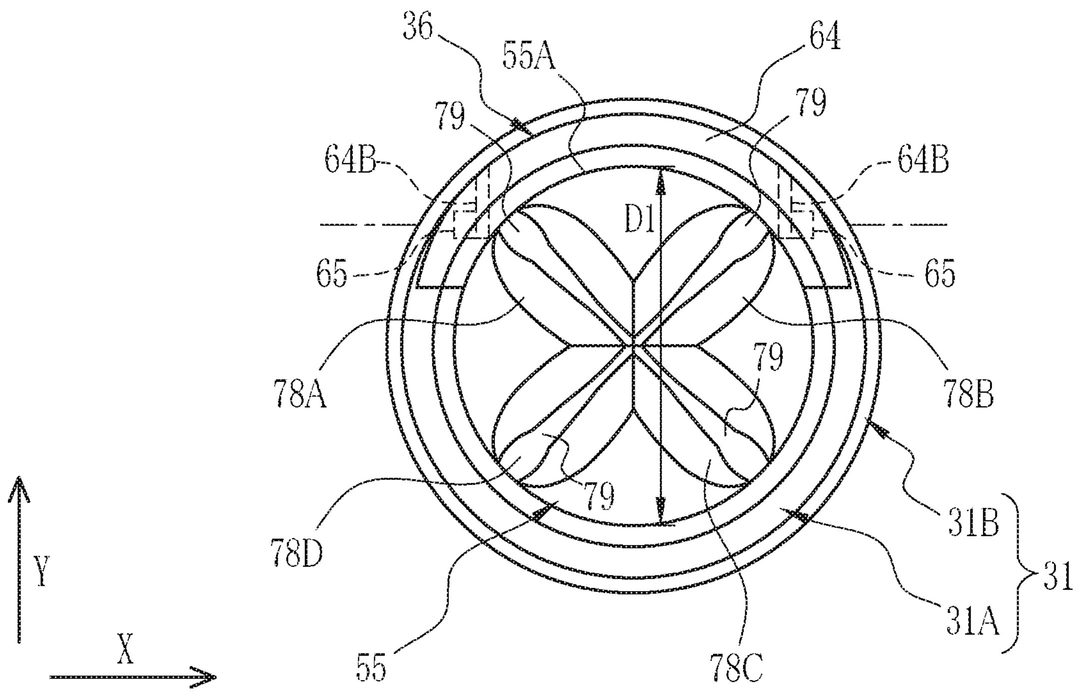


FIG. 23A



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78D
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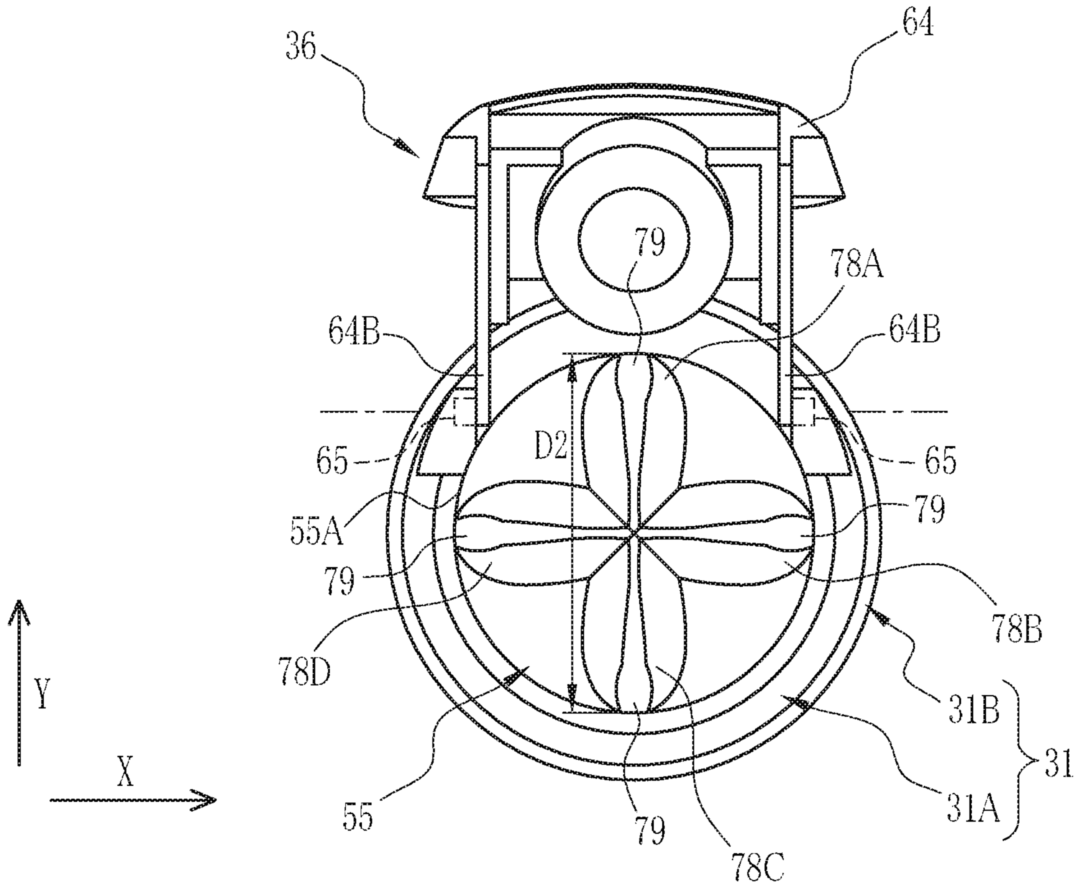
78C
31A

FIG. 23B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78C
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X

FIG. 24A

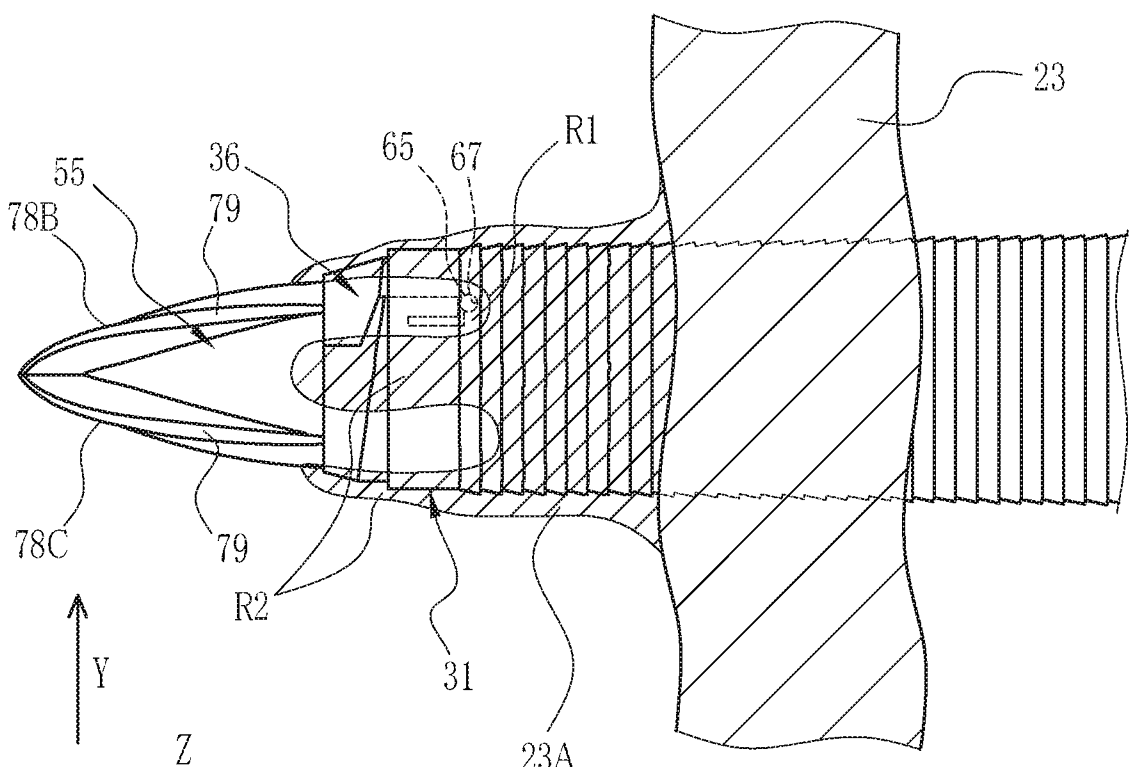


FIG. 24B

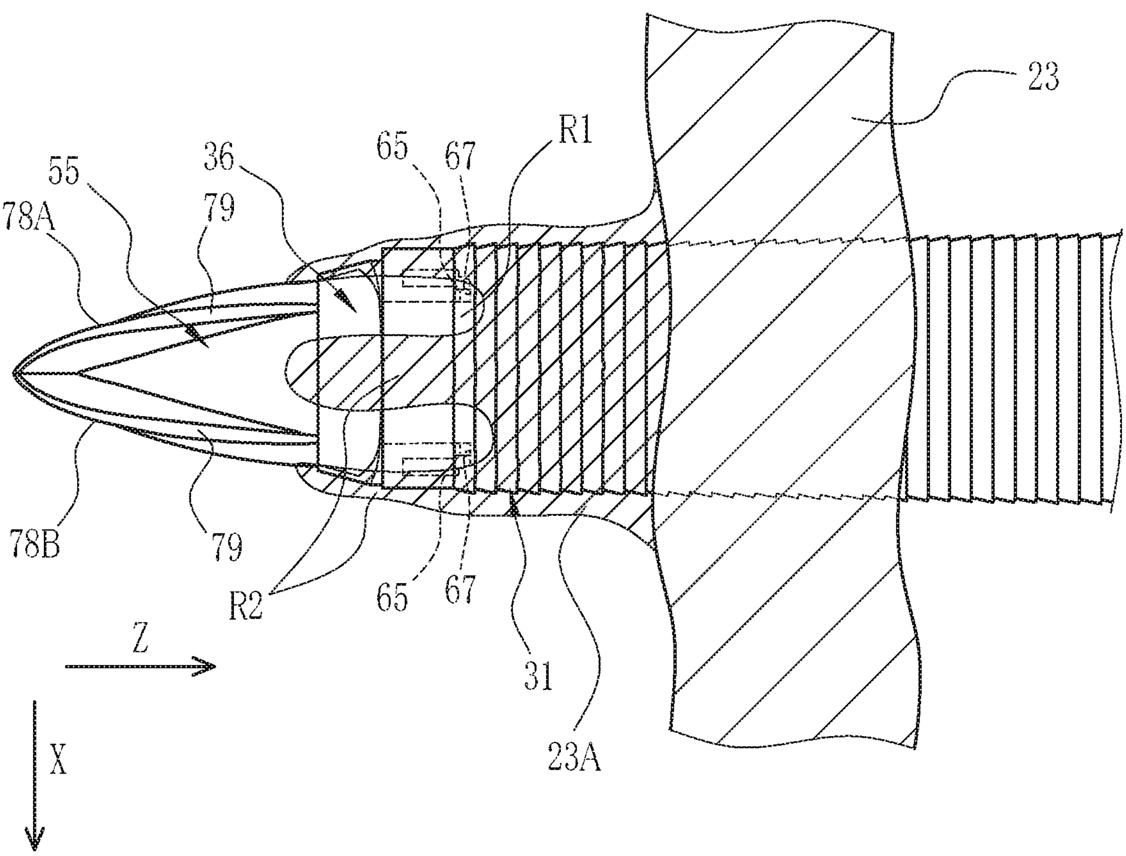


FIG. 25

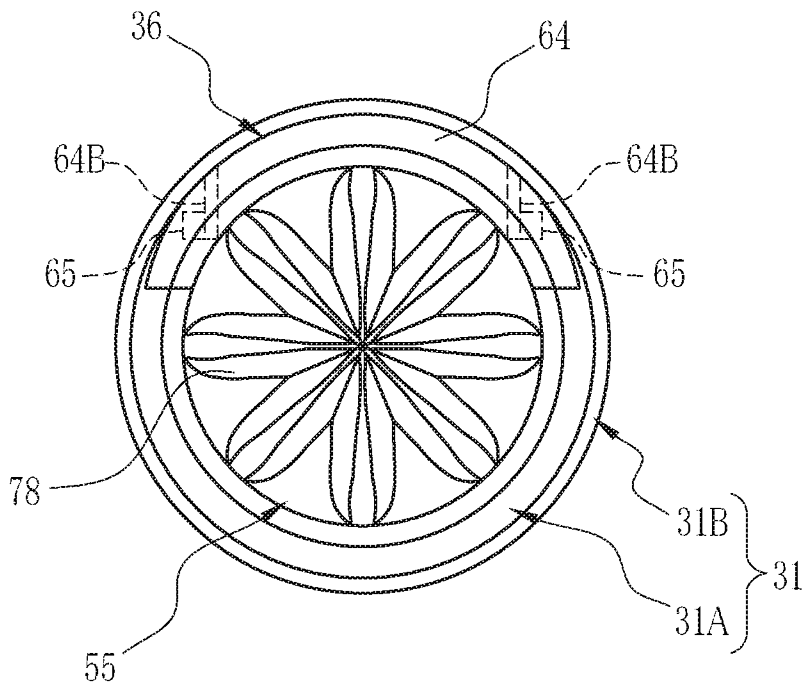


FIG. 26

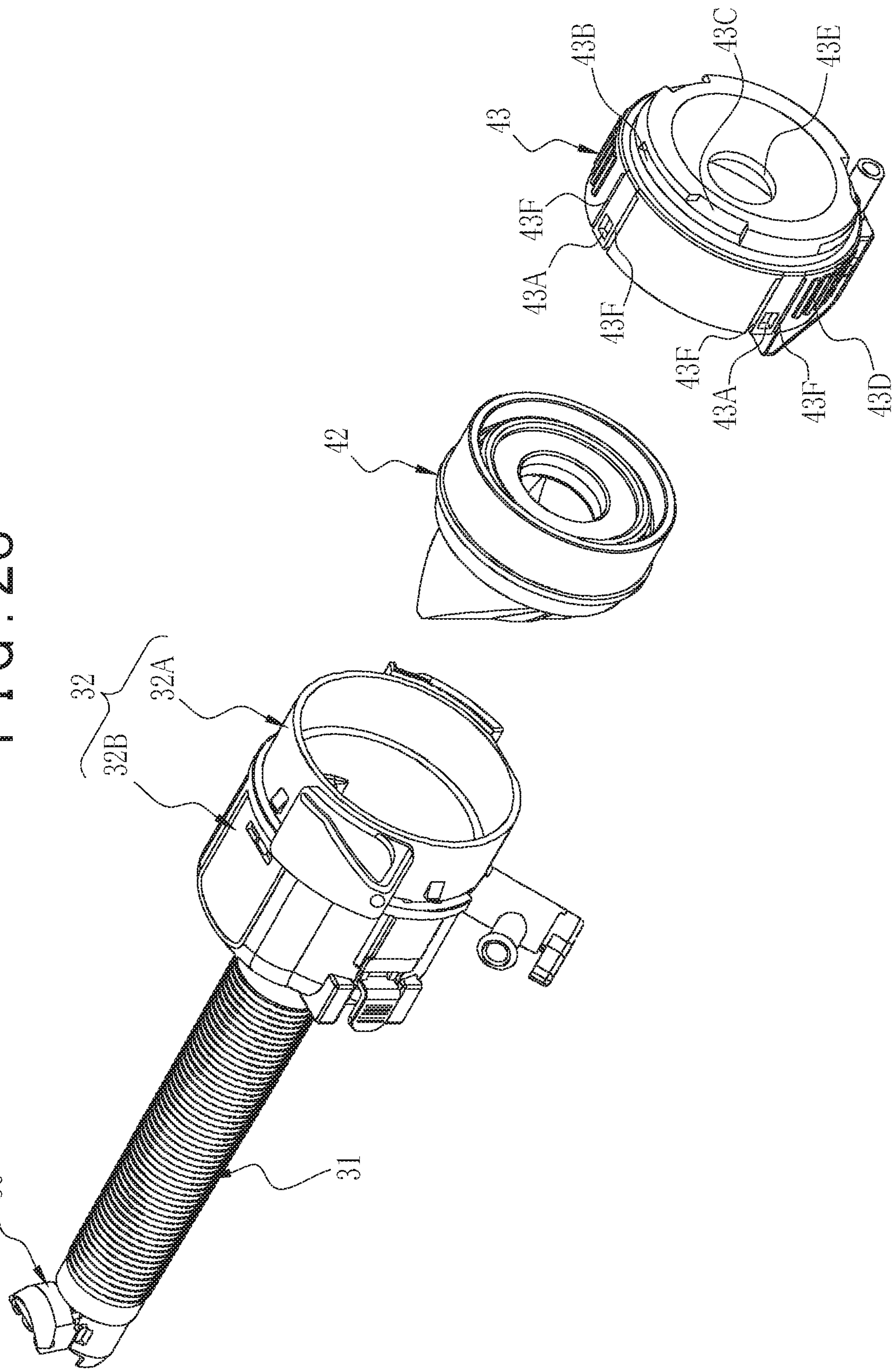
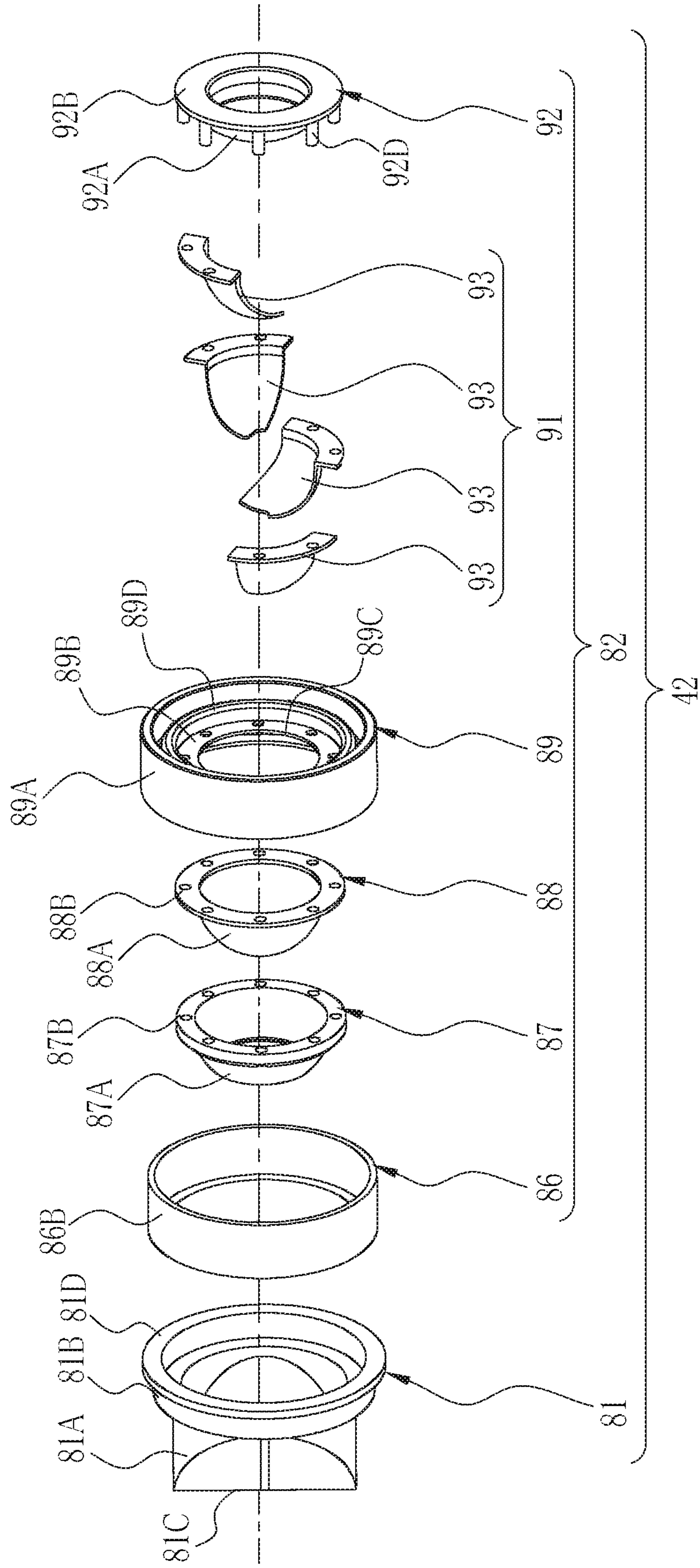


