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(54) **CONTROLLER AND COMPUTER**

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(57) **ABSTRACT**

To provide a controller that can reduce a sense of discomfort felt by a user. A pen-type controller with a grip according to the present disclosure includes a pen part that is formed in a pen shape, a grip part that intersects an axial direction of the pen part, and a battery that is arranged in the grip part.

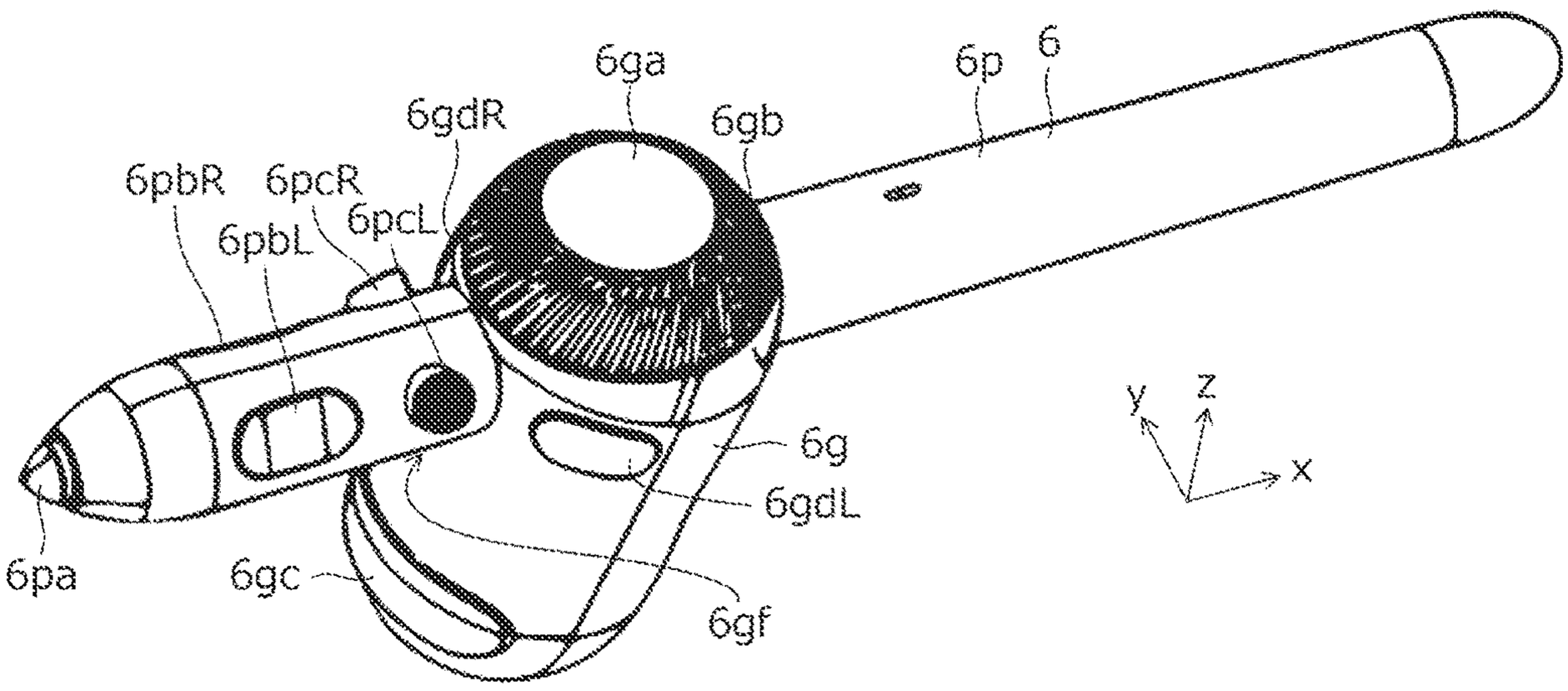


FIG. 1

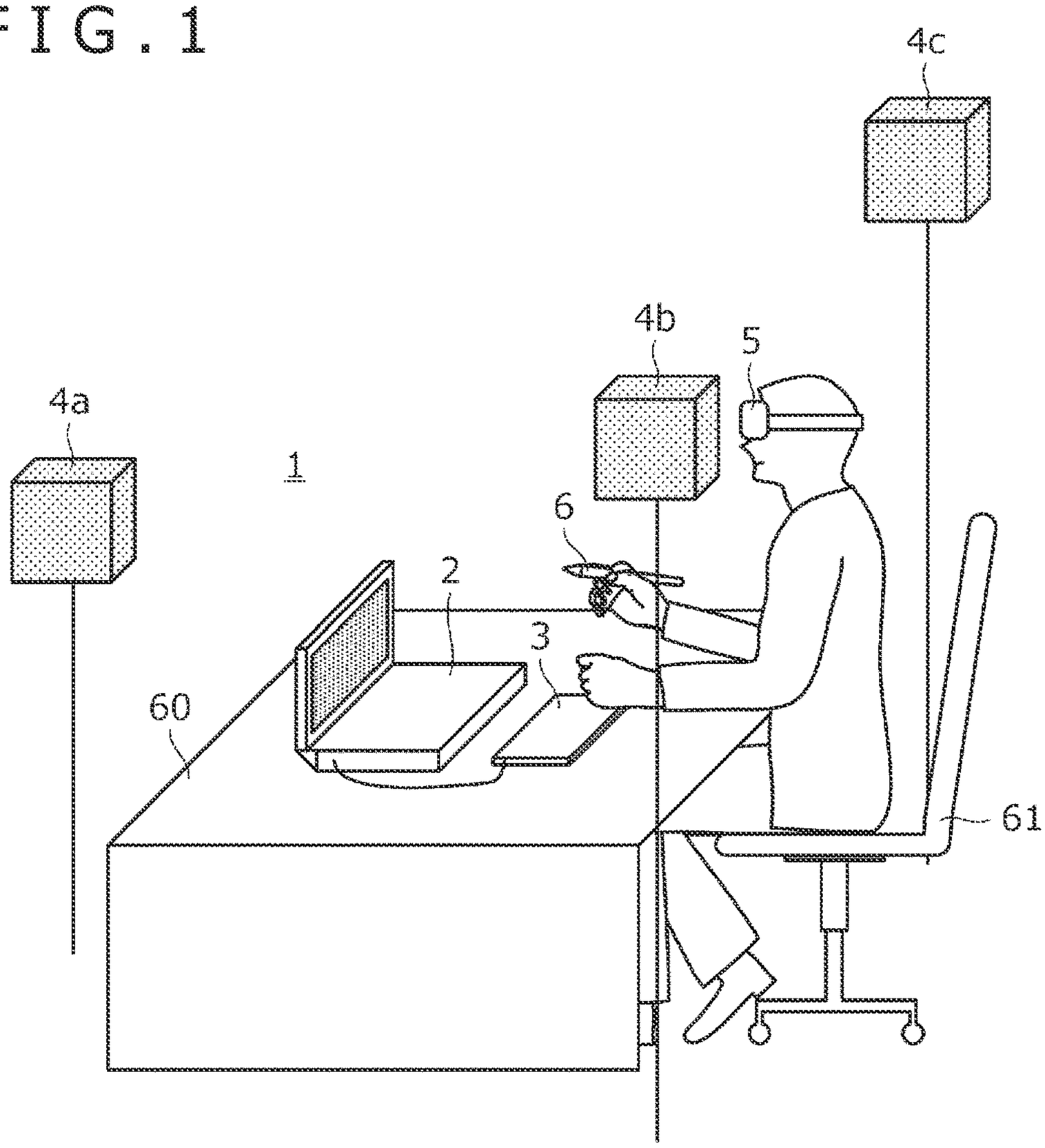
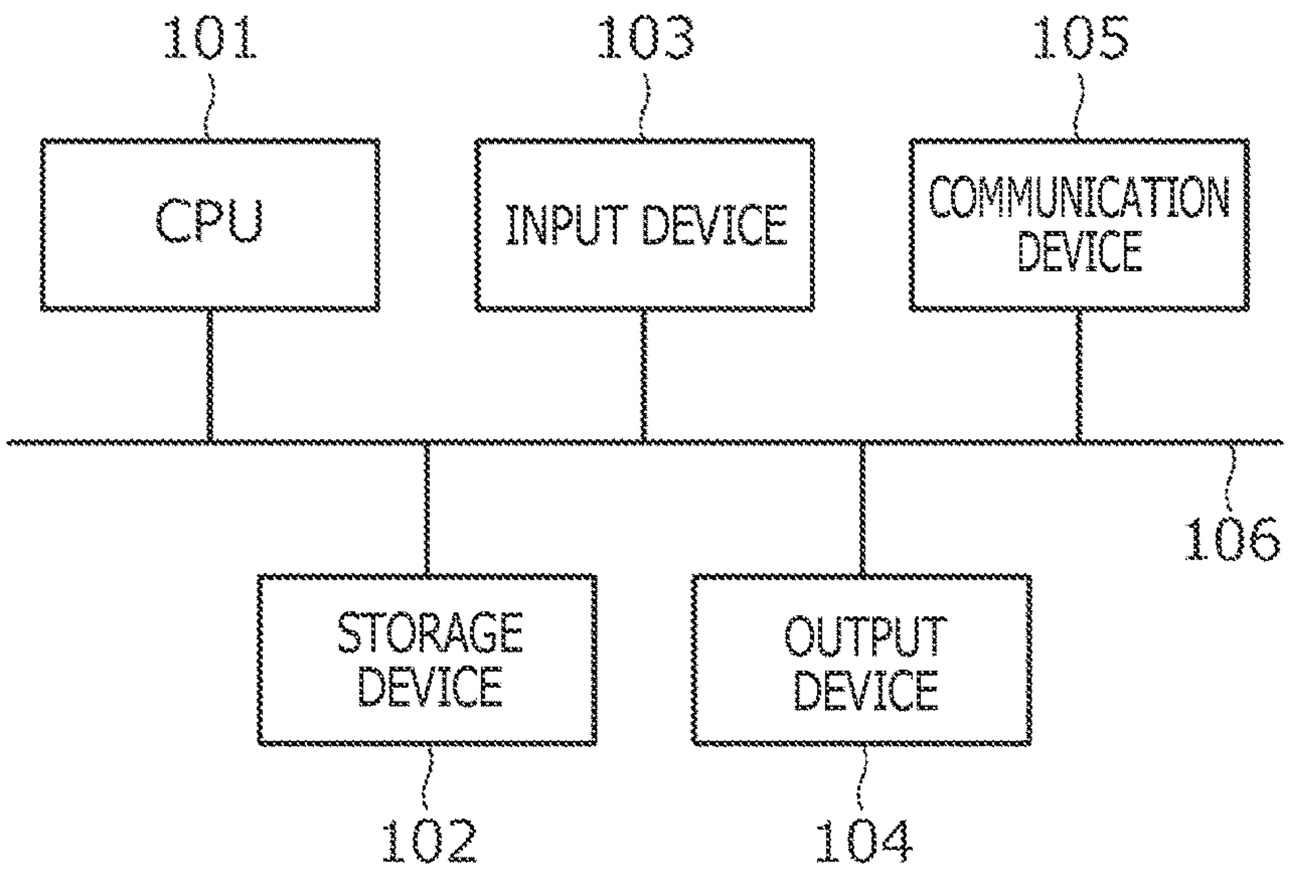

4a
1
4b
5
4c
6
2
3
60
61

FIG. 2


101
CPU
103
INPUT DEVICE
105
COMMUNICATION DEVICE
106
STORAGE DEVICE
102
OUTPUT DEVICE
104

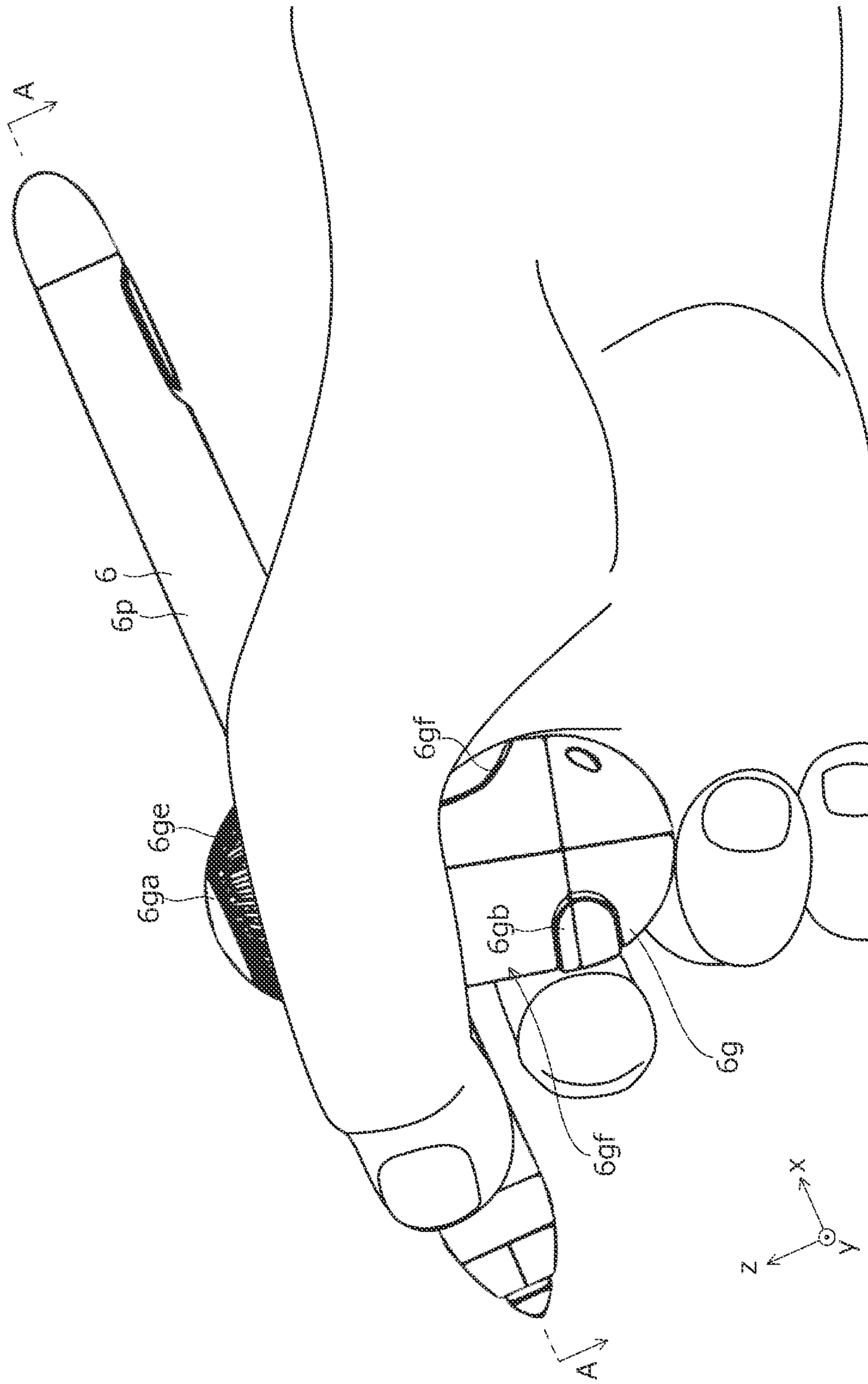


FIG. 3

FIG. 4A

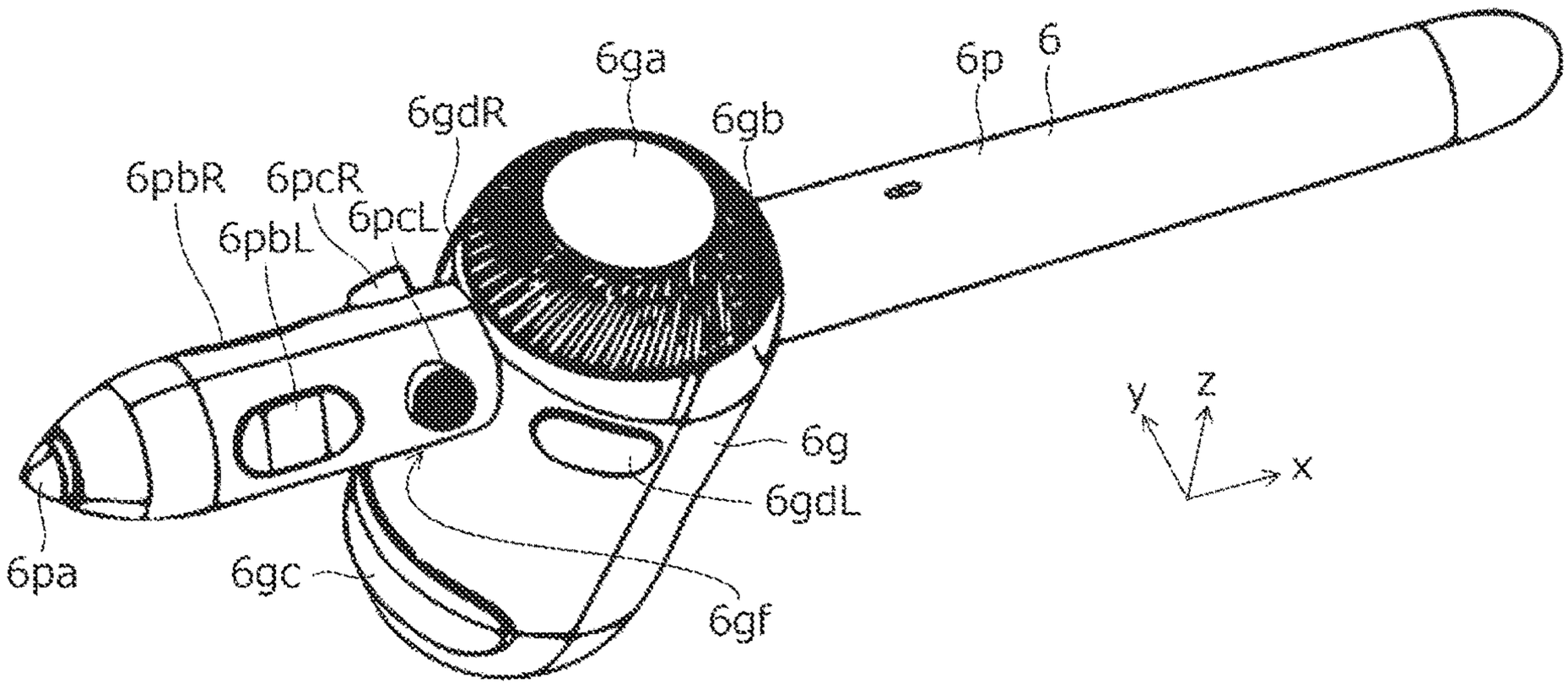
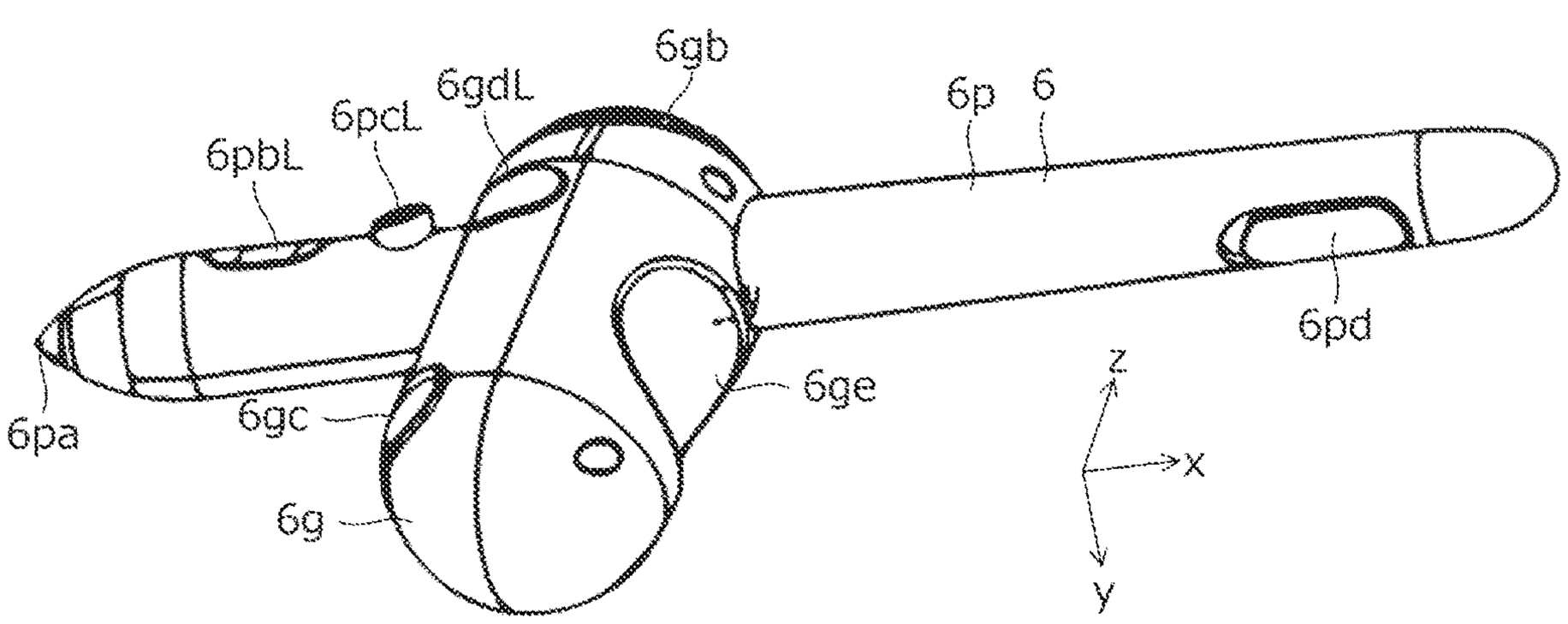