FIG. 27


92B
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92D
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89D
89C
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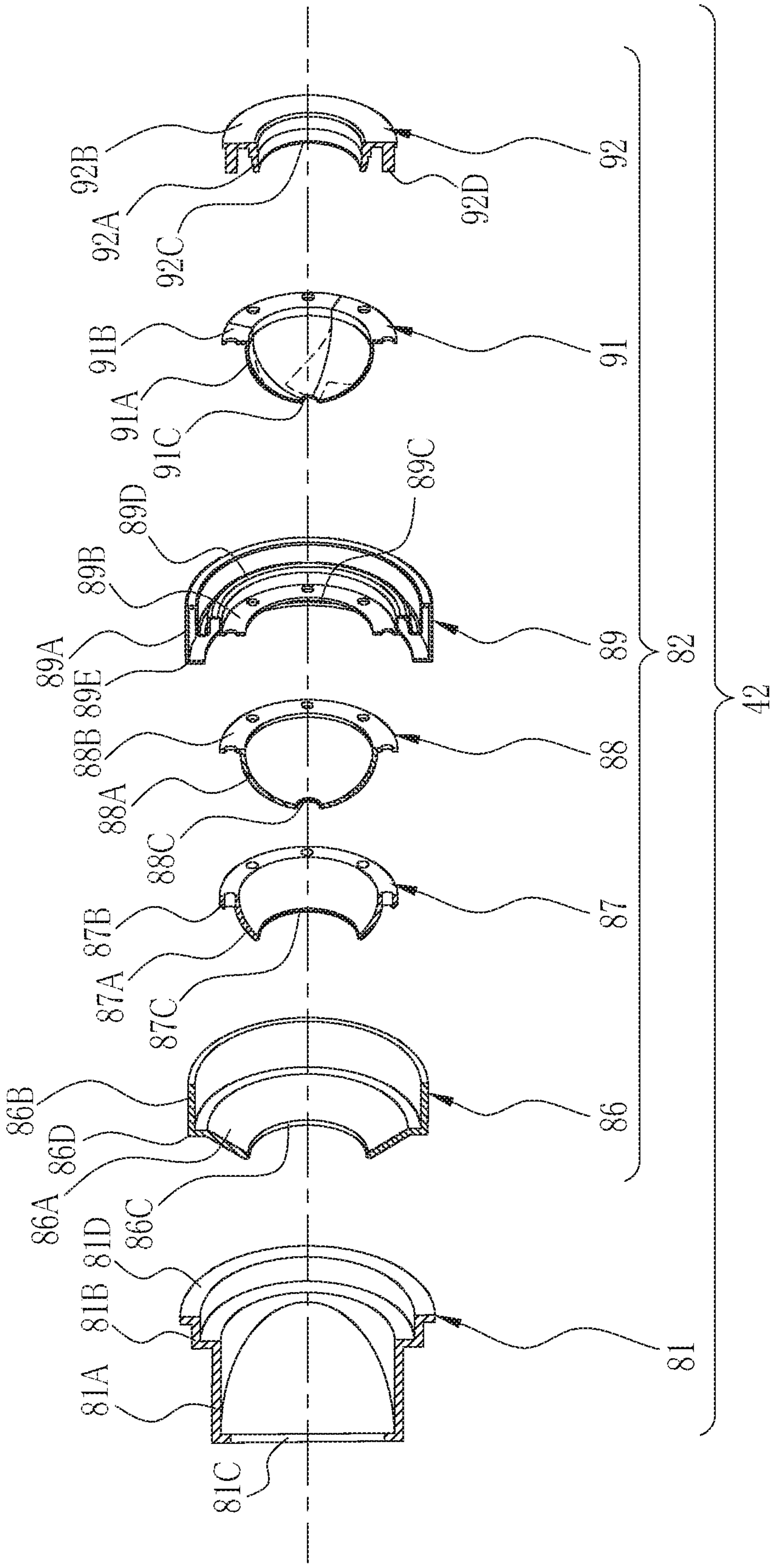
81D
81B
81A
81C
81

FIG. 28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88
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42

FIG. 29

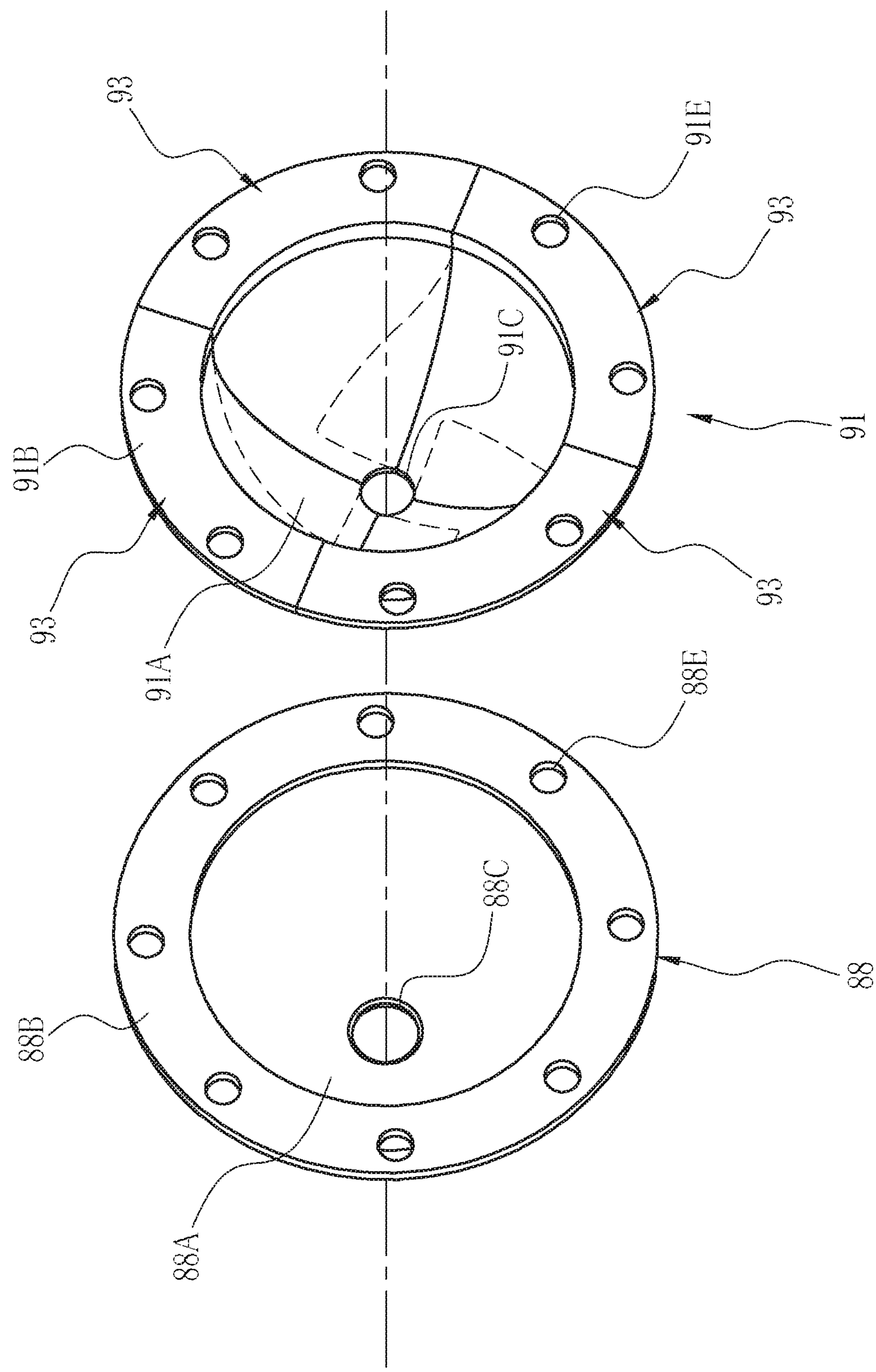
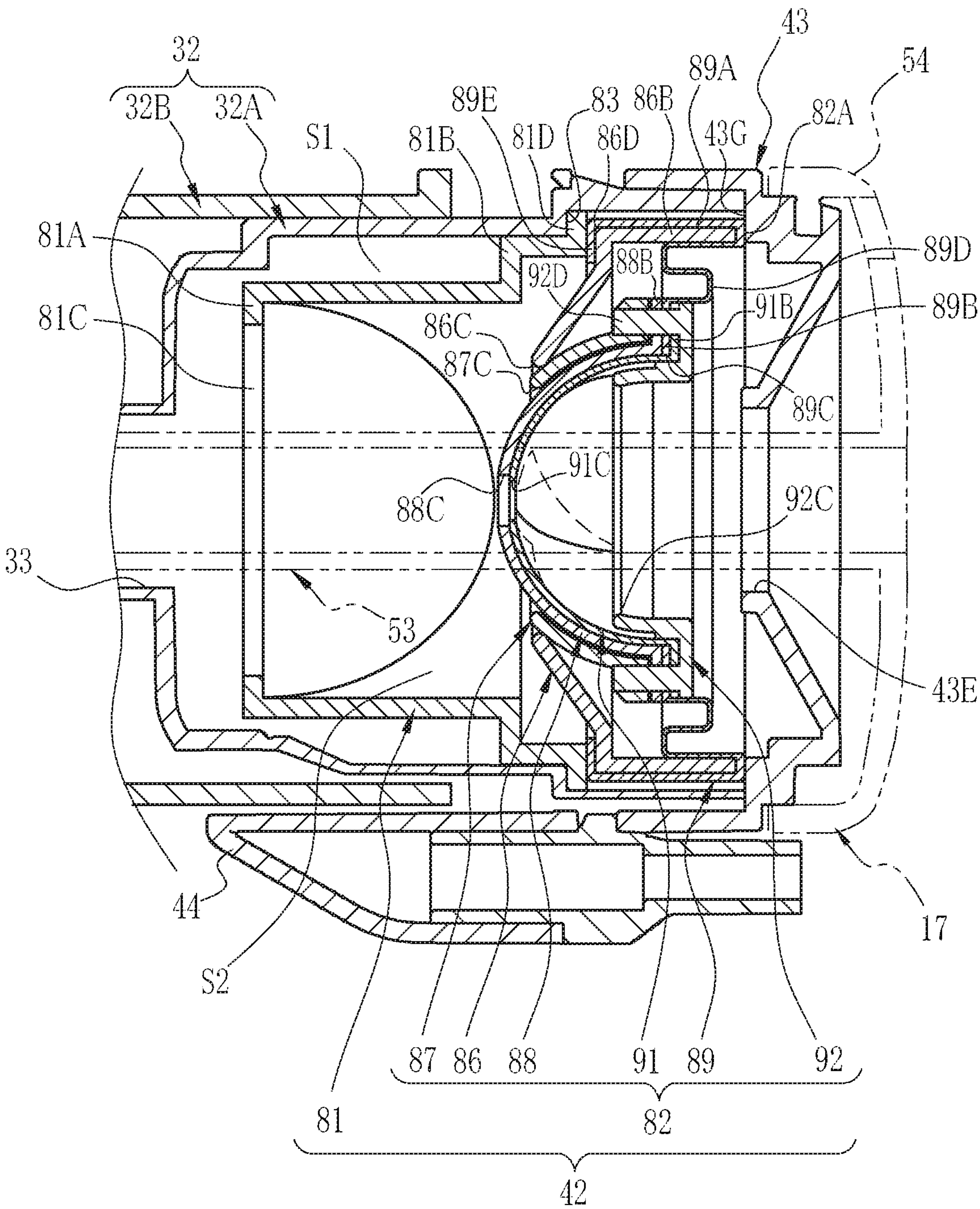


FIG. 30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81D
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92D
88B
91B
86C
87C
89C
91C
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42

FIG. 31A

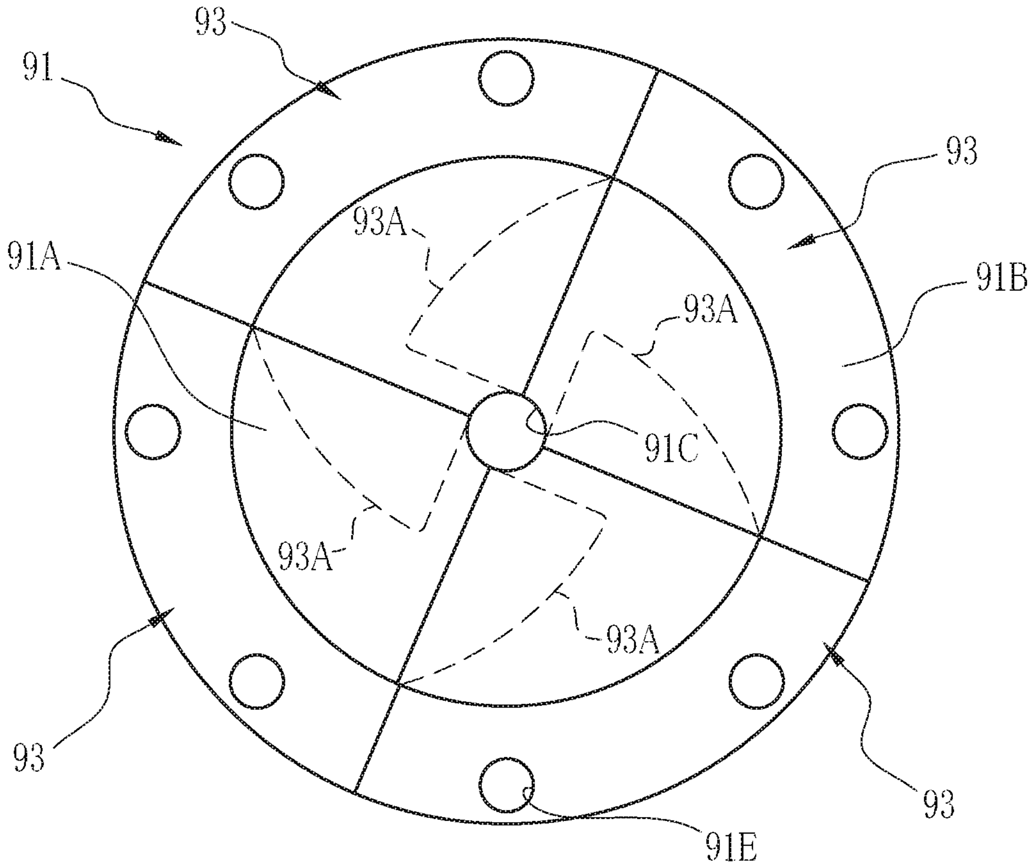


FIG. 31B

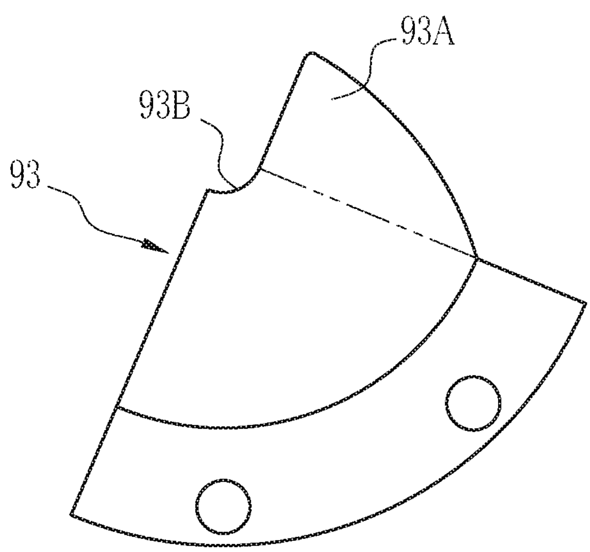


FIG. 32A

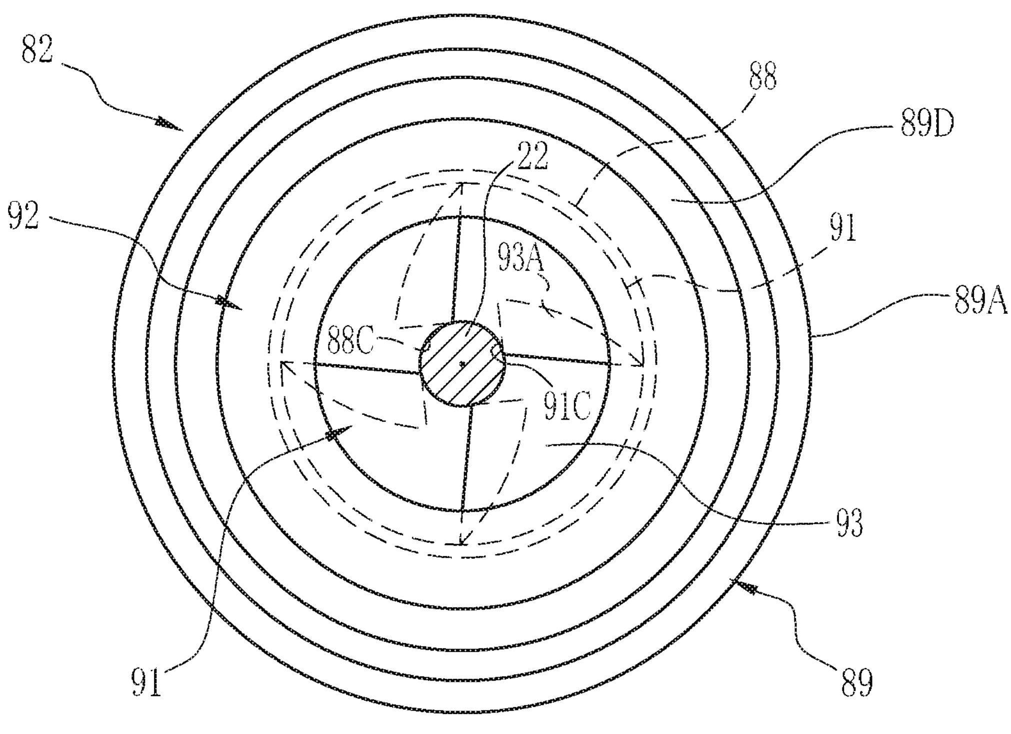


FIG. 32B

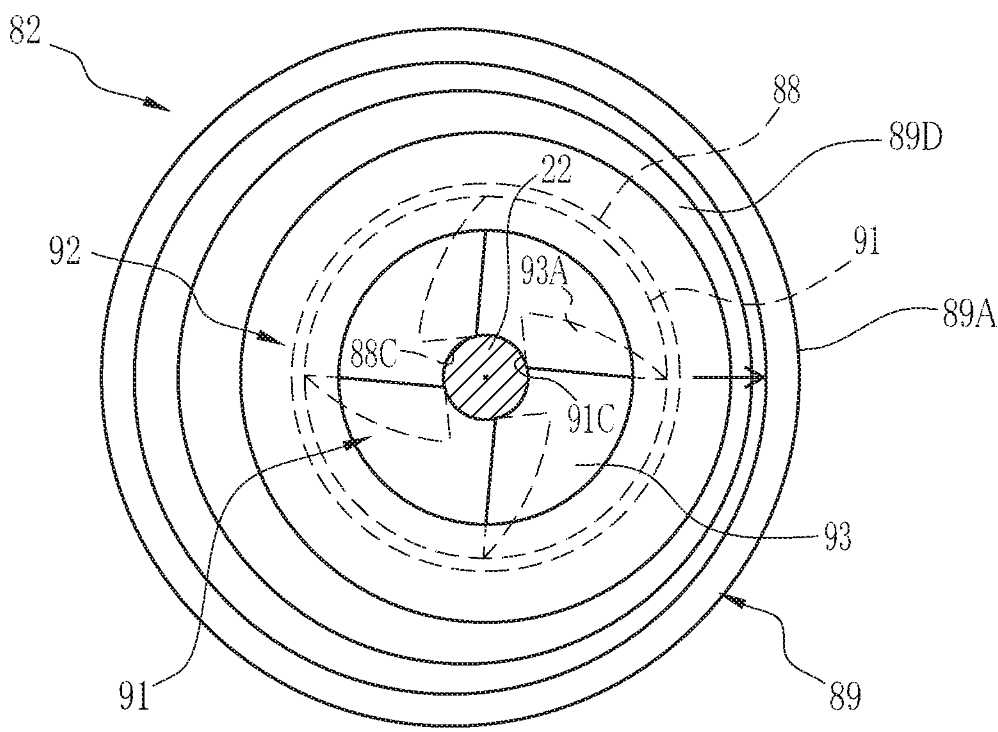


FIG. 33

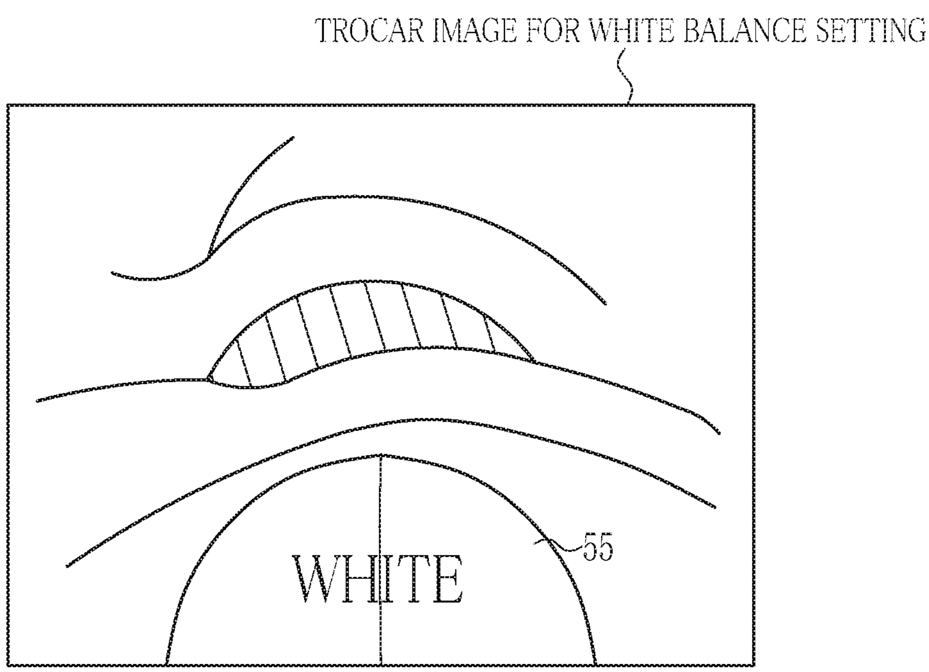


FIG. 34

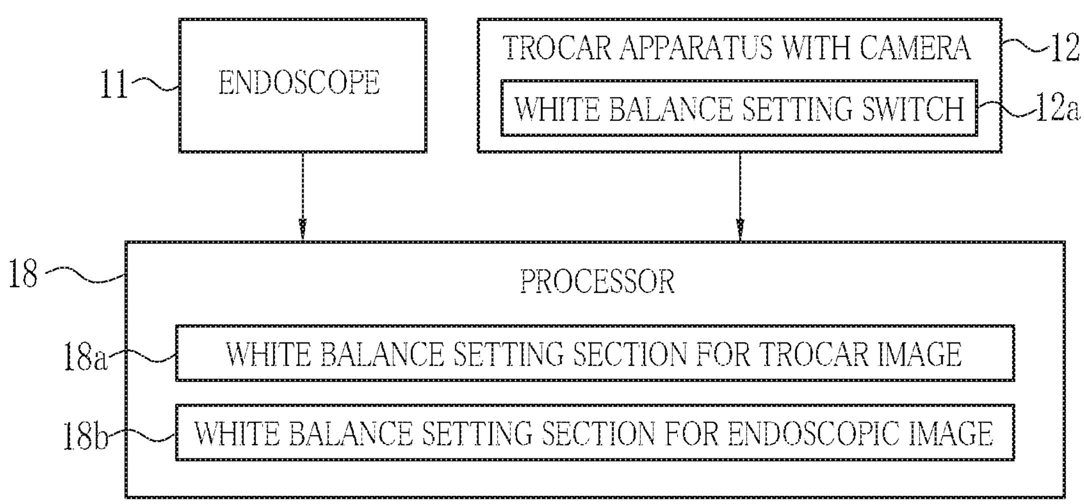
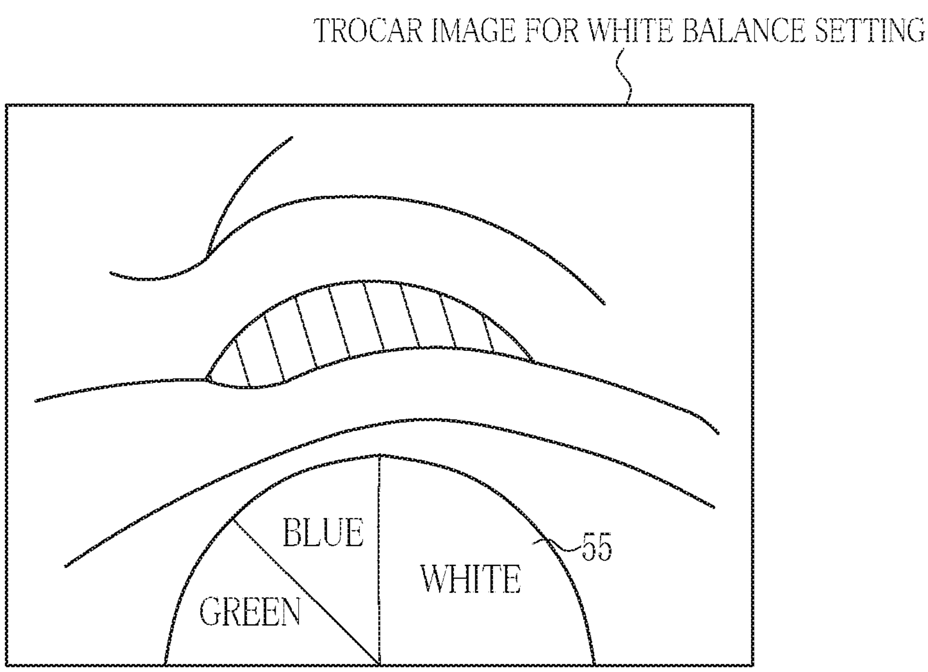

ENDOSCOPE
11
TROCAR APPARATUS WITH CAMERA
12
WHITE BALANCE SETTING SWITCH
12a
PROCESSOR
18
WHITE BALANCE SETTING SECTION FOR TROCAR IMAGE
18a
WHITE BALANCE SETTING SECTION FOR ENDOSCOPIC IMAGE
18b

FIG. 35



BODY CAVITY OBSERVATION SYSTEM, LAPAROSCOPE SYSTEM, TROCAR APPARATUS, AND OPERATION METHOD OF BODY CAVITY OBSERVATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation of PCT International Application No. PCT/JP2017/040482 filed on 9 Nov. 2017, which claims priority under 35 U.S.C § 119(a) to Japanese Patent Application No. 2016-220049 filed on 10 Nov. 2016. The above application is hereby expressly incorporated by reference, in its entirety, into the present application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present application is subject to "Development of Medical Devices through Collaboration between Medicine and Industry" commissioned research of Japan Agency for Medical Research and Development, 2016 and to Industrial Technology Enhancement Act, Article 19, and relates to a body cavity observation system, a laparoscope system, a trocar apparatus, and an operation method of body cavity observation system.

2. Description of the Related Art

In the medical field, observation of the state of a body cavity is performed using an endoscope apparatus such as a laparoscope or a capsule endoscope. Such the endoscope apparatus is provided with an imaging element and other elements for imaging an observation target in the body cavity, but due to individual difference among these imaging elements, it is necessary to perform calibration such as white balance. However, since inside of body cavity is mostly reddish visceral tissue, it is necessary to insert a white reference from outside the body into the body cavity for performing white balance in the body cavity. For example, in case of using a laparoscope, it may be considered that a piece of white gauze is inserted into the body cavity from a port different from a port provided with the laparoscope and the white gauze is imaged with the laparoscope, to perform the white balance. However, such the task is very troublesome and imposes a burden on a user.

Therefore, for performing observation with the endoscope apparatus, a white chart is imaged and white balance is performed based on the obtained image, before the endoscope apparatus is inserted in the body cavity. For example, in case of a laparoscope, a distal end of the laparoscope is inserted into a device provided with a reference material of white balance to perform white balance, as in JP5266065B2 (corresponding to US2008/161646A1). In case of a capsule endoscope, the entire capsule endoscope is placed in a device provided with an image quality adjustment sheet corresponding to a white chart to perform white balance, as in JP2009-195558A.

SUMMARY OF THE INVENTION

In an endoscopic operation using a laparoscope, a field of view of a target site to be treated is provided exclusively by a laparoscopic image. Therefore, the field of view is remarkably restricted as compared with an abdominal operation capable of observing the target site to be treated with naked

eyes. In such the endoscopic operation, in order to perform appropriate procedures, it has been required to eliminate blind spots as much as possible by providing another field of view different from the laparoscopic image.

In order to meet such the demand, a trocar apparatus with camera, which has a camera at the distal end of a trocar for inserting a treatment tool such as a forceps, an electronic knife, a stapler or so on, has been proposed (JP2016-016053A). According to the trocar apparatus with camera, since a new body cavity image different from the laparoscopic image can be obtained, it is possible to widen the field of view. The trocar apparatus with camera is a retractable type to displace between a storage position where a camera is stored in a pipe section having an insertion of a treatment tool and a deployed position where the camera is popped up in a direction projecting from the outer peripheral surface of the pipe portion. The camera is displaced to the storage position for inserting/extracting the trocar device into/from the body cavity, and is displaced to the deployed position for observing inside the body cavity.

The trocar apparatus with camera is sealed with a package or the like to prevent attachment of germs and so on until immediately before use. At the time of starting to use, the trocar apparatus with camera is opened from the package. As for the trocar apparatus with camera, as described above, it is necessary to perform white balance. However, from the viewpoint of avoiding attachment of germs and so on, it is preferable that the trocar device is inserted into the body cavity right after taken out from the package, and white balance is performed in the body cavity.

An object of the present application is to provide a body cavity observation system, a laparoscope system, a trocar apparatus, and an operation method of body cavity observation system, which are capable of performing white balance in a body cavity.

A body cavity observation system of the present application comprises a trocar with camera including a trocar having a pipe section that is insertable into a body cavity, a trocar shaft attached to the trocar when the trocar is inserted into the body cavity, the trocar shaft having a white part formed on a surface of a puncture member at a distal end of the trocar shaft, the puncture member that is exposed from a distal end of the pipe section, a camera section disposed in a distal end area of the pipe section, the camera section obtaining a trocar image, that includes an image of the white part, by performing imaging when the puncture member of the trocar shaft is exposed, and a white balance setting section, which sets a white balance for subsequent trocar images based on the image of the white part in the trocar image. It is preferable that the camera section is displaceable between a storage position where the camera section is stored in the pipe section and a deployed position where the camera section is deployed in a direction projecting from the outer peripheral surface of the pipe section, and the camera section performs imaging at the deployed position.

A laparoscope system of the present application comprises the body cavity observation system, and an endoscope inserted in a trocar different from the trocar of the body cavity observation system. The white part formed on the surface of the puncture member is illuminated with illumination light from the endoscope. It is preferable that the white balance for the trocar image is substantially the same as a white balance for an endoscopic image obtained by the endoscope.

A trocar apparatus of the present application is used for setting a white balance of a trocar image obtained inside a body cavity, the trocar apparatus comprising a trocar having a pipe section that is insertable into the body cavity, and a trocar shaft attached to the trocar when the trocar is inserted into the body cavity, the trocar shaft having a white part formed on a surface of a puncture member at a distal end of the trocar shaft, and the puncture member that is exposed from a distal end of the pipe section. The trocar image includes an image of the white part, that is used by a white balance setting section to set the white balance of subsequent trocar images.

It is preferable to provide a camera section disposed in a distal end area of the pipe section, to obtain the trocar image including the image of the white part by performing imaging when the puncture member of the trocar shaft is exposed. It is preferable that the camera section is displaceable between a storage position where the camera section is stored in the pipe section and a deployed position where the camera section is deployed in a direction projecting from the outer peripheral surface of the pipe section, and the camera section performs imaging at the deployed position. It is preferable that the white balance setting section is provided in a processor connected to the trocar.

An operation method of a body cavity observation system of the present application is for the body cavity observation system includes a trocar with camera including a trocar having a pipe section that is insertable into a body cavity, a trocar shaft attached to the trocar when the trocar is inserted into the body cavity, and a camera section disposed in a distal end area of the pipe section. The operation method comprising obtaining a trocar image, that includes an image of a white part, by the camera section performing imaging when a puncture member of the trocar shaft is exposed, the white part formed on a surface of the puncture member at a distal end of the trocar shaft, the puncture member exposed from a distal end of the pipe section, and setting a white balance for subsequent trocar images, by a white balance setting section, based on the image of the white part in the trocar image.

It is preferable that the operation method further comprising displacing the camera section between a storage position where the camera section is stored in the pipe section and a deployed position where the camera section is deployed in a direction projecting from the outer peripheral surface of the pipe section, and the camera section performs imaging at the deployed position.

According to the present application, a white balance can be performed in a body cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a laparoscopic system.

FIG. **2** is a cross-sectional view of an abdominal cavity in a state where a trocar is inserted.

FIG. **3** is an external perspective view of a trocar apparatus with camera in a state where a camera section is stored.

FIG. **4** is an external perspective view of the trocar apparatus with camera in a state where the camera section is deployed.

FIG. **5** is an exploded perspective view of a trocar with camera in a state where a trocar shaft is removed.

FIG. **6** is an exploded perspective view of the trocar with camera in a state where it is disassembled into an inner cylinder member and an outer cylinder member.

FIG. **7** is an exploded perspective view of the trocar with camera.

FIG. **8** is a front view of the trocar shaft.

FIG. **9**A is an enlarged view of a distal end portion of the trocar with camera in a state where the camera section is stored.

FIG. **9**B is an enlarged view of the distal end portion of the trocar with camera in a state where the camera section is deployed.

FIG. **10** is an explanatory diagram of a deployment mechanism of the camera section.

FIG. **11** is an explanatory view of the deployment mechanism viewed from the rear side of the camera section.

FIG. **12**A is a side view of the trocar device with camera in a state where the camera section is stored.

FIG. **12**B is a side view of the trocar device with camera in a state where the camera section is deployed.

FIG. **13**A is a cross-sectional view of the trocar device with camera in a state where the camera section is stored.

FIG. **13**B is a cross-sectional view of the trocar device with camera in a state where the camera section is deployed.

FIG. **14** is an explanatory view of a cam groove.

FIG. **15**A is an explanatory view of a deployment assist mechanism in a state where the trocar shaft is in an initial position.

FIG. **15**B is an explanatory view of the deployment assist mechanism in a state where the trocar shaft starts contacting with the camera section.

FIG. **15**C is an explanatory view of the deployment assist mechanism in a state where the trocar shaft is in a terminal position.

FIG. **16**A is an explanatory view showing a positional relationship between a pressing part of the trocar shaft and the camera section.

FIG. **16**B is a rear perspective view of the pressing part of the trocar shaft.

FIG. **17** is an exploded perspective view showing an outer cylinder locking mechanism.

FIG. **18**A is a first explanatory diagram of a method for assembling a lock releasing member.

FIG. **18**B is a second explanatory diagram of the method for assembling the lock releasing member.

FIG. **18**C is a third explanatory diagram of the method for assembling the lock releasing member.

FIG. **19**A is an explanatory view of the lock releasing member in a state where an outer cylinder is in a holding position.

FIG. **19**B is an explanatory view of the lock releasing member in a state where the lock of the outer cylinder is released.

FIG. **19**C is an explanatory view of the lock releasing member in a state where the outer cylinder is in a release position.

FIG. **20**A is an enlarged view of a hinge portion in a state where the camera section is deployed.

FIG. **20**B is an enlarged view of the hinge portion in a state where the camera section is stored.

FIG. **21**A is a first explanatory diagram of a method for attaching the camera section.

FIG. **21**B is a second explanatory diagram of the method for attaching the camera section.

FIG. **21**C is a third explanatory diagram of the method for attaching the camera section.

FIG. **22** is an enlarged view showing the positional relationship between a ridge section of a puncture member and the camera section.

FIG. **23**A is a front view of a pipe section and the ridge section of the puncture member, in a state where the camera section is stored.

FIG. **23**B is a front view of the pipe section and the ridge section of the puncture member, in a state where the camera section is deployed.

FIG. **24**A is a side view showing fat wrapping around the camera section.

FIG. **24**B is a top view showing fat wrapping around the camera section.

FIG. **25** is an explanatory view showing a modified example of the ridge section.

FIG. **26** is a rear perspective view of an airtight structure unit.

FIG. **27** is an exploded perspective view of the airtight structure unit.

FIG. **28** is an exploded perspective view (cross-sectional view) of the airtight structure unit.

FIG. **29** is a perspective view of a dome type seal and a centering guide.

FIG. **30** is a cross-sectional view of a head section in which the airtight structure unit is accommodated.

FIG. **31**A is a rear view of a centering guide.

FIG. **31**B is an explanatory diagram of a segment of the centering guide.

FIG. **32**A is a rear view of a seal unit in a state where a treatment tool is inserted.

FIG. **32**B is a rear view of the seal unit in a state where the inserted treatment tool is moved in a radial direction.

FIG. **33** is an image diagram showing a trocar image for white balance setting including an image of a white part of the puncture member.

FIG. **34** is a block diagram showing functions of a processor having a white balance setting section for trocar image and a white balance setting section for endoscopic image.

FIG. **35** is an image diagram showing a trocar image for white balance setting including an image of white, blue, and green parts of the puncture member.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

[Overall Configuration of Laparoscope System]

As shown in FIG. **1**, a laparoscopic system **10**, which is an example of a body cavity observation system, is used by medical staff ST including a doctor to observe inside a body cavity (more specifically intraperitoneal cavity) during laparoscopic operation. The laparoscopic system **10** includes an endoscope system and a trocar apparatus with camera **12**. The endoscope system includes an endoscope **11**, a processor **18**, a monitor **19**, and a console **20**. The trocar apparatus with camera **12** is constituted of a trocar with camera **16** and a trocar shaft **17** (see FIG. **5**).

The trocar with camera **16** is a trocar which is an insertion tool used as an insertion port for inserting a treatment tool **22** such as a forceps into a body cavity and has a camera function added to the trocar.

The processor **18** executes image processing on an endoscopic image of an abdominal cavity imaged by the endoscope **11** and a trocar image of the abdominal cavity imaged by the camera of the trocar with camera **16**. The processor **18** has an image compositing function of compositing the endoscopic image and each of the trocar images. As shown in FIG. **1**, on the monitor **19** of the processor **18**, a composite image of the endoscope image and the trocar images is displayed. Through the composite image, a field of view of the abdominal cavity is provided to the medical staff ST. Instead of or in addition to displaying the composite image, the endoscopic image and the trocar image may be displayed in independent display windows.

As shown in FIG. **2**, the endoscope **11** is inserted into the abdominal cavity of the patient P through a trocar **21**. The trocar **21** (endoscope trocar) for the endoscope **11** is a normal trocar with no camera, different from the trocar with camera **16**. The trocar **21** is an insertion tool used as an insertion port for inserting the endoscope **11** into the abdominal cavity. The trocar **21** has a substantially cylindrical pipe section (cannula, cannula sleeve) and a head section provided on the proximal end side of the pipe section. The head section has a larger diameter than that of the pipe section. The pipe section of the trocar **21** is provided with an insertion hole penetrating inside the pipe section in the axial direction, and the endoscope **11** is inserted through the insertion hole.

In laparoscopic surgery, for inserting each trocar **21**, **16** into the abdominal cavity, skin of an abdominal wall **23** of the patient P is incised with a scalpel to form incision parts **26**, **27**. The abdominal wall **23** is formed of skin, subcutaneous tissue such as fat **23**A (see FIGS. **24**A and **24**B), and muscle tissue. In this embodiment, in order to use the total of three trocars, one trocar **21** for the endoscope **11** and two trocars with camera **16**, the number of incision parts **26**, **27** is three in total, one incision part **26** for the endoscope **11** and two incision parts **27** for the treatment tools **22**. As for the positions of the three incision parts **26**, **27**, for example, the incision part **26** for the endoscope **11** is provided at the center, and the incision parts **27** for the treatment tools **22** are provided on the left and right from the incision part **26**. The number and position of the incision parts **26** and **27** in this embodiment are merely an example, and may be appropriately determined depending on the target site of the operation, the number of the treatment tools to be used, and so on.

The trocar **21** is inserted into the incision part **26** and fixed to the abdominal wall **23**. The trocar with camera **16** is inserted into each of the two incision parts **27** and fixed to the abdominal wall **23**. Accordingly, the trocar **21** can be used as an insertion port for the endoscope **11**, and the trocar with camera **16** can be used as an insertion port for the treatment tool **22**.

The endoscope **11** has an illumination function of emitting illumination light for illuminating the entire body cavity and an imaging function of imaging a target region in the body cavity. On the other hand, the trocar with camera **16** does not have the illumination function and has only the imaging function. Use of such the trocar with camera **16** can avoid an occurrence of flare due to extra light hitting the body cavity depending on the positional relationship between the trocar with camera **16** and the endoscope **11**. Therefore, a camera section **36** of the trocar with camera **16** takes an image of the subject illuminated with the illumination light from the endoscope **11**. Since the camera section **36** performs imaging using the illumination light from the endoscope **11**, it is necessary to perform white balance for trocar images while the illumination light from the endoscope **11** is illuminated. Details of the white balance for trocar images will be described later.

As shown in the screen of the monitor **19** in FIG. **1**, the endoscope **11** inserted in the central trocar **21** provides a field of view overlooking the entire treatment target area in the abdominal cavity. In addition, the trocars with camera **16** positioned on both sides of the endoscope **11**A provides a field of view around the distal end **22**A of the treatment tool **22**.

As shown in FIG. **2**, during laparoscopic surgery, a pneumoperitoneum procedure is performed in which carbon dioxide gas is injected into the abdominal cavity to expand the abdominal cavity. The pneumoperitoneum procedure secures a space for treatment in the abdominal cavity. A connection port to which an air feed pipe of a gas supply device (not shown) is connected is provided to the normal trocar **21** and the trocar with camera **16** (see FIG. **3** and FIG. **4** for a connection port **49** of the trocar with camera **16**). Carbon dioxide gas supplied from the gas supply device is injected into the abdominal cavity through the trocar **21** and the trocar with camera **16**.

As described above, since the pneumoperitoneum procedure is performed in the laparoscopic surgery, the trocar **21** and the trocar with camera **16** have an airtight structure for airtightly sealing the insertion hole in order to prevent gas leakage from inside to outside of the body cavity through the respective insertion holes. The airtight structure of the trocar with camera **16** will be described in detail later.

[Schematic Configuration of Endoscope]

As shown in FIG. **2**, the endoscope **11** is, for example, a rigid endoscope in which an insertion portion **11** is formed of a hard material such as a metal. At the distal end of the insertion portion **11**A, there are provided an illumination window for illuminating a subject (internal organs and so on) in the abdominal cavity with illumination light and a camera unit **28** for imaging the subject by receiving the reflected light from the subject. As well known, the camera unit **28** includes an imaging device (not shown) such as a CCD (Charge-Coupled Device) image sensor and a CMOS (Complementary Metal-Oxide-Semiconductor) for photoelectrically converting the received light, and an imaging lens (not shown) for forming an optical image of the subject on the imaging surface of the imaging device.

The imaging device is, for example, a color imaging device, and outputs a captured image as three color image signals of an R (Red) image signal, a G (Green) image signal, and a B (Blue) image signal. The imaging device is capable of capturing moving image and outputs image signals at a predetermined frame rate. Image signals are sequentially output to the processor **18** via a signal line.

In the insertion section **11**A, the signal line, a light guide and so on are provided. The light guide guides the illumination light supplied from a light source device (not shown) to the illumination window. At the proximal end portion of the endoscope **11**, provided is one end of a universal cable (not shown) for arranging the signal line and the light guide inside. On the other end of the universal cable, provided are a connector for connecting the light guide to the light source device and a connector for connecting the signal line to the processor **18**. The endoscope **11** is connected to the light source device and the processor **18** via the universal cable.

[Overall Structure of Trocar with Camera]

As shown in FIGS. **3** to **7**, the trocar apparatus with camera **12** is consisted of the trocar with camera **16** and the trocar shaft (obturator) **17**. The trocar shaft **17** is detachably attached to the trocar with camera **16**. The trocar with camera **16** has a cylindrical pipe section **31** and a head section **32** provided at the proximal end of the pipe section **31**. The head section **32** has a substantially cylindrical shape larger in diameter than the pipe section **31**. The trocar with camera **16** is provided with an insertion hole **33** penetrating inside the pipe section **31** in the axial direction (Z-axis direction), and through which the treatment tool **22** and so on are inserted.

[Schematic Configuration of Trocar with Camera]

As shown in FIG. **6**, the main part of the trocar with camera **16** is composed of an inner cylinder member **16**A and an outer cylinder member **16**B, and has a double structure in which most of the inner cylinder member **16**A is enclosed in the outer cylinder member **16**B. The inner cylinder member **16**A includes a pipe section inner sleeve **31**A and a head section inner sleeve **32**A provided on the proximal side of the pipe section inner sleeve **31**A. The pipe section inner sleeve **31**A and the head section inner sleeve **32**A are made of, for example, resin, and the both are formed integrally. The outer cylinder member **16**B includes a pipe section outer sleeve **31**B and a head section outer sleeve **32**B provided on the proximal side of the pipe section outer sleeve **31**B. In this embodiment, the pipe section outer sleeve **31**B and the head section outer sleeve **32**B are made of resin, for example, and the both are formed integrally.

A retractable camera section **36** is provided in the distal end area of the pipe section inner sleeve **31**A. The camera section **36** is displaceable between a storage position shown in FIG. **3**, where the camera section **36** is stored inside the pipe section inner sleeve **31**A, and a deployed position shown in FIG. **4**, where the camera section **36** is deployed by popping up in a direction protruding from the outer peripheral surface of the pipe section inner sleeve **31**A. The inner cylinder member **16**A and the outer cylinder member **16**B are provided so as to be relatively slidable along the axial direction (Z-axis direction). As will be described later, the deployment and storage of the camera section **36** is performed by sliding the pipe section outer tube **31**B with respect to the pipe section inner sleeve **31**A.

A slip resistance **41** is formed on the outer peripheral surface of the pipe section outer sleeve **31**B. The slip resistance **41** is for fixing the pipe section **31** to the abdominal wall **23** at a desired insertion position. The slip resistance **41** is configured in such a manner that a plurality of irregularities formed in the circumferential direction around the Z-axis are arranged in the Z-axis direction on the outer peripheral surface of the pipe section outer sleeve **31**B. The slip resistance **41** has a coefficient of friction higher than that of the portion having no irregularities. The slip resistance **41** is formed over substantially the entire length in the Z-axis direction of the pipe section outer sleeve **31**B. Therefore, the slip resistance **41** and the abdominal wall **23** can be engaged at any position in the Z-axis direction of the pipe section outer sleeve **31**B. By this engagement, the pipe section outer sleeve **31**B can be fixed to the abdominal wall **23** at a desired insertion depth.

As shown in FIGS. **6** and **7**, the main portion of the head section **32** is composed of the head section inner sleeve **32**A and the head section outer sleeve **32**B. As shown in FIG. **7**, the trocar with camera **16** incorporates an airtight structure unit **42**, and the airtight structure unit **42** is accommodated in the head section inner sleeve **32**A. On the proximal end portion of the head section inner sleeve **32**A, a rear cover **43** covering the opening portion on the proximal side is attached. Further, the head section inner sleeve **32**A is provided with the connection port **49** (see also FIG. **3** and FIG. **4**) to which the gas supply device is connected. As described above, the carbon dioxide gas is injected into the abdominal cavity through the connection port **49**, and the pneumoperitoneum treatment is performed. The airtight structure unit **42** has a function of preventing gas leakage from the abdominal cavity to the outside of the body.

In addition, the head section **32** is provided with a connector member **44**. The connector member **44** is a connector for connecting a communication cable (not shown) for electrically connecting to the processor **18**. The connector member **44** is provided in the rear cover **43**, and is disposed at a position facing the outer peripheral surface of the head section **32** in a state where the rear cover **43** is attached to the head section inner sleeve **32**A. The connector member **44** is electrically connected to the camera section **36** via a flexible cable (not shown) disposed in a gap between the inner cylinder member **16**A and the outer cylinder member **16**B. The connector member **44** relays the image signal from the camera section **36** to the processor **18** and relays the control signal from the processor **18** to the camera section **36**.

On the rear surface of the rear cover **43**, an opening **43**E for inserting the trocar shaft **17** and the treatment tool **22** is formed. Further, on the outer peripheral surface of the rear cover **43** in the circumferential direction around the Z-axis, a grip section **43**D is formed with a plurality of irregularities. The grip section **43**D functions as a slip resistance for gripping and operating the head section inner sleeve **32**A.

Also, on the outer peripheral surface of the rear cover **43**, four engagement holes **43**A are formed at intervals of about 90° in the circumferential direction. On the outer peripheral surface of the head section inner sleeve **32**A, engagement claws **35** are formed to engage with each engagement hole **43**A. The rear cover **43** is attached to the head section inner sleeve **32**A by engagement of the engagement hole **43**A and the engagement claw **35**.

Slots **43**F, which are grooves extending in the Z-axis direction, are formed on both sides of each engagement hole **43**A. Accordingly, the portion of the rear cover **43** where the engagement hole **43**A is formed can be elastically deformed. When the engagement hole **43**A and the engagement claw **35** engage with each other, the portion where the engagement hole **43**A is formed elastically deforms radially outward so as to ride on the engagement claw **35**. By forming the slot **43**F, engagement of the engagement hole **43**A with the engagement claw **35** is facilitated.

At the proximal end portion of the rear cover **43**, a fitting groove **43**B extending in a circular arc shape in the circumferential direction is formed. The fitting groove **43**B is engaged with an engaging claw **54**A (see FIG. **6**) provided on a handle member **54** of the trocar shaft **17**. By the engagement between the fitting groove **43**B and the engaging claw **54**A, the trocar shaft **17** is attached to the head section inner sleeve **32**A as shown in FIGS. **3** and **4**.

As shown in FIGS. **6** and **7**, a cutout **43**C is formed in a part of the fitting groove **43**B. The engaging claw **54**A and fitting groove **43**B are fitted by inserting the engaging claw **54**A from the cutout **43**C into the fitting groove **43**B, and rotating the handle member **54** around the axis from the inserted position. The fitting completion position corresponds to an initial position (see FIGS. **12**A, **13**A, and **3**) of the trocar shaft **17** described later.

On the outer peripheral surface of the head section outer sleeve **32**B, a lock releasing member **46** is arranged. The lock releasing member **46** is an operation section for releasing an outer cylinder locking mechanism which locks the slide of the outer cylinder member **16**B with respect to the inner cylinder member **16**A. As described later, the lock releasing member **46** is a component of the outer cylinder locking mechanism, together with an engaging member **47** provided on the outer peripheral surface of the head section inner sleeve **32**A. The engaging members **47** are provided on the outer peripheral surface of the head section inner sleeve **32**A, and are arranged at two positions opposite to each other in the circumferential direction about the axis of the outer peripheral surface, that is, two positions at about 180° intervals in the circumferential direction.

The lock releasing members **46** are disposed at positions facing the two engaging members **47** in the circumferential direction about the Z-axis of the head section outer sleeve **32**B. The unlocking operation is performed by simultaneously operating two lock releasing members **46** disposed opposite to each other with holding them by hand. Upon the unlocking operation, the outer cylinder member **16**B becomes slidable relative to the inner cylinder member **16**A.

In addition, the head section outer sleeve **32**B is provided with a cam plate **51** extending rearward from the proximal end. A cam groove **52** is formed on the outer peripheral surface of the cam plate **51**. The cam plate **51** is arranged at two opposing positions in the circumferential direction of the head section outer sleeve **32**B, that is, at intervals of about 180° in the circumferential direction. The cam plate **51** engages with the handle member **54** (see FIG. **6**) of the trocar shaft **17** to change the rotation movement around the axis of the trocar shaft **17** to the slide movement in the direction of the Z-axis of the outer cylinder member **16**B. As will be described in detail later, the rotation of the trocar shaft **17** causes the head section outer sleeve **32**B to slide so that the deployment and storing of the camera section **36** are performed.

[Schematic Configuration of Trocar Shaft]

As shown in FIGS. **3** and **4**, the trocar shaft **17** is attached to the trocar with camera **16** for inserting the pipe section **31** into the body cavity. In FIG. **5** showing a state where the trocar shaft **17** is pulled out from the trocar with camera **16**, the trocar shaft **17** has a shaft member **53** and a handle member **54** which is provided at the proximal end of the shaft member **53** and has a diameter larger than that of the shaft member **53**. A puncture member **55** is provided at the distal end of the shaft member **53**. In a state where the trocar shaft **17** is attached to the trocar with camera **16**, the shaft member **53** is inserted into the insertion hole **33** of the pipe section **31**. In this state, as shown in FIG. **3**, the shaft member **53** passes through the insertion hole **33**, and the puncture member **55** protrudes from the distal end of the pipe section **31** and is exposed to the outside.

As shown in FIG. **3**, the puncture member **55** has a tapered shape in which the outer diameter around the Z-axis is the smallest at the distal end and gradually increases toward the proximal end side. In this embodiment, the puncture member **55** has a cannonball shape in which an outline indicating the outer peripheral surface is a curved line in a longitudinal cross section (Y-Z cross section) cut along the Z-axis direction. Note that the shape of the puncture member **55** may be conical in which the outline indicating the outer peripheral surface is a straight line in the longitudinal cross section. When the trocar with camera **16** is inserted into the body cavity, the incision part **27** (see FIG. **2**) is punctured from the puncture member **55**. Then, the incision part **27** is pushed and spread by the puncture member **55**, and the pipe section **31** at the rear of the puncture member **55** is inserted into the incision part **27** which is pushed out.

As shown in FIG. **5**, the shaft member **53** has the puncture member **55**, a shaft member body **56**, and a connecting member **57**. The connecting member **57** connects the puncture member **55** and the shaft member body **56**. Between the puncture member **55** and the shaft member body **56**, the maximum diameter is approximately equal and the cross-sectional area of the cross section (X-Y cross section) orthogonal to the Z-axis direction is also approximately equal. On the other hand, in the cross section (X-Y cross section) of the shaft member **53**, the cross sectional area of the connecting member **57** is smaller than the cross sectional area of the puncture member **55** and the shaft member body **56**. The connecting member **57** is disposed offset from the central axis of the shaft member **53**. Specifically, the connecting member **57** is offset in a direction away from the storage position of the camera section **36**.

In a state in which the trocar shaft **17** is attached, the camera section **36** is positioned behind the puncture member **55**. When inserting the pipe section **31** into the body cavity, the camera section **36** is stored in the pipe section **31**. The connecting member **57** is provided to secure a space for storing the camera section **36** behind the puncture member **55**, in a state where the trocar shaft **17** is attached to the trocar with camera **16**.

The handle member **54** is gripped when the trocar shaft **17** is attached to or removed from the trocar with camera **16**, or rotated in the inserted state. On the outer peripheral surface of the handle member **54**, two pin arrangement plates **58** are provided. The pin arrangement plate **58** extends to the distal end side where the puncture member **55** is provided, and a cam pin **59** engaging with the cam groove **52** of the head section outer sleeve **32**B is provided on an inner peripheral surface **58**C opposite to the cam plate **51**. The two pin arrangement plates **58** are provided at two positions facing each other in the circumferential direction around the Z-axis of the handle member **54**, that is, at two places at intervals of about 180° in the circumferential direction in accordance with the positions of the two cam plates **51**.

More specifically, the two pin arrangement plates **58** are designed to have following shapes in consideration of moldability by a mold.

As shown in FIG. **8**, the two pin arrangement plates **58** are provided so that the cam pins **59** are arranged at intervals of 180° in the circumferential direction around the Z-axis. In the two pin arrangement plates **58**, the cam pins **59** are disposed at one end side of the pin arrangement plate **58**, and extension parts **58**E extending in the direction orthogonal to the coupling line Lp connecting the two opposing cam pins **59** are provided. The coupling line Lp coincides with the projecting direction of the cam pin **59**.

Furthermore, the extension part **58**E is formed in a direction that is point-symmetrical with respect to the rotation center O of the trocar shaft **17**. That is, in FIG. **8**, the extension part **58**E of the pin arrangement plate **58** on the right side extends downward from the position of the cam pin **59**, and conversely, the extension part **58**E of the pin arrangement plate **58** of left side extends upward from the position of the cam pin **59**.

The cross section orthogonal to the Z-axis of the trocar shaft **17** in the pin arrangement plate **58** has a wedge shape whose thickness is large on the cam pin **59** side and decreases as the distance from the cam pin **59** increases in the extension part **58**E. The inner peripheral surface **58**C of the pin arrangement plate **58** is formed to be a plane extending in a direction orthogonal to the coupling line Lp of the cam pin **59**. In an outer peripheral surface **58**D of the pin arrangement plate **58**, a part of the cross-sectional shape is formed by a curved surface having a portion overlapping with the arc shape of a circle centered on the rotation center O (for example, a concentric circle of the outer peripheral surface of the pipe section **31**).

Since the pin arrangement plates **58** are formed in such a configuration and shape, moldability by a mold becomes good. For example, when using molds divided into two above and below the coupling line Lp, the extraction direction of the two molds after molding is the vertical direction orthogonal to the coupling line Lp. In this case, if the inner peripheral surface **58**C of the pin arrangement plate **58** is formed as a plane extending in the direction orthogonal to the coupling line Lp, it becomes possible to extract the two molds along the vertical direction.

In addition, since the cross section of the pin arrangement plate **58** has the wedge shape whose thickness is large on the cam pin **59** side and decreases as the distance from the cam pin **59** increases in the extension part **58**E, and the outer peripheral surface **58**D has the part of the cross-sectional shape formed by a curved surface having a portion overlapping with the arc shape of a circle centered on the rotation center O, the shape of the cross section of the pin arrangement plate **58** becomes thinner along the mold extraction direction. Accordingly, there is no obstacle in the mold extraction. This ensures good formability of the pin arrangement plate **58**.

[Camera Unit and Deployment Mechanism]

As shown in FIGS. **9**A, **9**B and **10**, the camera section **36** is provided in a cutout **61** formed in the distal end area of the pipe section inner sleeve **31**A. The camera section **36** includes a camera unit **62**, a mount **63**, and a housing **64**. Like the camera unit **28** of the endoscope **11**, the camera unit **62** includes an imaging device such as a CCD image sensor or a CMOS image sensor, and an imaging lens **62**A. In addition, in the camera unit **62**, illumination units (not shown) configured by light emitting elements such as LEDs (Light Emitting Diodes) may be provided on both sides of a lens barrel **62**B having the imaging lens **62**A.

The camera unit **62** is communicably connected to the connector member **44** provided in the head section **32** by a flexible cable (not shown). Communication of image signals output from the camera unit **62** and control signals transmitted from the processor **18** is performed between the camera unit **62** and the processor **18** via the flexible cable and the connector member **44**. Though not shown, one end of the flexible cable is connected to the proximal end side of the camera section **36**, the flexible cable is disposed in a gap between the pipe section inner sleeve **31**A and the pipe section outer sleeve **31**B, and the other end of the flexible cable extends to the connector member **44**.

The camera unit **62** is attached to the housing **64** via the mount **63**. Here, in case the pipe section **31** is viewed from the distal end side in the Z-axis direction, the position where the cutout **61** and the camera section **36** are disposed is defined as the upper side of the pipe section **31**. The housing **64** is shaped so as to surround the upper and widthwise side ends of the camera unit **62**, and has an upper face section **64**A covering the upper side and a side face section **64**B covering each of the two side faces.

The upper face section **64**A has a shape corresponding to the shape of the cutout **61** of the pipe section **31**, and the outer peripheral surface is configured with a curved surface according to the outer diameter of the pipe section **31**. Accordingly, as shown in FIG. **9**A, when the camera section **36** is in the storage position, the housing **64** is fitted into the cutout **61** and constitutes a part of the upper surface of the pipe section **31**.

The camera section **36** is provided rotatably between the storage position and the deployed position with the proximal end side as a fulcrum. As shown in FIG. **10**, a pair of right and left rotation pins **65** are provided on an outer surface of each side face section **64**B located at both ends of the camera section **36**. Each of the rotation pins **65** protrudes outward from each of the both ends of the camera section **36** in the width direction of the camera section **36**. The rotation pins **65** constitute a rotating shaft of the camera section **36**. On the proximal end side of the inner periphery of the cutout **61**, bearings **67** for rotatably supporting the each rotation pin **65** are provided. Here, the rotation pins **65** provided on the each side face section **64**B at the both ends of the camera section **36** and the respective bearings **67** provided on the inner periphery of the cutout **61** constitute hinge sections provided on the both ends of the camera section **36**.

By the action of the hinge sections, the camera section **36** is held displaceably. Specifically, the camera section **36** rotates from the storage position shown in FIG. **9**A around the rotation pin **65** on the proximal end side, and deploys as its distal end side being flipped up as shown in FIG. **9**B. At the deployed position shown in FIG. **9**B, the imaging lens **62**A is disposed so as to face the distal end side so that the treatment tool **22** protruding from the insertion hole **33** can be imaged.

As shown in FIGS. **10** and **11**, a spring **71** is attached to the camera section **36**, and the camera section **36** is biased to the deployed position by the spring **71**. The spring **71** is, for example, a coil spring, and two springs are used. The proximal end of the housing **64** is provided with a hook **64**C to which one end of the spring **71** is attached. In the pipe section inner sleeve **31**A, on the proximal end side of the cutout **61**, two housing recesses **72** for respectively accommodating the two springs **71** are provided. The two housing recesses **72** are formed so that their longitudinal direction coincides with the Z-axis direction and are arranged in parallel. The groove of the housing recess **72** is formed in such a depth that the spring **71** does not protrude from the outer diameter of the pipe section inner sleeve **31**A when the spring **71** is accommodated. This prevents interference between the spring **71** and the inner peripheral surface of the pipe section outer sleeve **31**B which slides relative to the pipe section inner sleeve **31**A.

Each housing recess **72** is provided with a hook **72**A to which the other end of the spring **71** is attached. The spring **71** is attached respectively to the hook **64**C and the hook **72**A in a state where the spring **71** is extended from the natural length in which no external force is applied. Therefore, in a state where the spring **71** is attached to the hooks **64**C and the hooks **72**A, a biasing force is generated in the contracting direction. Since the hook **64**C provided at the proximal end of the camera section **36** is located above the rotation pin **65**, the hook **64**C is pulled toward the proximal side by the biasing force in the contraction direction generated by the spring **71**. By this pulling force, a rotational force acts on the camera section **36** with the rotation pin **65** as a fulcrum toward the deployed position, and the camera section **36** is biased toward the deployed position.

As shown in FIGS. **12**A and **12**B and FIGS. **13**A and **13**B, the deployment and storage of the camera section **36** are performed by the slide operation of the pipe section outer sleeve **31**B. As shown in FIGS. **12**A and **13**A, the pipe section outer sleeve **31**B slides along the axial direction between a holding position where the camera section **36** is held at the storage position and a release position where the camera section **36** is retracted further rearward from the holding position to release the holding, as shown in FIGS. **12**B and **13**B.

As described above, the camera section **36** is biased by the spring **71** toward the deployed position. As shown in FIGS. **12**A and **13**A, in the holding position, the distal end of the pipe section outer sleeve **31**B covers the rear portion of the camera section **36**. Thus, the pipe section outer sleeve **31**B restricts the deployment of the camera section **36** against the biasing force of the spring **71**, and holds the camera section **36** at the storage position. Further, as shown in FIG. **13**A, in a state where the trocar shaft **17** is attached to the trocar with camera **16**, the camera section **36** is stored in the housing space formed by the connecting member **57** at the storage position.

On the other hand, when the pipe section outer sleeve **31**B slides to the release position shown in FIGS. **12**B and **13**B, the distal end of the pipe section outer sleeve **31**B retracts from the rear portion of the camera section **36**. As a result, the holding of the pipe section outer sleeve **31**B with respect to the camera section **36** is released. When the holding is released, the camera section **36** pops up and deploys by the bias of the spring **71**.

The spring **71** and the outer cylinder member **16**B constitute the deployment mechanism which releases the holding of the camera section **36** by the release operation of the outer cylinder member **16**B so that the camera section **36** pops up and deploys to the deployed position.

[Operation Mechanism for Deployment and Storing Camera Section]

As shown in FIGS. **12**A and **12**B, the sliding operation of the pipe section outer sleeve **31**B is performed by the rotation operation about the axis of the trocar shaft **17**. As described above, the head section outer sleeve **32**B of the outer cylinder member **16**B is provided with the cam plate **51** in which the cam groove **52** is formed. The cam groove **52** engages with the cam pin **59** (see FIG. **5**) provided on the trocar shaft **17**. The cam groove **52** and the cam pin **59** constitute an operation mechanism for sliding the pipe section outer sleeve **31**B to the proximal side by the rotation operation of the trocar shaft **17**.

As shown in FIG. **14**, the outer peripheral surface of the cam plate **51** is formed of a curved surface in accordance with the curvature of the head section outer sleeve **32**B (see also FIGS. **3** and **4**). The cam groove **52** has an inclined section **52**E inclined with respect to the axial direction, and a first end **52**A on one side of the inclined section **52**E and a second end **52**B on the other side are different in position in the Z-axis direction. The first end **52**A is relatively positioned in the proximal side, and the second end **52**B is positioned in the distal side, regarding the Z-axis direction.

In addition to the inclined section **52**E, the cam groove **52** has a guide groove **52**C and a linear section **52**D. The guide groove **52**C is connected to the second end **52**B at one end, and extends in the Z-axis direction toward the proximal side. The linear section **52**D is connected to the first end **52**A at one end, and extends in the circumferential direction.

As shown in FIGS. **12**A, **12**B and **13**A, **13**B, in a state where the trocar shaft **17** is attached to the trocar with camera **16**, the handle member **54** is attached to the head section inner sleeve **32**A by the engagement between the engaging claw **54**A and the fitting groove **43**B. Therefore, the position of the trocar shaft **17** in the Z-axis direction is fixed with respect to the inner cylinder member **16**A. When the trocar shaft **17** is attached to the trocar with camera **16**, the cam pin **59** provided on the head section outer sleeve **32**B and the cam groove **52** provided on the head section inner sleeve **32**A engage with each other. Since the position of trocar shaft **17** in the Z-axis direction is fixed with respect to the inner cylinder member **16**A, as the trocar shaft **17** rotates, the engagement of the cam pin **59** with the inclined section **52**E of the cam groove **52** causes the outer cylinder member **16**B to slide relative to the trocar shaft **17** and the inner cylinder member **16**A.

Specifically, first, as shown in FIGS. **12**A and **13**A, when the pipe section outer sleeve **31**B is in the holding position, the camera section **36** is in the storage position. When in the holding position, the cam pin **59** is located in the section between the first end **52**A and the linear section **52**D of the cam groove **52**. The initial position of the trocar shaft **17** is a position where the cam pin **59** contacts on the end opposite to the first end **52**A side in the linear section **52**D. That is, the initial position of the trocar shaft **17** is the end position when the trocar shaft **17** is rotated counterclockwise as viewed from the distal side in the Z-axis direction.

Even when the trocar shaft **17** is rotated clockwise as viewed from the distal side, while the cam pin **59** is positioned between the initial position and the first end **52**A, that is, while the cam pin **59** is in the section of the linear section **52**D, the pipe section outer sleeve **31**B does not slide in the axial direction and maintains the holding position. The linear section **52**D is provided to secure a play that prevents the pipe section outer sleeve **31**B from starting to slide immediately after the trocar shaft **17** is rotated. Because of this play, even when the trocar shaft **17** at the initial position is slightly rotated carelessly, it is prevented from releasing the holding of the camera section **36**.

As the trocar shaft **17** starts to rotate clockwise from the initial position as viewed from the distal side, the cam pin **59** reaches the first end **52**A. Then, as the trocar shaft **17** is further rotated clockwise, the cam pin **59** engages with the inclined section **52**E of the cam groove **52**, and the engagement position of the cam pin **59** moves from the first end **52**A toward the second end **52**B. By the interaction between the cam pin **59** and the inclined section **52**E, as shown in FIGS. **12**B and **13**B, the pipe section outer sleeve **31**B slides backward with respect to the pipe section inner sleeve **31**A and retracts to the release position. As a result, since the holding of the camera section **36** is released, the camera section **36** pops up and deploys to the deployed position.

Here, the position where the cam pin **59** of the trocar shaft **17** reaches the second end **52**B is defined as a release completion position of the trocar shaft **17**. The release completion position is the end position of the clockwise rotation of the trocar shaft **17**.

On the other hand, as shown in FIGS. **12**B and **13**B, when the camera section **36** is in the deployed position, the pipe section outer sleeve **31**B is in the release position, and the trocar shaft **17** is in the release completion position. In the release completion position, the cam pin **59** is located at the second end **52**B of the cam groove **52**. From this state, as the trocar shaft **17** is rotated counterclockwise as viewed from the distal side, the cam pin **59** moves from the second end **52**B to the first end **52**A of the inclined section **52**E. Due to the interaction between the cam pin **59** and the inclined section **52**E of the cam groove **52**, as shown in FIGS. **12**A and **13**A, the pipe section outer sleeve **31**B slides forward with respect to the pipe section inner sleeve **31**A and advances to the holding position.

By advancing the pipe section outer sleeve **31**B, the housing **64** corresponding to the rear part of the camera section **36** in the deployed position is pressed by the tip of the pipe section outer sleeve **31**B, and the camera section **36** is rotated about the rotation pin **65** and pushed into the storage position. In the storage position, the rear part of the camera section **36** is covered with the tip of the pipe section outer sleeve **31**B. As a result, the pop-up deployment to the deployed position of the camera section **36** by the bias of the spring **71** is restricted, and the camera section **36** is held at the storage position.

As described above, since the cam groove **52** and the cam pin **59** constitute the operation mechanism for sliding the pipe section outer sleeve **31**B to the proximal side by the rotation operation of the trocar shaft **17**, a smoother slide operation of the pipe section outer sleeve **31**B becomes possible compared to the case where the pipe section outer sleeve **31**B is slid by hand. In case that the medical staff ST who is the operator directly grips and slides the pipe section outer sleeve **31**B, the gripping force of the hand easily applies a force in a direction other than the Z-axis direction of the pipe section outer sleeve **31**B. Such a force inhibits a smooth sliding of the pipe section outer sleeve **31**B. However, in case that the force acting in the direction other than the Z-axis direction with respect to the pipe section outer sleeve **31**B is reduced by the above operation mechanism, the smooth slide operation of the pipe section outer sleeve **31**B becomes possible.

In addition, when the pipe section outer sleeve **31**B is in the release position, the cam pin **59** is located at the second end **52**B of the cam groove **52**. Since the guide groove **52**C is formed to extend from the second end **52**B in the axial direction, by moving the cam pin **59** along the guide groove **52**C, the trocar shaft **17** can be axially slid toward the proximal side with respect to the pipe section outer sleeve **31**B. As shown in FIGS. **12**B and **13**B, when the pipe section outer sleeve **31**B is in the release position, the camera section **36** is in the deployed position. In the pipe section inner sleeve **31**A, since the camera section **36** is retracted from behind the puncture member **55**, the puncture member **55** can be retracted. Therefore, in a state where the camera section **36** is deployed, it is possible to extract the trocar shaft **17** from the trocar with camera **16**.

Also, when attaching the trocar shaft **17** to the trocar with camera **16**, the pipe section outer sleeve **31**B of trocar with camera **16** is put in the state where the trocar shaft **17** has been extracted, that is, the pipe section outer sleeve **31**B is set to the release position where the camera section **36** is in the deployed position, as shown in FIGS. **12**B and **13**B. In this state, the shaft member body **56** is inserted from the head section **32** into the insertion hole **33** of the pipe section **31**. Since the camera section **36** is in the deployed position, the camera section **36** is retracted from the path of the puncture member **55** also at the tip of the pipe section **31**. Therefore, the puncture member **55** can be protruded from the tip of the pipe section **31**.

Thereafter, the handle member **54** is rotated to align the position of the cam pin **59** with the position of the guide groove **52**C. When the positions of the cam pin **59** and the guide groove **52**C are aligned, the circumferential position of the engaging claw **54**A shown in FIGS. **6** and **7** also faces the cutout **43**C of the fitting groove **43**B. From this state, as the trocar shaft **17** is advanced toward the distal side with the cam pin **59** following along the guide groove **52**C, and the cam pin **59** reaches the second end **52**B, the engaging claw **54**A enters into the fitting groove **43**B from the cutout **43**C. As the trocar shaft **17** is rotated to the initial position, the interaction between the cam pin **59** and the cam groove **52** causes the pipe section outer sleeve **31**B to advance to the holding position and the camera section **36** to be stored as shown in FIGS. **12**A and **13**A.

In this way, the guide groove **52**C functions as a groove for starting and releasing the engagement of the cam pin **59** of the trocar shaft **17** and the cam groove **52** of the pipe section outer sleeve **31**B when the trocar shaft **17** is attached to or removed from the trocar with camera **16**.

On the other hand, in the cam groove **52**, on the side where the first end **52**A and the linear section **52**D exist, a guide groove for disengaging the cam pin **59** is not formed. Therefore, in the state where the pipe section outer sleeve **31**B is in the holding position, that is, the camera section **36** is in the storage position as shown in FIGS. **12**A and **13**A, withdrawal of the trocar shaft **17** is restricted. As shown in

FIG. 13A, in the storage position, the camera section 36 is stored in the storage space formed by the connecting member 57 of the trocar shaft 17. If an extraction operation of the trocar shaft 17 is carelessly performed in this state, the rear end of the puncture member 55 may come into contact with the camera section 36, possibly damaging the camera section 36. In order to prevent this, the guide groove 52C is formed only on the second end 52B side and is not formed on the first end 52A side.

Further, as shown in FIG. 5, two pairs of the cam pin 59 on the pin arrangement plate 58 and the cam groove 52 on the cam plate 51 are provided, and these pairs are provided around the Z-axis of the outer cylinder member 16B so as to be opposite to each other at an interval of about 180° in the circumferential direction. Since a plurality of pairs of the cam pin 59 and the cam groove 52 are provided and arranged to be opposite to each other, the engagement state is stabilized. Also, it is easy to grip and has good operability.

In addition, since the trocar shaft 17 is provided with the handle member 54 with a larger diameter compared to the shaft member 53, the trocar shaft 17 can be easily rotated.

Further, as shown in FIG. 14, in the handle member 54 of the trocar shaft 17, a position arrangement mark 58A and a direction mark 58B are provided on the pin arrangement plate 58 provided with the cam pin 59 engaging with the cam groove 52. The position mark 58A is arranged on the outer peripheral surface of the pin arrangement plate 58, and indicates the position of the cam pin 59 arranged on the inner peripheral surface.

Since the cam pins 59 are provided on the inner peripheral surface of the pin arrangement plate 58, they are difficult to be seen from the outside. By providing the position mark 58A on the outer peripheral surface of the pin arrangement plate 58, it becomes easy to grasp the position of the cam pin 59 from the outside, and to check the engagement state between the cam pin 59 and the cam groove 52, such as which part of the cam pin 59 is engaged with the cam groove 52. This makes it easy to operate the deployment and storage of the camera section 36 through the trocar shaft 17 and to attach and detach the trocar shaft 17 to the outer cylinder member 16B.

The direction mark 58B indicates the rotational direction when the trocar shaft 17 is attached to the head section 32, that is, the rotational direction from the release completion position to the initial position of the trocar shaft 17.

Note that in this embodiment, the cam formed on the cam plate 51 is the cam groove and the cam formed on the pin arrangement plate 58 is the cam pin. However, the first cam section the cam formed on the cam plate 51 may be a cam pin and the cam formed on the pin arrangement plate 58 may be a cam groove.

[Deployment Assist Mechanism of Camera Section]

As described above, when the trocar shaft 17 is rotated, the holding of the camera section 36 by the pipe section outer sleeve 31B is released, and the camera section 36 pops up and deploys to the deployed position by the bias of the spring 71. The trocar apparatus with camera 12 has a deployment assist mechanism in which the connecting member 57 contacts on the camera section 36 and pushes the camera section 36 from the storage position to the deployed position, when the trocar shaft 17 is rotated during the deployment of the camera section 36. The deployment assist mechanism is constituted by the trocar shaft 17 which is rotatable in the pipe section inner sleeve 31A and has the connecting member 57 which can contact with the camera section 36.

FIGS. 15A to 15C show a cross section (X-Y cross section) orthogonal to the Z-axis direction of the pipe section 31 in a section where the camera section 36 and the connecting member 57 are disposed. As shown in FIGS. 15A to 15C, in the cross section of the pipe section 31, the connecting member 57 is disposed at a lower position opposite to the camera section 36 disposed on the upper part of the pipe section 31. FIGS. 15A and 15B show the camera section 36 in the storage position, and FIG. 15C shows the camera section 36 in the deployed position.

Further, in FIG. 15A, the rotational position of the trocar shaft 17 indicates the initial position, that is, a state where the cam pin 59 is in the linear section 52D of the cam groove 52 (see FIG. 3). In FIG. 15B, the rotational position of the trocar shaft 17 indicates a state in which the cam pin 59 is in the process of moving from the first end 52A to the second end 52B of the inclined section 52E. In FIG. 15C, the rotational position of the trocar shaft 17 indicates the release completion position, that is, a state where the cam pin 59 is at the second end 52B of the cam groove 52 (see FIG. 4).

As shown in FIGS. 15A to 15C, when the pipe section 31 is viewed from the front end side in the Z-axis direction, a cross section of the connecting member 57 has a chevron shape in which a foot extends from the radial center of the pipe section 31 toward the inner wall of the pipe section 31. The bottom surface on the foot side of the connecting member 57 has a curved shape in accordance with the curvature of the inner wall of the pipe section inner sleeve 31A, and contacts on the inner wall of the pipe section inner sleeve 31A. When the trocar shaft 17 rotates clockwise, the connecting member 57 rotates clockwise along the inner wall of the pipe section inner sleeve 31A.

When the trocar shaft 17 rotates clockwise from the initial position shown in FIG. 15A, and reaches the position shown in FIG. 15B, the connecting member 57 starts contact on the side face section 64B of the camera section 36. Since the cam pin 59 and the inclined section 52E of the cam groove 52 are engaged in the state shown in FIG. 15B, when the trocar shaft 17 rotates, the pipe section outer sleeve 31B also slides toward the release position. Therefore, the holding of the camera section 36 is gradually released according to the slide of the pipe section outer sleeve 31B. Then, the camera section 36 starts popping up by the biasing force of the spring 71 toward the deployed position. At this timing, the connecting member 57 starts contact with the camera section 36 and pushes the camera section 36 toward the deployed position.

Due to assistance from the pressing force of the connecting member 57 in addition to the biasing force of the spring 71 to make the camera section 36 pop up and deploy, the pop-up of the camera section 36 can be reliably performed compared with a case where the pop-up is performed only by the biasing force of the spring 71. More specifically, the fat 23A (see FIGS. 24A and 24B) or the like may be attached to the outer peripheral surface of the camera section 36, which may be a resistance at the time of pop-up. Even in such a case, since the deployment assist mechanism constituted of the connecting member 57 is provided, the pop-up can be reliably performed.

As shown in FIGS. 15A to 15C, in the connecting member 57, on the slope in contact with the side face section 64B, a pressing part 57B protruding outward from a body part 57A is provided. Further, as shown in FIGS. 16A and 16B, the pressing part 57B is not provided over the entire length of the connecting member 57 in the Z-axis direction, but is provided over a part thereof. Specifically, the pressing part 57B is provided in a range opposed to the side face section

64B of the camera section 36 in the Z-axis direction of the connecting member 57. By minimizing the range where the pressing part 57B is provided, it is possible to prevent the storage space of the camera section 36 from being unnecessarily compressed.

Also, as shown in FIG. 15A, when the trocar shaft 17 is in the initial position and the camera section 36 is in the storage position, the center position of the connecting member 57 in the width direction (X-axis direction) is offset from the center line C1 in the width direction (X-axis direction) of the camera section 36, in the case where the pipe section 31 is viewed from the distal side in the Z-axis direction. The center line C1 is a line connecting the center position of the camera section 36 in the width direction (X-axis direction) and the center of the pipe section 31. The center line C2 is a center line in the width direction (X-axis direction) of only the body part 57A of the connecting member 57, not including the pressing part 57B. Being offset means that the center line C1 and the center line C2 do not match.

More specifically, in FIG. 15A, in a state where the camera section 36 is in the storage position, the connecting member 57 is disposed to face the camera section 36. In this state, the center line C1 in the width direction of the camera section 36 and the center line C2 in the width direction (X-axis direction) of the connecting member 57 do not match, and the center line C2 is offset with respect to the center line C1 in the opposite direction to the slope contacting on the side face section 64B (right direction in FIG. 15A).

Since the center position of the connecting member 57 in the width direction (X-direction) is offset from the center line C1 of the camera section 36 in the state that the trocar shaft 17 is in the initial position and the camera section 36 is in the storage position, it is easy to adjust the amount of rotation of the trocar shaft 17, as described below.

That is, by its rotation, the trocar shaft 17 functions not only as the deployment assist mechanism of the camera section 36, but also functions as the operation mechanism that slides the pipe section outer sleeve 31B to deploy and store the camera section 36. Thus, in the case that the trocar shaft 17 has multiple functions, it is necessary to adjust the amount of rotation of the trocar shaft 17 in accordance with each function.

For example, when the amount of rotation of the trocar shaft 17 required for the operation mechanism is determined, the amount of stroke of the connecting member 57 (the amount of rotation of the connecting member 57 in the circumferential direction) is also determined. In order for the deployment assist mechanism to function, the distance between the connecting member 57 and the side face section 64B of the camera section 36 must be adjusted in accordance with the determined stroke amount. By offsetting the connecting member 57, it is easy to finely adjust the distance between the connecting member 57 and the side face section 64B. Since it is easy to make fine adjustments, even when the trocar shaft 17 have multiple functions, the amount of rotation required for one function can be determined with a certain degree of freedom, and as a result the amount of rotation of the trocar shaft 17 can be easily adjusted.

In other words, by making the cross-section of the connecting member 57 to have such the shape and arrangement, flexibility in the design is ensured. Specifically, in this embodiment, the center line C2 of the body part 57A of the connecting member 57 is offset from the center line C1 of the camera section 36. However, theoretically, even in the case that the pressing part 57B is provided, it is possible to provide the body part 57A such that the center line C2 and the center line C1 coincide (without offset).

The reason for offsetting in this example is that in order to secure the distance between pressing part 57B of the connecting member 57 and the side face section 64B of the camera section 36 in the cam design, since the deployment of the camera section 36 is also related to the sliding amount of the outer cylinder member 16B. By offsetting the center line C2 with respect to the center line C1 of the body part 57A and making the cross-sectional shape of the connecting member 57 including the pressing part 57B asymmetric with respect to the center line C2, the distance between the side face section 64B and the pressing part 57B is extended. Thus, flexibility in the design is improved.

[Locking Mechanism at Deployment and Storage of Camera]

The trocar apparatus with camera 12 is provided with the outer cylinder locking mechanism which regulates the slide in the direction of the Z-axis of the outer cylinder member 16B having the pipe section outer sleeve 31B to lock the outer cylinder member 16B in each of the holding position and the release position. As described above, the lock releasing member 46 is the operation member that performs the releasing operation of the outer cylinder locking mechanism, and configures the outer cylinder locking mechanism together with the engaging member 47.

As shown in FIG. 17, the engaging member 47 formed on the outer peripheral surface of the head section inner sleeve 32A has two engaging grooves 47A and 47B extending in the direction orthogonal to the Z-axis direction. Each engaging groove 47A, 47B has a different position in the Z-axis direction. The engaging groove 47A is a groove for locking the outer cylinder member 16B with the pipe section outer sleeve 31B in the holding position, and the engaging groove 47B is a groove for locking the outer cylinder member 16B with the pipe section outer sleeve 31B in the release position.

The lock releasing member 46 is attached to the outer periphery of the head section outer sleeve 32B of the outer cylinder member 16B. The lock releasing member 46 has an operation section 46A and a supporting section 46B. The supporting section 46B is connected to the operation section 46A and supports the operation section 46A in the head section outer sleeve 32B. A step is formed between the operation section 46A and the supporting section 46B, and the longitudinal cross section of the lock releasing member 46 has a substantially crank shape.

In the part where the operation section 46A and the supporting section 46B are joined in the lock releasing member 46, mount pins 46C are provided at both ends in the width direction. The supporting section 46B is provided with a mount hole 46D to which a spring 68 for biasing the lock releasing member 46 in a predetermined direction is attached. Further, in the supporting section 46B, an engaging projection 46E (see FIGS. 19A to 19C) is provided on the side opposite to the mount hole 46D. As will be described later, the engaging projection 46E engages with each of the engaging grooves 47A and 47B and regulates the slide of the outer cylinder member 16B.

The head section outer sleeve 32B is provided with a mounting member 66 for mounting the lock releasing member 46. The mounting member 66 has an opening 66A and a bearing 66B which is formed on the inner periphery of the opening 66A and rotatably supports the mount pin 46C.

FIGS. 18A to 18C show a method of assembling the lock releasing member 46. As shown in FIG. 18A, the lock releasing member 46 is inserted into the opening 66A, for example, with the spring **68** attached to the supporting section **46**B. Then, as shown in FIG. **18**B, the mount pin **46**C is attached to the bearing **66**B. After that, the lock releasing member **46** is rotated about the mount pin **46**C, and the posture of the lock releasing member **46** is adjusted so that the supporting section **46**B and the inner peripheral surface of the head section outer sleeve **32**B become parallel.

In this state, the spring **68** is sandwiched between the supporting section **46**B and the inner peripheral surface of the head section outer sleeve **32**B. While maintaining this posture, as shown in FIG. **18**C, the inner cylinder member **16**A is inserted into the outer cylinder member **16**B, and the supporting section **46**B is sandwiched between the inner peripheral surface of the outer cylinder member **16**B and the engaging member **47** formed on the outer peripheral surface of the inner cylinder member **16**A. The supporting section **46**B is rotated clockwise about the mount pin **46**C by the biasing force of the spring **68** in FIG. **18**C and biased in a direction to press the engaging projection **46**E toward the engaging member **47**.

FIGS. **19**A-**19**C show engagement states of the lock releasing member **46** and the engaging member **47**. FIG. **19**A shows a state where the pipe section outer sleeve **31**B is in the holding position where the camera section **36** is held at the storage position. In the state shown in FIG. **19**A, the engaging projection **46**E engages with the engaging groove **47**A, and the bias of the spring **68** pushes the engaging projection **46**E toward the engaging groove **47**A. Therefore, the engagement of the engaging projection **46**E and the engaging groove **47**A restricts the axial slide of the outer cylinder member **16**B with respect to the inner cylinder member **16**A, and the pipe section outer sleeve **31**B is locked at the holding position (see FIGS. **12**A and **13**A) where the camera section **36** is held at the storage position.

FIG. **19**B shows a state in which the slide lock of the outer cylinder member **16**B is released by operation of the lock releasing member **46**. When the operation section **46**A is pressed, the lock releasing member **46** rotates counterclockwise around the mount pin **46**C against the bias of the spring **68**. By this rotation, the supporting section **46**B is separated from the engaging member **47**, and the engaging projection **46**E and the engaging groove **47**A are disengaged. Thereby, the slide lock of the outer cylinder member **16**B is released. When the slide lock of the outer cylinder member **16**B is released, it is possible to retract the pipe section outer sleeve **31**B toward the proximal side to the release position.

FIG. **19**C shows a state where the pipe section outer sleeve **31**B is in the release position. As shown in FIG. **19**B, when the outer cylinder member **16**B is retracted toward the proximal side in the unlocked state, the engaging projection **46**E of the supporting section **46**B reaches the engaging groove **47**B. As shown in FIG. **19**C, when the engaging projection **46**E reaches the engaging groove **47**B, the biasing of the spring **68** causes the engaging projection **46**E to fall into the engaging groove **47**B, and the two become engaged. In the release position where the engaging projection **46**E and the engaging groove **47**B are engaged, since the holding of the camera section **36** by the pipe section outer sleeve **31**B is released, the camera section **36** pops up and deploys.

In the state shown in FIG. **19**C, the engaging projection **46**E engages with the engaging groove **47**B, and the bias of the spring **68** presses the engaging projection **46**E toward the engaging groove **47**B. Therefore, the engagement of the engaging projection **46**E and the engaging groove **47**A restricts the axial slide of the outer cylinder member **16**B with respect to the inner cylinder member **16**A, and the pipe section outer sleeve **31**B is locked at the release position (see FIGS. **12**B and **13**B) that allows the camera section **36** to deploy.

The following effect is obtained by the outer cylinder locking mechanism provided with the lock releasing member **46** and the engaging member **47**. That is, in the trocar with camera **16**, the outer cylinder member **16**B including the pipe section outer sleeve **31**B is located at the outermost periphery of the pipe section **31** of the trocar with camera **16**. As such the pipe section outer sleeve **31**B is used as the operation member for holding into and deploying from the storage position of the camera section **36**, the operator's hand is easy to touch and an inadvertent slide against the operator's intention is likely to occur.

When the pipe section outer sleeve **31**B slides carelessly, there becomes a concern that the camera section **36** which should be in the storage position may be deployed or the camera section **36** which should be in the deployed position may be stored contrary to the operator's will. According to the outer cylinder locking mechanism, since the pipe section outer sleeve **31**B can be locked at the holding position and the release position, it is possible to prevent the careless slide of the pipe section outer sleeve **31**B.

In addition, the engagement projection **46**E, which regulates the slide of the outer cylinder member **16**B by engaging with the engaging grooves **47**A and **47**B, is integrally formed with the lock releasing member **46**, so that the structure becomes simple. Therefore, it is advantageous in terms of parts cost and assembly.

Further, since the lock releasing member **46** is disposed in the head section **32** larger in diameter than the pipe section **31**, the operability becomes good.

[Bearing Structure of Camera Section]

As shown in FIGS. **20**A and **20**B, the camera section **36** is attached to the pipe section inner sleeve **31**A, and is rotatably supported between the storage position and the deployed position. FIG. **20**A shows the camera section **36** in the storage position, and FIG. **20**B shows the camera section **36** in the deployed position. As also shown in FIG. **10**, the pair of left and right rotation pins **65** are provided at both ends in the width direction (X-axis direction) of the camera section **36**, and the each rotation pin **65** is attached to each of the pair of left and right bearings **67** formed in the cutout **61** of the pipe section inner sleeve **31**A. The pair of bearings **67** rotatably support the each rotation pin **65**.

The each bearing **67** has a distal side receiving opening **67**A that receives the rotation pin **65** on the distal side of the pipe section inner sleeve **31**A. In the bearing **67**, the shape of the cross section orthogonal to the rotation pin **65** is substantially semicircular, and the cutout corresponding to the remaining semicircle corresponds to the distal side receiving opening **67**A. The distal side receiving opening **67**A can receive the rotation pin **65** entering from the distal side of the pipe section **31** along the Z-axis direction of the pipe section **31**. A detachment prevention member **76** for preventing detachment of the rotation pin **65** supported by the bearing **67** is disposed at a position opposite to the distal side receiving opening **67**A. The detachment prevention member **76** is an axially extending band-like tongue and is provided in the pipe section inner sleeve **31**A.

The detachment prevention member **76** is integrally formed with, for example, the pipe section inner sleeve **31**A. One end of the detachment prevention member **76** is a fixed end **76**A fixed to the pipe section inner sleeve **31**A, and the other end on the proximal side is a free end **76**B having elasticity. With this configuration, the detachment prevention member **76** can be elastically deformed such that the free end **76**B is displaced in the width direction (X-axis direction) of the camera section **36** with respect to the fixed end **76**A (see FIG. **21**B). The detachment prevention member **76** is made of resin and is molded integrally with the pipe section inner sleeve **31**A. The detachment prevention member **76** is formed to a length such that the free end **76**B is located at the distal side receiving opening **67**A, and the free end **76**B is disposed opposite to the distal side receiving opening **67**A. The free end **76**B cooperates with the bearing **67** to support the rotation pin **65** and covers the distal side receiving opening **67**A to prevent the rotation pin **65** from falling off from the bearing **67**. A bearing structure of the camera section **36** is constituted of the rotation pin **65** corresponding to the pivot, the bearing **67**, and the detachment prevention member **76**.

As shown in FIGS. **21**A to **21**C, the each free end **76**B of the left and right detachment prevention members **76** is provided with a projecting section **76**C projecting inward, that is, projecting toward the mutually opposing free ends **76**B (See also FIG. **10**).

FIGS. **21**A-**21**C show how to attach the camera section **36**. As shown in FIG. **21**A, the camera section **36** is attached to the bearing **67** from the distal end side of the pipe section inner sleeve **31**A. At this time, as shown in FIG. **21**B, the left and right rotation pins **65** are inserted between the left and right detachment prevention members **76** and contact with the inside of the each detachment prevention member **76**. In this state, the camera section **36** is moved along the Z-axis direction of the pipe section inner sleeve **31**A.

The distance between the left and right rotation pins **65** is wider than the distance between the left and right detachment prevention members **76**. Therefore, in the state where the left and right rotation pins **65** are in contact with the left and right detachment prevention members **76**, the free ends **76**B elastically deform outward with respect to the fixed ends **76**A. The elastic deformation of the detachment prevention members **76** continue until the left and right rotation pins **65** are accepted by the left and right bearings **67** through the distal side receiving openings **67**A.

As shown in FIG. **21**B, when the left and right rotation pins **65** moving toward the bearings **67** from the distal end reach the positions of the projecting sections **76**C, the outward deformation amount of the free ends **76**B of the detachment prevention members **76** become maximum. In this state, the free end **76**B withdraws from the front of the distal side receiving opening **67**A of the bearing **67**. This allows the rotation pin **65** to enter the bearing **67**.

As the camera section **36** is further moved toward the proximal side, the rotation pin **65** enters the bearing **67** and is accepted, as shown in FIG. **21**C. When the rotation pin **65** is received by the bearing **67**, the contact between the inside of the detachment prevention member **76** and the rotation pin **65** is released. Therefore, the outwardly deformed free end **76**B is displaced inward by elasticity, and returns to the initial position opposite to the distal side receiving opening **67**A. As a result, since the distal side receiving opening **67**A of the bearing **67** that has received the rotation pin **65** is covered, it is possible to prevent the rotation pin **65** from falling off from the bearing **67**. In addition, the outer peripheral surface of the rotation pin **65** around the axis is covered by the bearing **67** and the distal side receiving opening **67**A, so as to be supported rotatably by these cooperation.

Since the bearing structure of the rotation pin **65** is configured by the bearing **67** having the distal side receiving opening **67**A and the detachment prevention member **76** disposed opposite to the distal side receiving opening **67**A, it becomes possible to prevent lowering of strength of the rotation pin **65** of the camera section **36** while securing the good mountability of the camera section **36**.

That is, since the distal side receiving opening **67**A is configured by a substantially semicircular notch, the cross-sectional shape in the direction orthogonal to the rotation axis can be made circular in the rotation pin **65**. If the receiving port of the bearing **67** is smaller than the radius of the rotation pin **65**, the rotation pin **65** can not be inserted into the bearing **67**. In that case, in order to reduce the cross-sectional size of the rotation pin **65**, it is necessary to apply for example a D-cut or an I-cut at least to a part of the rotation pin **65**. Such processing leads to a reduction in the strength of the rotation pin **65**. If the strength of the rotation pin **65** decreases, for example, the rotation pin **65** may be damaged in the abdominal cavity. Such the danger can be avoided by preventing the strength of the rotation pin **65** from being reduced.

Further, since the detachment prevention member **76** is disposed in the distal side receiving opening **67**A, the rotation pin **65** is prevented from dropping off from the bearing **67**.

Furthermore, since the detachment prevention member **76** is elastically deformable, when attaching the camera section **36** to the bearing **67**, the detachment prevention member **76** can be elastically deformed and retracted from the distal side receiving opening **67**A. Therefore, since the rotation pin **65** can enter the bearing **67** from the distal side receiving opening **67**A only by moving the camera section **36** along the axial direction from the distal side, the mountability of the camera section **36** becomes also good.

In addition, the projection section **76**C projecting inward is provided at the free end **76**B of the detachment prevention member **76**. Accordingly, the free end **76**B can be largely deformed outward immediately before the rotation pin **65** reaches the distal side receiving opening **67**A. As a result, the amount of evacuation of the free end **76**B is increased, so that the rotation pin **65** can easily enter into the distal side receiving opening **67**A.

Note that in the bearing **67** of this embodiment, the substantially semicircular shape means a semicircle having a circular arc with a length of 50% of the circular circumference, or having a range of plus or minus 10% based on the semicircle, that is, an arc having a length of 40% to 60% of the circular circumference. Regarding the distal side receiving opening **67**A, as the length of the arc of the bearing **67** approaches 60%, the size of the opening decreases, and as the length of the arc of the bearing **67** approaches 40%, the size of the opening increases.

For example, if the length of the arc of the bearing **67** is 60%, the size of the distal side receiving opening **67**A may be slightly smaller than the radius of the rotation pin **65**. However, even in that case, it is possible to receive the rotation pin **65** in the bearing **67** if the distal side receiving opening **67**A can be elastically deformed to expand the size of the opening. Further, as the size of the distal side receiving opening **67**A is reduced, the effect of preventing the dropout of the rotation pin **65** from the bearing **67** becomes greater.

[Ridge Section of Puncture Member]

As shown in FIG. **22**, on the outer peripheral surface of the puncture member **55** of the trocar shaft **17**, a plurality of ridge sections **78** protruding in the radial direction and extending along the Z-axis direction of the puncture member **55** are formed. As described in FIGS. **2** and **3**, the puncture member **55** is first inserted into the incision part **27** formed in the abdominal wall **23** of the patient P, when inserting the trocar with camera **16** into the abdominal cavity of the patient P. As described above, the abdominal wall **23** is formed of a subcutaneous tissue such as the fat **23**A (see FIGS. **24**A and **24**B), and the puncture member **55** plays the role of spreading the abdominal wall **23**. The ridge section **78** tears the subcutaneous tissue and prevents wrapping of a subcutaneous tissue on the outer peripheral surface of the puncture member **55**, particularly wrapping of the fat **23**A.

In this embodiment, four ridge sections **78** are provided. Note that with regard to the four ridge sections **78**, when it is necessary to distinguish each of the ridge sections **78**, the symbols will be separately described as the ridge sections **78**A to **78**D, and if it is not necessary to distinguish them, it will be described simply as the ridge section **78**.

As shown in FIGS. **23**A and **23**B, the four ridge sections **78**A, **78**B, **78**C, **78**D are arranged in a crosswise manner as a whole as the puncture member **55** is viewed from the distal end side in the Z-axis direction. Specifically, the four ridge sections **78**A, **78**B, **78**C, **78**D are arranged at 90° intervals in the circumferential direction around the Z-axis of the puncture member **55** at the proximal end, and the distal ends of the ridge sections intersect at the distal end of the puncture member **55**.

FIG. **23**A shows a positional relationship between the plurality of ridge sections **78** and the camera section **36** when the camera section **36** is in the storage position, that is, when the trocar shaft **17** is in the initial position (see FIGS. **3** and **12**A and so on). FIG. **23**B shows a positional relationship between the plurality of ridge sections **78** and the camera section **36** in the state where the trocar shaft **17** is in the release completion position (see FIGS. **4** and **12**B and so on).

As shown in FIG. **23**A, when the trocar shaft **17** is in the initial position (the camera section **36** is in the storage position), of the four ridge sections **78**A to **78**D, the two ridge sections **78**A and **78**B are arranged at positions where the end on the proximal side corresponds to the position of each hinge section at both ends of the camera section **36** in the circumferential direction about the Z-axis of the puncture member **55**. Each hinge section is provided at both ends of the camera section **36** as described above, and is configured by the rotation pin **65** provided on the each side face section **64**B of the camera section **36** and the each bearing **67** provided on the inner periphery of the cutout **61**.

FIGS. **24**A and **24**B are explanatory diagrams showing wrapping of the fat **23**A on the distal end of the pipe section **31** in which the camera section **36** is disposed, based on the findings obtained through animal experiments. FIG. **24**A is a side view of the pipe section **31** as viewed from the side, and FIG. **24**B is a top view of the pipe section **31** as viewed from above where the camera section **36** is disposed. As shown in FIGS. **24**A and **24**B, in the pipe section **31** behind the puncture member **55**, a region R**1** corresponding to the ridge section **78** has less wrapping of the fat **23**A than the other region R**2**. Therefore, by arranging the ridge sections **78**A and **78**B at the positions corresponding to the hinge sections of the camera section **36** provided in the pipe section **31**, it is possible to suppress the wrapping of the fat **23**A on the peripheral region (the region R**1** in FIGS. **24**A and **24**B) including the hinge sections of the camera section **36**.

Since the fat **23**A wrapped around the camera section **36** becomes a resistance when the camera section **36** pops up to the deployed position, it becomes a factor that disturbs the smooth deployment of the camera section **36**. By arranging the ridge sections **78**A and **78**B at positions corresponding to the hinge sections of the camera section **36**, the wrapping of the fat **23**A can be suppressed. This enables smooth deployment of the camera section **36**.

Further, in the each ridge section **78**, an upper end part **79** corresponding to the ridge line along the Z-axis direction has a flat surface, not a tapered shape like a blade edge. By making the upper end part **79** a flat surface, following effects can be obtained. First, even if the operator touches the puncture member **55** with a hand wearing a rubber glove, the rubber glove can be prevented from being damaged. Second, even when a large force acts on the puncture member **55** when the trocar apparatus with camera **12** is inserted into the abdominal cavity, the ridge section **78** is less likely to be broken than in the case where the upper end part **79** has a tapered shape. Third, breakage of a seal unit contained in the airtight structure unit **42** can be prevented. When inserting the trocar shaft **17** into the trocar with camera **16**, the puncture member **55** passes through the airtight structure unit **42**. However, by making the ridge section **78** a flat surface, it is possible to prevent the seal unit contained in the airtight structure unit **42** from being damaged.

Further, as shown in FIGS. **23**A and **23**B, the maximum diameter D**2** in the radial direction of the plurality of ridge sections **78** is equal to or less than the maximum diameter D**1** of a portion where the ridge section **78** is not formed on the outer peripheral surface **55**A of the puncture member **55**. In this embodiment, the maximum diameter D**1** is the diameter at the proximal end of the tapered shape puncture member **55**, and the maximum diameter D**2** of the ridge section **78** is a diameter connecting the upper end parts **79** of the plural ridge sections **78** arranged circumferentially at the proximal end of the ridge section **78**.

Thus, the maximum protrusion amount of the ridge section **78** can be regulated by setting the maximum diameter D**2** of the ridge section **78** to the maximum diameter D**1** of the puncture member **55** or less. Therefore, the above-described first to third effects, by making the upper end part **79** of the ridge section **78** a flat surface, can be further enhanced.

Note that although the four ridge sections **78** are provided in this embodiment, the number of ridge sections **78** may be other than four. For example, three or five or more ridge sections **78** may be used, as long as the two ridge sections **78**A and **78**B disposed at positions corresponding to the hinge sections of the camera section **36** are included. Also, two or more ridge sections **78** may be arranged at a position corresponding to one hinge section.

FIG. **25** shows an example in which eight ridge sections **78** are provided. Two of these are arranged at positions corresponding to the hinge sections of the camera section **36**, as same as the ridge sections **78**A and **78**B shown in FIG. **23**A. Further, as in the examples of providing the four ridge sections **78** shown in FIGS. **23**A and **23**B and providing the eight ridge sections **78** shown in FIG. **25**, the arrangement intervals of the plurality of ridge sections **78** are preferably equal. This is because it is considered that the effect of preventing wrapping of the fat **23**A by providing a plurality of ridge sections **78** can be equally obtained in the circumferential direction of the puncture member **55**, when the arrangement intervals are equal.

[Airtight Structure Unit]

FIG. **26** is a perspective view of the airtight structure unit **42** shown in FIG. **7** as viewed from the proximal side. As described above, the airtight structure unit **42** has the function of preventing gas leakage from the inside of the abdominal cavity to the outside of the body. The airtight structure unit **42** is accommodated in the head section inner sleeve **32**A, and the rear opening portion of the head section inner sleeve **32**A is closed by the rear cover **43**.

As shown in FIGS. **27** and **28**, the airtight structure unit **42** is configured of a duckbill valve **81** and a seal unit **82** disposed on the proximal side of the duckbill valve **81**. The duckbill valve **81** prevents gas from leaking out of the insufflated body cavity through the insertion hole **33** when the treatment tool **22** is not inserted into the trocar with camera **16**. On the other hand, the seal unit **82** prevents gas from leaking out of the body cavity through the insertion hole **33** in the state where the treatment tool **22** is inserted.

(Configuration of Duckbill Valve)

The duckbill valve **81** is a valve mechanism shaped like a duck bill as well known, and has a valve section **81**A and a circular section **81**B integrally formed at the proximal end of the valve section **81**A. The duckbill valve **81** is formed of an elastomer such as silicone rubber. The valve section **81**A has two opposite slopes intersecting at the distal end and extending toward the proximal end. At the distal end of the valve section **81**A, a linear opening **81**C is formed. At the proximal end of the circular section **81**B, a flange **81**D that protrudes outward is formed (see also FIG. **4**).

As shown in a sectional view of FIG. **30**, on the inner wall surface of the head section inner sleeve **32**A to which the airtight structure unit **42** is attached, provided is an abutment surface **83** which abuts the flange **81**D of the duckbill valve **81**. In the head section inner sleeve **32**A, the inner diameter on the distal side of the abutment surface **83** is substantially the same as the outer diameter of the circular section **81**B of the duckbill valve **81**.

(Configuration of Seal Unit)

As shown in FIGS. **27** and **28**, the seal unit **82** includes a seal holder **86**, a first mount **87**, a dome type seal **88**, an airtight rubber cover **89**, a centering guide **91**, and a second mount **92**. These members are disposed in this order from the distal end side to the proximal end side with the seal holder **86** at the top, and are united as the seal unit **82**.

The dome type seal **88** is a member having a circular planar shape and having a convex dome shape toward the distal end side. The dome type seal **88** has a dome-shaped seal section **88**A and a circular flange **88**B formed on the outer periphery of the seal section **88**A. At the radial center of the seal section **88**A, that is, at the central portion located at the apex of the dome shape, formed is an opening **88**C through which the treatment tool **22** and the trocar shaft **17** are inserted. The dome type seal **88** is made of a single piece of material having a circular planar shape, and the material is silicone rubber. The opening **88**C expands by elastic deformation, with being in close contact with the outer peripheral surface of the treatment tool **22** being inserted therein. The outer peripheral surface of the treatment tool **22** and the inner circumference of the opening **88**C are airtightly sealed. Thereby, the gas leakage from the opening **88**C is prevented in the state where the treatment tool **22** is inserted.

The diameter of the opening **88**C of the dome type seal **88** is determined according to the outer diameter of the treatment tool **22** to be inserted. The outer diameter of a typical treatment tool **22** is about 5 mm. Therefore, in this embodiment, the diameter of the opening **88**C is set to 4 mm, which is slightly smaller than the outer diameter of the treatment tool **22**. Accordingly, as the treatment tool **22** is inserted, the opening **88**C is expanded by elastic deformation so that the inner periphery of the opening **88**C and the outer periphery of the treatment tool **22** can be closely attached.

The silicone rubber used in the dome type seal **88** is a silicone rubber having a JIS A hardness of 30 according to durometer measurement, and is a relatively flexible material having a thickness of about 0.8 mm. By using a flexible material, the good operability of the treatment tool **22** is ensured.

As also shown in FIG. **29**, the centering guide **91** is disposed behind the dome type seal **88** (proximal side of the trocar with camera **16**). The centering guide **91** is composed of four segments **93**. The centering guide **91** is configured to have a convex dome shape toward the distal end side as a whole by combining the segments **93**. In the each segment **93**, the adjacent segments **93** are partially overlapped.

The overall shape of the centering guide **91** corresponds to the shape of the dome type seal **88**. The centering guide **91** has a dome-shaped guide section **91**A and a flange **91**B formed on the outer periphery of the guide section **91**A. In the central portion corresponding to the apex of the dome shape of the guide section **91**A, formed is an opening **91**C through which the treatment tool **22** and the trocar shaft **17** are inserted. The diameter of the opening **91**C is the same as or slightly smaller than the opening **88**C of the dome type seal **88**. In this embodiment, it is 4 mm, the same as the opening **88**C. The material of the centering guide **91** is polyurethane having a JIS A hardness of 90 according to durometer measurement, and has a thickness of about 0.5 mm.

In FIG. **29**, FIG. **31**A, and FIG. **31**B which show a state where the centering guide **91** is viewed from the proximal end side, the four segments **93** constituting the centering guide **91** are substantially fan-shaped, and the length of the arc is ¼ of the circumference of the centering guide **91**. Here, the expression "¼ of the circumference" includes a margin of plus or minus 10%.

In addition, the area of overlapping region **93**A where the adjacent segments **93** overlap is half or less of the total area of the segments **93**. Further, as shown in FIGS. **31**A and **31**B, the overlapping region **93**A has a shape in which the width of the overlapping region **93**A monotonously increases from the outer periphery toward the center of the centering guide **91**.

In each of the segments **93**, a cutout **93**B that is a part of the opening **91**C is formed. Further, in the overlapping region **93**A, the edge on the opening **91**C side is smoothly connected to the cutout **93**B. In addition, the edge on the opening **91**C side extends in a direction parallel to the radial direction of the centering guide **91**.

When the treatment tool **22** is inserted, the opening **91**C expands in accordance with the outer diameter of the treatment tool. This expansion is performed by displacing the adjacent segments **93** in a direction in which they are separated. The opening **91**C is composed of the cutouts **93**B of the each segment **93**, and the adjacent segments **93** have the overlapping region **93**A. Therefore, even when the opening **91**C is expanded, the overlap between the adjacent segments **93** is maintained, so that a gap is hardly generated between the opening **91**C and the outer periphery of the treatment tool **22**.

The centering guide **91** guides the distal end of the treatment tool **22** to the opening **88**C at the center of the dome type seal **88** by the guide section **91**A and the opening **91**C when the treatment tool **22** is inserted.

The first mount **87** has an opening **87**C disposed on the distal end side of the dome type seal **88** and exposing the seal section **88**A, and has a mount section **87**A with a convex shape projecting toward the distal end side and a flange **87**B formed on the outer periphery of the mount section **87**A. The first mount **87** is formed of, for example, a resin material such as polyester. The first mount **87** supports the distal end side of the seal section **88**A of the dome type seal **88** by the mount section **87**A, and supports the flange **88**B from the distal end side by the flange **87**B. The diameter of the opening **87**C is larger than the diameter of the trocar shaft **17** and the treatment tool **22**, so that these can be inserted to the opening.

The seal holder **86** has an opening **86**C that exposes the seal section **88**A of the dome type seal **88**, and has a substantially conical cover section **86**A with a convex shape projecting toward the distal end side and a cylinder section **86**B formed on the proximal side of the cover section **86**A. The diameter of the opening **86**C of the seal holder **86** is slightly larger than the diameter of the opening **87**C of the first mount **87**. The seal holder **86** is formed of, for example, a resin material such as polyester.

The cover section **86**A supports and covers the periphery of the mount section **87**A of the first mount **87**, that exposes the seal section **88**A of the dome type seal **88**, from the distal end side. When the dome type seal **88** and the mount section **87**A move to the distal end side in accordance with the operation of the treatment tool **22**, the cover section **86**A functions as an abutment member for the mount section **87**A to restrict the movement amount toward the distal end side.

The cylinder section **86**B functions as a frame to which the airtight rubber cover **89** is attached. The inside diameter of the cylinder section **86**B is large enough to accommodate the first mount **87**, the dome type seal **88**, the centering guide **91**, and the second mount **92** inside. In the cylinder section **86**B, a distal peripheral edge **86**D (see FIG. **30**) located around the cover section **86**A functions as an abutment surface for the flange **81**D of the duckbill valve **81** via the airtight rubber cover **89**.

The second mount **92** is disposed on the proximal side of the centering guide **91**. The second mount **92** has a mount section **92**A with a convex shape projecting toward the distal end side and a flange **92**B formed on the outer periphery of the mount section **92**A. The second mount **92** is formed of, for example, a resin material such as polyester. The second mount **92** supports the proximal side of the guide section **91**A of the centering guide **91** by the mount section **92**A, and supports the flange **91**B from the proximal side by the flange **92**B. An opening **92**C is formed in the mount section **92**A. The opening **92**C has almost the same diameter as the opening **87**C of the first mount **87**, so that the trocar shaft **17** and the treatment tool **22** can be inserted therein.

The flange **92**B is formed with a plurality of pins **92**D projecting toward the distal end side. The pins **92**D are equally spaced on the circumference of the flange **92**B. The plurality of pins **92**D are inserted into small holes **91**E (see FIG. **29**) of the flange **91**B of the centering guide **91**, small holes **88**E (see FIG. **29**) of the flange **88**B of the dome type seal **88**, and small holes of the flange **87**B of the first mount **87**. As a result, the centering guide **91**, the dome type seal **88**, the first mount **87**, and the second mount **92** are assembled together as shown in FIG. **30**.

The pin **92**D is caulked, for example, by heat welding such as ultrasonic welding in a state where the pin **92**D is inserted into the small holes **91**E, **88**E, and so on. As a result, the flange **87**B of the first mount **87**, the flange **88**B of the dome type seal **88**, and the flanges of the second mount **92** and the centering guide **91** are fixed in a close contact state. Since the pin **92**D is provided on the second mount **92** and protrudes to the distal end side, the distal end side of the caulked pin **92**D is not visible from the proximal end side of the airtight structure unit **42**. Accordingly, the appearance is improved.

The airtight rubber cover **89** has a cylinder section **89**A with a cylindrical shape and an inner flange **89**B provided inside the cylinder section **89**A. The inner flange **89**B is formed with an opening **89**C through which the trocar shaft **17** and the treatment tool **22** are inserted. Further, a bellows portion **89**D is provided between the cylinder section **89**A and the inner flange **89**B. The airtight rubber cover **89** is formed of an elastomer such as silicone rubber having a HS A hardness of 30 according to durometer measurement. The hardness of the airtight rubber cover **89** is as soft as the dome type seal **88**. In addition, in the airtight rubber cover **89**, the bellows portion **89**D is formed thinner than other portions such as the cylinder section **89**A and a folded portion **89**E. The bellows portion **89**D has the thickness of 0.3 mm and the other parts have the thickness of 0.5 mm.

The inner flange **89**B also has small holes into which the pins **92**D of the second mount **92** are inserted. As shown in FIG. **30**, by inserting the pins **92**D into the small holes, the inner flange **89**B is sandwiched between the flange **88**B of the dome type seal **88** and the flange **91**B of the centering guide **91**. As a result, the first mount **87**, the dome type seal **88**, the centering guide **91**, and the second mount **92** are attached to the airtight rubber cover **89**. Further, since the bellows portion **89**D elastically deforms and stretches, the dome type seal **88**, the centering guide **91** and the like are movably supported inside the airtight rubber cover **89**. The bellows portion **89**D allows radial movement of the dome type seal **88** and the centering guide **91**.

The cylinder section **89**A of the airtight rubber cover **89** is attached so as to cover the outer peripheral surface of the cylinder section **86**B of the seal holder **86**. The folded portion **89**E folded inward is provided at the periphery of the distal end side of the cylinder section **89**A, and the folded portion **89**E is put on the peripheral edge **86**D of the cylinder section **86**B of the seal holder **86**.

(Assembling of Seal Unit)

Assembling of the seal unit **82** is performed, for example, as follows. First, the segments **93** are superimposed to form the centering guide **91**, and the centering guide **91** is attached to the second mount **92** by inserting the pins **92**D into the small holes **91**E of the flange **91**B.

Next, the second mount **92** with the centering guide **91** attached is attached to the airtight rubber cover **89** by inserting the pins **92**D into the small holes of the inner flange **89**B. The pins **92**D protrude from the small holes of the inner flange **89**B of the airtight rubber cover **89**. In this state, the flange **88**B of the dome type seal **88** and the flange **87**B of the first mount **87** are sequentially attached from the distal end side to the pins **92**D protruding from the inner flange **89**B of the airtight rubber cover **89**. After these mountings are completed, the pins **92**D are caulked.

Finally, the airtight rubber cover **89** is applied from the proximal side of the seal holder **86**. The cylinder section **89**A is attached to the outer periphery of the cylinder section **86**B, and the peripheral edge **86**D is covered with the folded portion **89**E. The first mount **87**, the dome type seal **88**, the centering guide **91**, and the second mount **92**, which are fixed to the inner flange **89**B, are accommodated inside the seal holder **86**. As a result, the seal holder **86**, the first mount **87**, the dome type seal **88**, the centering guide **91**, the second mount **92**, and the airtight rubber cover **89** are integrated to complete the seal unit **82**.

(Attachment of the Airtight Structure Unit to the Head Section)

As shown in the sectional view of FIG. **30**, the duckbill valve **81** is mounted such that the outer peripheral surface of the circular section **81**B is in pressure contact with the inner wall of the head section inner sleeve **32**A, and the flange **81**D is pushed distally until it abuts the abutment surface **83**.

As the duckbill valve **81** is mounted, an internal space S**1** is formed in the head section inner sleeve **32**A by the outer peripheral surface of the duckbill valve **81** and the inner peripheral surface of the head section inner sleeve **32**A. The internal space S**1** communicates with the insertion hole **33** of the pipe section inner sleeve **31**A, and the connection port **49** to which carbon dioxide is supplied is also connected to the internal space S**1**.

After the duckbill valve **81** is attached, the seal unit **82** is attached to the proximal end side of the duckbill valve **81**. The seal unit **82** is attached in a state where the folded portion **89**E of the airtight rubber cover **89** which covers the peripheral edge **86**D of the seal holder **86** is in contact with the proximal end of the flange **81**D of the duckbill valve **81**. After the seal unit **82** is attached, the rear cover **43** is attached from the proximal end side of the seal unit **82**.

When the rear cover **43** is attached to the head section inner sleeve **32**A, the seal unit **82** receives the pressure from the rear cover **43**, and the duckbill valve **81** is pushed toward the distal end side. As a result, the flange **81**D of the duckbill valve **81** is pressed to the abutment surface **83**. In addition, the outer peripheral surface of the duckbill valve **81** and the inner wall of the head section inner sleeve **32**A are hermetically sealed. Thereby, the internal space S**1** is hermetically sealed.

Also, as the rear cover **43** is attached, the abutment surface **43**G on the distal side of the rear cover **43** is in pressure contact with a peripheral edge **82**A on the proximal side of the seal unit **82** covered by the airtight rubber cover **89**. In the distal end side of the seal unit **82**, the folded portion **89**E is in pressure contact with the flange **81**D of the duckbill valve **81**. By this pressure contact, in an internal space S**2** of the duckbill valve **81**, the proximal end side peripheral portion of the duckbill valve **81** is sealed. Further, by the attachment of the rear cover **43**, the seal unit **82** is held between the duckbill valve **81** in the distal end side and the rear cover **43** in the proximal end side so as not to move in the Z-axis direction.

In addition, in the seal unit **82**, the inner flange **89**B of the airtight rubber cover **89** and the flange **88**B of the dome type seal **88** are in pressure contact and sealed airtightly by caulking of the pin **92**D. Therefore, when the treatment tool **22** is inserted through the opening **88**C of the dome type seal **88**, the internal space S**2** of the duckbill valve **81** is airtightly sealed.

(Functions of Airtight Structure Unit)

When trocar with camera **16** is inserted into the body cavity and insufflation is performed by supply of carbon dioxide gas, the pressure in the internal space S**1** increases, and pressure in the direction to block the opening **81**C works on the two slopes of the valve section **81**A of the duckbill valve **81**. When the treatment tool **22** is not inserted into the opening **81**C, the opening **81**C is hermetically sealed by the air pressure. Also, the duckbill valve **81** is airtightly attached to the pipe section inner sleeve **31**A. Therefore, when the treatment tool **22** is not inserted into the opening **81**C, gas leakage from the internal space S**1** to the outside of the body is prevented.

When the trocar shaft **17** or the treatment tool **22** is inserted into the opening **88**C of the dome type seal **88** or the like, the opening **88**C spreads due to elasticity and closely contacts the outer peripheral surface of the trocar shaft **17** or the treatment tool **22**. On the other hand, the opening **81**C of the duckbill valve **81** opens when the trocar shaft **17** or the treatment tool **22** is inserted thereto. Since the opening **81**C is a linear opening, when the opening **81**C is opened, a gap is generated between the opening **81**C and the outer peripheral surface of the trocar shaft **17** or the treatment tool **22**, and the seal is released.

However, when the trocar shaft **17** or the treatment tool **22** is inserted, the proximal end side of the internal space S**2** in the duckbill valve **81** is sealed by the seal unit **82** including the dome type seal **88**. For this reason, even if the opening **81**C of the duckbill valve **81** is opened by the trocar shaft **17** or the treatment tool **22** being inserted, it is possible to prevent the gas from leaking out of the body cavity through the insertion hole **33**.

The seal unit **82** improves the air tightness by using the one-piece dome type seal **88** having the opening **88**C, as compared with a conventional seal in which a seal is constituted of a plurality of segments, because the seal unit **82** has no gap which would be caused between such segments.

Further, on the proximal side of the dome type seal **88**, disposed is the centering guide **91** having hardness higher than that of the dome type seal **88** and having the opening **91**C. Therefore, when the treatment tool **22** is inserted into the trocar with camera **16**, it is easy to guide the treatment tool **22** to the position of the opening **88**C at the center of the dome type seal **88**. This is because the treatment tool **22** will be guided to the position of the opening **88**C of the dome type seal **88** by abutting the treatment tool **22** to the proximal end side of the centering guide **91** and detecting the position of the opening **91**C with a tactile sense. The opening position can be easily found as compared with a conventional case where a protector having no opening is disposed on the proximal end side of a seal. In addition, since the hardness of the centering guide **91** is higher than that of the dome type seal **88**, the frictional resistance of the treatment tool **22** is reduced, which facilitates guiding.

In this embodiment, the seal unit **82** uses the dome type seal **88**, the centering guide **91** composed of the plurality of segments **93**, and the airtight rubber cover **89** in combination. Further, the hardness of each of the dome type seal **88** and the airtight rubber cover **89** is lower than the hardness of the centering guide **91**. Therefore, as described below, even if a radial force acts on the opening **88**C of the dome type seal **88** by the movement of the treatment tool **22**, the deformation of the opening **88**C is prevented. As the deformation of the opening **88**C is prevented, a gap does not easily occur between the opening **88**C and the outer peripheral surface of the treatment tool **22**, so that good sealing performance can be ensured.

FIGS. **32**A and **32**B are views of the seal unit **82** in a state where the treatment tool **22** has been inserted, as viewed from the proximal side. FIG. **32**A shows a state in which the treatment tool **22** is at the radial center of the seal unit **82**, and FIG. **32**B shows a state in which the treatment tool **22** has moved in the radial direction of the seal unit **82**, that is, toward the right in the figure, from the state in FIG. **32**A.

When the treatment tool **22** is inserted, the opening **88**C of the dome type seal **88** and the opening **91**C of the centering guide **91** expand according to the outer diameter of the treatment tool **22**. As shown in FIG. **32**A, in the state where the treatment tool **22** is at the center, the bellows portion **89**D of the airtight rubber cover **89** maintains the initial state where the distance to the cylinder section **89**A is uniform over the entire circumference.

When the treatment tool **22** is operated to move in the radial direction (to the right side in the figure) as shown in FIG. **32**B, a force acts in a direction to expand the opening **91**C of the centering guide **91**. In order for the opening **91**C to expand, the adjacent segments **93** must move in a direction away from each other, but a frictional resistance is generated due to the contact in the overlapping region **93**A. The frictional resistance against the force for expanding the opening **91**C is larger than the resistance against the force for expanding the opening **88**C of the dome type seal **88** and the resistance against the force for elastically deforming the bellows part **89**D of the airtight rubber cover **89**.

Therefore, the bellows portion **89**D elastically deforms earlier than the opening **91**C expands. When the bellows portion **89**D is elastically deformed, the centering guide **91** and the dome type seal **88** held on the inner flange **89**B of the airtight rubber cover **89** move in the radial direction as a whole. As a result, the force for expanding the opening **88**C of the dome type seal **88** is also reduced, so that the deformation of the opening **88**C is prevented.

Also, by making the shape of segments **93** constituting the centering guide **91** into the fan shape having the arc whose length is ¼ of the circumference of the centering guide **91**, the overlapping amount of the adjacent segments **93** is reduced as compared with a prior art using a protector formed of semicircular segments. This improves the smoothness of the insertion and removal of the treatment tool **22** with respect to the opening **91**C. In addition, by setting the area of the overlapping region to be half or less of the total area of the segment, the amount of overlap is reduced compared to the prior art, and the smoothness is further improved.

Further, the overlapping region **93**A between the adjacent segments **93** has the shape in which the overlapping width monotonously increases from the outer periphery toward the opening **91**C at the center, thereby further improving the smoothness of insertion and extraction of the treatment tool **22** with respect to the opening **91**C. Since the treatment tool **22** is inserted near the center where the opening **91**C is located, the adjacent segments **93** are easy to be separated. On the other hand, as it gets closer to the outer circumference, it gets farther from the treatment tool **22** near the center, so that the amount of separation between the adjacent segments **93** decreases.

As described above, considering the smoothness of insertion and extraction of the treatment tool **22**, it is better for the overlapping region **93**A to be smaller. By making the overlapping width of the overlapping region **93**A monotonously increase from the outer periphery toward the opening **91**C at the center, the width of the overlapping region **93**A can be minimized while preventing the formation of a gap between the adjacent segments **93**.

[White Balance for Trocar Image or Endoscopic Image]

In the trocar apparatus with camera **12**, as shown in FIG. **33**, by forming a white part **94** on the surface of the puncture member **55** of the trocar shaft **17** which is to be inserted into the abdominal cavity, it is possible to set a white balance for trocar images inside the body cavity. To perform the white balance for trocar images, after popping up the camera section **36** to the deployed position in the abdominal cavity, the white part **94** formed on the surface of the puncture member **55** is entered in the field of view of the camera section **36**, and the white part **94** is illuminated with the illumination light from the endoscope **11**. In this state, the white balance setting switch **12***a* provided in the trocar apparatus with camera **12** is operated. As a result, a trocar image for setting the white balance including the image of the white part **94** is obtained. Note that the white balance setting switch **12***a* may be provided on the console **20**. Also, the white part **94** may be provided on the entire of the puncture member **55** or may be provided in a part of the puncture member **55**.

As shown in FIG. **34**, the trocar image for setting the white balance is sent to a white balance setting section for trocar image **18***a* provided in the processor **18**. The white balance setting section for trocar image **18***a* sets the white balance for trocar images based on the trocar image for white balance setting. Specifically, the white balance setting section for trocar image **18***a* identifies a specific region in a lower part of the image as the image region of the white part **94**, from the trocar image for setting the white balance, and performs the white balance setting based on the image in this specific region. Here, since the positional relationship between the camera section **36** and the white part **94** when the camera section **36** is set to the deployed position is known in advance, the specific region is preset based on this positional relationship. Note that it is known that the puncture member **55** occupies about 10% of the area of the trocar image for setting the white balance.

For the image in the specific region of the trocar image for setting white balance, a gain coefficient Gb of the B image signal, a gain coefficient Gg of the G image signal, and a gain coefficient Gr of the R image signal are set such that the ratio of the signal values of the B image signal, the G image signal and the R image signal becomes 1:1:1. This completes the setting of the white balance for trocar images. After setting the white balance, a white object will be displayed in white on the monitor **19** by multiplying the trocar image obtained from the camera section **36** by the gain coefficients Gb, Gg, and Gr.

The processor **18** is also provided with a white balance setting section for endoscopic image **18***b* that sets a white balance for endoscopic images. The white balance for endoscopic images may be made before inserting the endoscope **11** into the body cavity, or may be made substantially the same as the white balance for trocar images after setting the white balance for trocar images. When the white balance for endoscopic images is made substantially the same as the white balance for trocar images, for example, the gain coefficients Gb, Gg, and Gr for the trocar image set in the white balance setting section for trocar image **18***a* are sent to the white balance setting section for endoscopic image **18***b*. The white balance setting section for endoscopic image **18***b* sets the received gain coefficients Gb, Gg, and Gr as the gain coefficients to be used for the white balance for endoscopic images. A white object in the endoscopic image is displayed in white on the monitor **19** by multiplying the endoscopic image by the set gain coefficients Gb, Gg, and Gr.

Although the white balance can be performed in the body cavity by forming the white part **94** on the puncture member **55** of the trocar shaft **17**, but a part of the puncture member **55** may be a colored part for setting a color balance so that the color balance can be performed in addition to the white balance. For example, since there are few blue and green subjects in the body cavity, as shown in FIG. **35**, it is preferable to provide a blue part **95** and a green part **96** in addition to the white part **94** on the puncture member **55** to set the blue and green color balance.

In addition, when using a plurality of trocar apparatuses, the white part **94** should be provided in the puncture member **55** of the trocar shaft **17** of a specific trocar apparatus among the plurality of trocar apparatuses, but it is possible to set the white balance for trocar images even if the puncture member **55** of the trocar shaft **17** of the other trocar apparatus is not provided with the white part **94**. In this case, the specific trocar apparatus exposes the white part **94** of the puncture member **55** of the trocar shaft **17** in the body cavity so that the white part **94** becomes in the field of view of the camera section **36** of the trocar apparatus other than the specific trocar apparatus. In this state, the trocar apparatus other than the specific trocar apparatus images the white part **94** of the puncture member **55** of the trocar shaft **17** of the specific trocar apparatus, and performs the white balance setting using the trocar image obtained by this imaging. Note that the specific trocar apparatus may be a cameraless trocar apparatus that does not have the camera section **36** as long as the puncture member **55** of the trocar shaft **17** is provided with the white part **94**. This cameraless trocar apparatus is similar to the trocar with camera **16** except that it does not have the camera section **36**.

Hereinafter, the operation of the above configuration will be described. When performing laparoscopic surgery, the endoscope **11** and the trocar with camera **16** are connected to the processor **18**. After the connection is completed, the processor **18** is activated. Accordingly, driving of the camera unit **28** of the endoscope **11** and the camera unit **62** of the trocar with camera **16** is started for imaging. The image signals from the camera unit **28** and the camera unit **62** are input to the processor **18**. The processor **18** performs image processing on the image signals, and displays on the monitor **19** the composite image obtained by combining the endoscopic image and the trocar image.

The medical staff ST performs insertion of the endoscope **11** and the trocars **16** and **17** into the abdominal cavity while confirming the composite image displayed on the monitor **19**. First, the three incision parts **26** and **27** are opened in the abdomen of the patient P, for example as shown in FIG. **2**. The normal trocar **21** without a camera function is inserted in the middle incision part **26**.

On the other hand, the two trocar with camera **16** are inserted in the two incision parts **27**. The trocar shaft **17** is mounted to the trocar with camera **16** for the insertion of the trocar with camera **16**. For the mounting, as shown in FIGS. **12**B and **13**B, the outer cylinder member **16**B of the trocar with camera **16** is set to the release position in which the camera section **36** is in the deployed position.

The outer cylinder member **16**B is locked by the lock releasing member **46** so as not to slide. Therefore, in the holding position, as shown in FIG. **19**B, the outer cylinder member **16**B is slid to the release position on the proximal side in the state where the lock releasing member **46** is pressed to release the lock. As shown in FIG. **19**C, when the engaging projection **46**E reaches the engaging groove **47**B by sliding the outer cylinder member **16**B toward the release position, the engaging projection **46**E and the engaging groove **47**B are engaged by the action of the spring **68**, and the outer cylinder member **16**B is locked at the release position.

In this state, the shaft member **53** is inserted from the head section **32** into the insertion hole **33** of the pipe section **31**. With the cam pin **59** aligned with the guide groove **52**C as shown by the two-dot chain line in FIG. **14**, the trocar shaft **17** is advanced distally to engage the cam pin **59** with the guide groove **52**C. When the cam pin **59** reaches the second end **52**B, the engaging claw **54**A shown in FIG. **6** enters the fitting groove **43**B from the cutout **43**C shown in FIG. **7** to be in the state shown in FIGS. **4**, **12**B and **13**B. This state is the release position of the outer cylinder member **16**B, where the camera section **36** is in the deployed position.

When the trocar shaft **17** is rotated toward the initial position, the lock releasing member **46** is pressed to lock the slide of the outer cylinder member **16**B. In this state, the handle member **54** of the trocar shaft **17** is rotated. The rotation of the trocar shaft **17** causes the outer cylinder member **16**B to slide distally along the Z-axis direction by the action of the cam pin **59** and the cam groove **52**. By this slide, the distal end of the pipe section **31** abuts on the camera section **36** at the deployed position from behind, and rotates the camera section **36** toward the storage position. As the outer cylinder member **16**B reaches the holding position, the storage of the camera section **36** is completed as shown in FIGS. **3**, **12**A and **13**A.

As described above, since the outer cylinder member **16**B is slid by the rotation of the trocar shaft **17**, the force acting in directions other than the Z-axis direction is reduced as compared with the case where the pipe section outer sleeve **31**B is directly grasped and operated. Therefore, smooth slide operation of the pipe section outer sleeve **31**B is possible.

When the trocar shaft **17** is attached to the trocar with camera **16**, the puncture member **55** is exposed from the distal end of the pipe section **31**. In the insertion of the trocar with camera **16**, the puncture member **55** is firstly inserted into the incision part **27**. The puncture member **55** enters the body cavity while spreading the abdominal wall **23**, and the pipe section **31** enters after the puncture member **55**. The puncture member **55** advances while tearing the subcutaneous tissue of the fat **23**A.

At this time, the subcutaneous tissue of fat **23**A constituting the abdominal wall **23** is wrapped around the puncture member **55** and the pipe section **31**. As shown in FIG. **23**A, when the trocar shaft **17** is in the initial position and the camera section **36** is in the storage position, the two ridge sections **78** of the puncture member **55** are disposed at the positions corresponding to the hinge sections of the camera section **36**. Therefore, as shown in FIGS. **24**A and **24**B, in the region R**1** around the hinge section including the hinge section of the camera section **36** behind the puncture member **55**, the wrapping of the fat **23**A is suppressed as compared with the other region R**2**.

After the pipe section **31** of the trocar with camera **16** is inserted to a desired depth in the body cavity, the camera section **36** is deployed. For the deployment, the lock releasing member **46** is pressed to release the slide lock of the outer cylinder member **16**B. In this state, the handle member **54** of the trocar shaft **17** is rotated from the initial position to the release completion position. Then, by the actions of the cam pin **59** and the cam groove **52**, the outer cylinder member **16**B slides proximally from the holding position to the release position. As described above, since the outer cylinder member **16**B is slid by rotating the trocar shaft **17**, smooth operation is possible. By this slide, the holding of the camera section **36** is released, and the biasing force of the spring **71** causes the camera section **36** to pop up toward the deployed position.

When rotating the trocar shaft **17** toward the release completion position, as shown in FIGS. **15**A to **15**C, the pressing part **57**B provided on the connecting member **57** contacts the camera section **36** and pushes the camera section **36** toward the deployed position. The fat **23**A may be attached to the distal end of the pipe section **31** to which the camera section **36** is provided, which may be a resistance against the pop-up of the camera section **36**. Even in such a case, the deployment assist mechanism constituted of the connecting member **57** assists the biasing force of the spring **71**, so that the deployment by pop-up of the camera section **36** can be reliably performed.

In addition, since the two ridge sections **78**A and **78**B of the puncture member **55** also suppress the wrapping of the fat **23**A on the region R1 around the hinge section of the camera section **36**, smooth deployment of the camera section **36** becomes possible.

In the release position where the camera section **36** is in the deployed position, as shown in FIG. **19**C, the outer cylinder member **16**B engages with the engagement projection **46**E and the engaging groove **47**B, and is locked not to slide. Therefore, it is prevented that the camera section **36** is stored by a careless slide of the outer cylinder member **16**B.

After deploying the camera section **36**, the white balance for trocar images is set before removing the trocar shaft **17**. The user operates the white balance setting switch **12***a* so that the camera section **36** captures the trocar image for white balance setting including the white puncture member **55**. The white balance setting section for trocar image **18***a* sets the white balance for trocar images based on the trocar image for white balance setting.

After the setting of the white balance for trocar images is completed, the trocar shaft **17** will be removed from the trocar with camera **16**. When the camera section **36** is deployed, the trocar shaft **17** is in the release completion position. In this state, the cam pin **59** has reached the second end **52**B as indicated by the two-dot chain line in FIG. **14**. Therefore, the trocar shaft **17** can be removed from the trocar with camera **16** while moving the cam pin **59** along the guide groove **52**C.

After trocar shaft **17** is removed, carbon dioxide gas is supplied into the body cavity through the connection port **49** and the insertion hole **33** of the trocar with camera **16** to perform the insufflation procedure. When the treatment tool **22** is not inserted into the trocar with camera **16**, the internal space S1 (see FIG. **30**) communicating with the insertion hole **33** is hermetically sealed by the duckbill valve **81**. Therefore, no gas leak occurs in this state.

After completion of the insufflation procedure, the endoscope **11** is inserted into the body cavity with the trocar **21** as the insertion port. Then, the treatment tool **22** is inserted into the body cavity with the trocar with camera **16** as the insertion port.

When the treatment tool **22** is inserted, by the action of the centering guide **91** which has the opening **91**C and is harder than the dome type seal **88**, it becomes easy to guide the treatment tool **22** to the opening **88**C of the dome type seal **88**.

When the treatment tool **22** is inserted, the opening **81**C of the duckbill valve **81** is opened. The treatment tool **22** is inserted into the opening **88**C of the dome type seal **88** of the airtight structure unit **42**, and the opening **88**C and the treatment tool **22** are in close contact with each other. Therefore, the seal by the duckbill valve **81** is released, but the airtight structure unit **42** maintains the seal of the internal space S2 (see FIG. **30**) communicating with the insertion hole **33**. In addition, since the dome type seal **88** has the single-piece configuration, the sealing performance is better than in the case where it is configured with a plurality of segments.

The medical staff ST performs a procedure by manipulating the treatment tool **22** while observing the body cavity through the composite image displayed on the monitor **19**. The high flexibility of the dome type seal **88** ensures good operability of the treatment tool **22**. Even if the treatment tool **22** moves in the radial direction, by the combination of the dome type seal **88**, the bellows portion **89**D of the airtight rubber cover **89**, and the centering guide **91** whose hardness is higher than these, deformation of the opening **88**C is prevented as shown in FIG. **32**B. Sealing performance can be secured by preventing deformation of the opening **88**C.

The present application is not limited to the above-described embodiment, but includes modifications in which the above-described embodiment is appropriately modified within the scope of the present application. For example, although the plurality of applications are included in the above-mentioned embodiment, they may be carried out alone or two or more applications may be combined appropriately. Also, in the above embodiment, the seal unit provided with the dome type seal and the centering guide can be applied to a normal trocar without a camera. Further, in the above embodiment, the trocar with camera **16** has only the imaging function. However, in addition to the imaging function, an illumination function for emitting illumination light may be provided. Also, the camera-less trocar apparatus without the camera section **36** may be provided with the illumination function.

EXPLANATION OF REFERENCES

10 laparoscope system
11 endoscope
11A insertion section
12 trocar with camera
12*a* white balance setting switch
16 trocar with camera
16A inner cylinder member
16B outer cylinder member
17 trocar shaft (obturator)
18 processor
18*a* white balance setting section for trocar image
18*b* white balance setting section for endoscopic image
19 monitor
20 console
21 trocar(trocar)
22 treatment tool
22A distal end
23 abdominal wall
23A fat
26, **27** incision part
28 camera unit
31 pipe section (cannula, cannula sleeve)
31A pipe section inner sleeve
31B pipe section outer sleeve
32 head section
32A head section inner sleeve
32B head section outer sleeve
33 insertion hole
35 engagement claw
36 camera section
41 slip resistance
42 airtight structure unit
43 rear cover
43A engagement hole
43B fitting groove
43C cutout
43D grip section
43E opening
43F slot
43G abutment surface
44 connector member
46 lock releasing member
46A operation section
46B supporting section
46C mount pin

46D mount hole
46E engaging projection
47 engaging member
47A, **47**B engaging groove
49 connection port
51 cam plate
52 cam groove
52A first end
52B second end
52C guide groove
52D linear section
52E inclined section
53 shaft member
54 handle member
54A engaging claw
55 puncture member
55A outer peripheral surface
56 shaft member body
57 connecting member
57A body part
57B pressing part
58 pin arrangement plate
58A position mark
58B direction mark
58C inner peripheral surface
58D outer peripheral surface
58E extension part
59 cam pin
61 cutout
62 camera unit
62A imaging lens
62B lens barrel
63 mount
64 housing
64A upper face section
64B side face section
64C hook
65 rotation pin
66 mounting member
66A opening
66B bearing
67 bearing
67A distal side receiving opening
68 spring
71 spring
72 housing recess
72A hook
76 detachment prevention member
76A fixed end
76B free end
76C projecting section
78 ridge section
79 upper end part
81 duckbill valve
81A valve section
81B circular section
81C opening
81D flange
82 seal unit
82A peripheral edge
83 abutment surface
86 seal holder
86A cover section
86B cylinder section
86C opening
86D peripheral edge
87 first mount
87A mount section
87B flange
87C opening
88 dome type seal
88A seal section
88B flange
88C opening
88E small hole
89 airtight rubber cover
89A cylinder section
89B inner flange
89C opening
89D bellows portion
89E folded portion
91 centering guide
91A guide section
91B flange
91C opening
91E small hole
92 second mount
92A mount section
92B flange
92C opening
92D pin
93 segment
93A overlapping region
94 white part
95 blue part
96 green part
C**1**, C**2** center line
D**1**, D**2** maximum diameter
Lp coupling line
P patient
R**1** region
R**2** region
S**1** internal space
S**2** internal space
ST medical staff

What is claimed is:

1. A body cavity observation system comprising:

a trocar with camera comprising:

a trocar comprising a pipe section that is insertable into a body cavity;

a trocar shaft configured to be attached to the trocar when the trocar is inserted into the body cavity, the trocar shaft comprising a puncture member at a distal end of the trocar shaft and a white part formed on a surface of the puncture member and the puncture member is configured to be exposed from a distal end of the pipe section; and

a camera section disposed in a distal end area of the pipe section, the camera section configured to obtain a trocar image that comprises an image of the white part when the puncture member of the trocar shaft is exposed,

wherein

the camera section is displaceable between a storage position where the camera section is stored in the pipe section and a deployed position where the camera section is deployed in a direction projecting from an outer peripheral surface of the pipe section, and wherein the camera section is configured to perform imaging in the deployed position; and

a processor configured to be connected to the trocar, the processor comprising a white balance setting section that is configured to set a white balance of subsequent trocar images based on the image of the white part in the trocar image.

2. A laparoscope system comprising:

the body cavity observation system according to claim **1**, and

an endoscope configured to be inserted in a trocar different from the trocar of the body cavity observation system,

wherein

the white part formed on the surface of the puncture member is configured to be illuminated with illumination light from the endoscope.

3. The laparoscope system according to claim **2**, wherein the white balance for the trocar image is substantially the same as a white balance for an endoscopic image configured to be obtained by the endoscope.

4. A trocar apparatus configured to set a white balance of a trocar image configured to be obtained inside a body cavity, the trocar apparatus comprising:

a trocar comprising a pipe section that is insertable into the body cavity;

a trocar shaft configured to be attached to the trocar when the trocar is inserted into the body cavity, the trocar shaft comprising a puncture member at a distal end of the trocar shaft and a white part formed on a surface of the puncture member, and the puncture member is configured to be exposed from a distal end of the pipe section; and

a camera section disposed in a distal end area of the pipe section, the camera section configured to obtain the trocar image comprising an image of the white part when the puncture member of the trocar shaft is exposed,

wherein

the camera section is displaceable between a storage position where the camera section is stored in the pipe section and a deployed position where the camera section is deployed in a direction projecting from an outer peripheral surface of the pipe section, and wherein the camera section is configured to perform imaging in the deployed position.

5. The trocar apparatus according to claim **4**, further comprising:

a processor configured to be connected to the trocar, the processor comprising a white balance setting section that is configured to set a white balance of subsequent trocar images based on the image of the white part.

6. An operation method of a body cavity observation system, the body cavity observation system comprising a trocar with camera that comprises a pipe section that is insertable into a body cavity, a trocar shaft configured to be attached to the trocar when the trocar is inserted into the body cavity, the trocar shaft comprising a white part formed on a surface of a puncture member at a distal end of the trocar shaft, the puncture member configured to be exposed from a distal end of the pipe section, and a camera section disposed in a distal end area of the pipe section, the operation method comprising:

displacing the camera section between a storage position where the camera section is stored in the pipe section and a deployed position where the camera section is deployed in a direction projecting from an outer peripheral surface of the pipe section, and wherein the camera section performs imaging in the deployed position;

obtaining a trocar image, that comprises an image of the white part, by the camera section performing imaging; and

setting a white balance for subsequent trocar images, by a white balance setting section, based on the image of the white part in the trocar image.

7. The body cavity observation system according to claim **1**, wherein

the camera section is configured to deploy to the deployed position by rotation of the trocar shaft.

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