6ga
6p
6
6gdR
6gb
6pbR
6pcR
6pcL
6pbL
6g
6gdL
y
z
x
6pa
6gc
6gf

FIG. 4B


6gb
6gdL
6pcL
6pbL
6p
6
6pd
6ge
6pa
6gc
6g
z
x
y

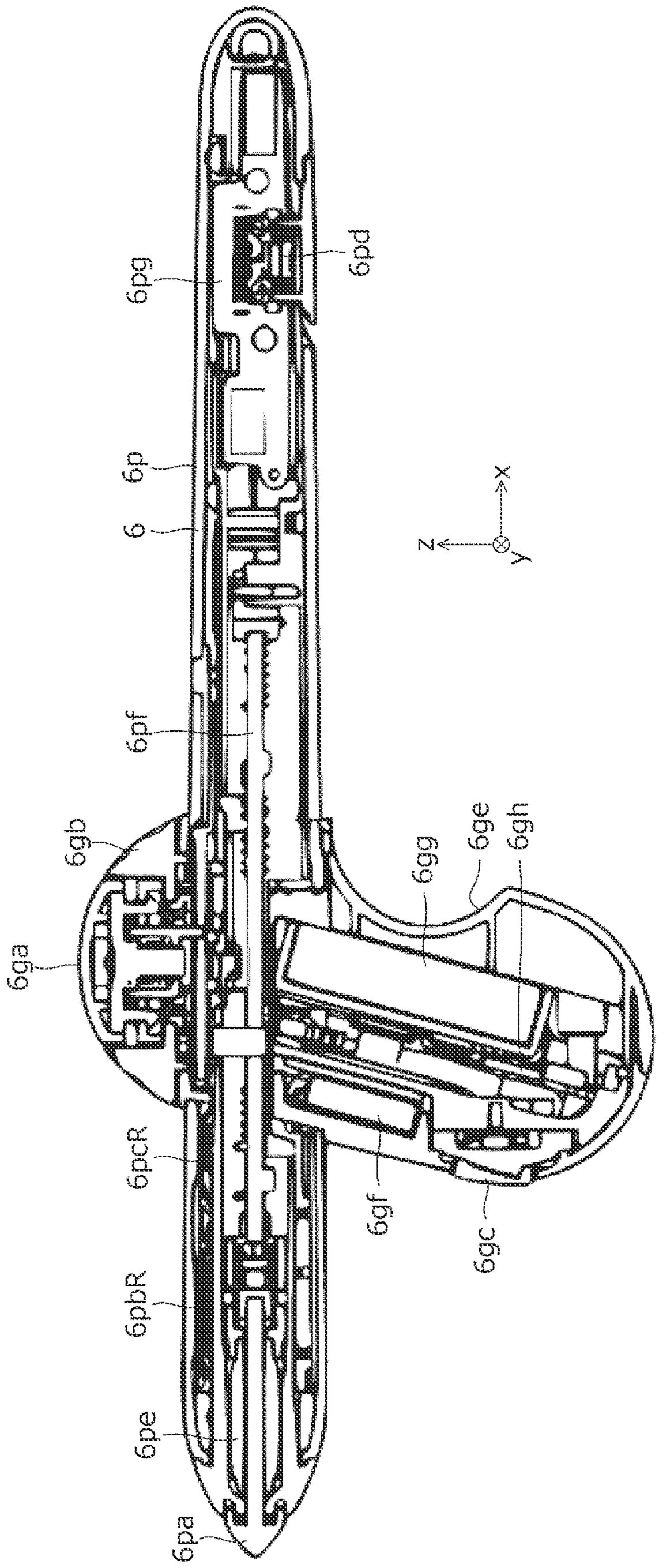

6pg
6pd
6p
6
6pf
6gb
6ga
6pcR
6pbR
6pe
6pa
6gg
6ge
6gh
6gf
6gc
X
Z
Y

FIG. 5

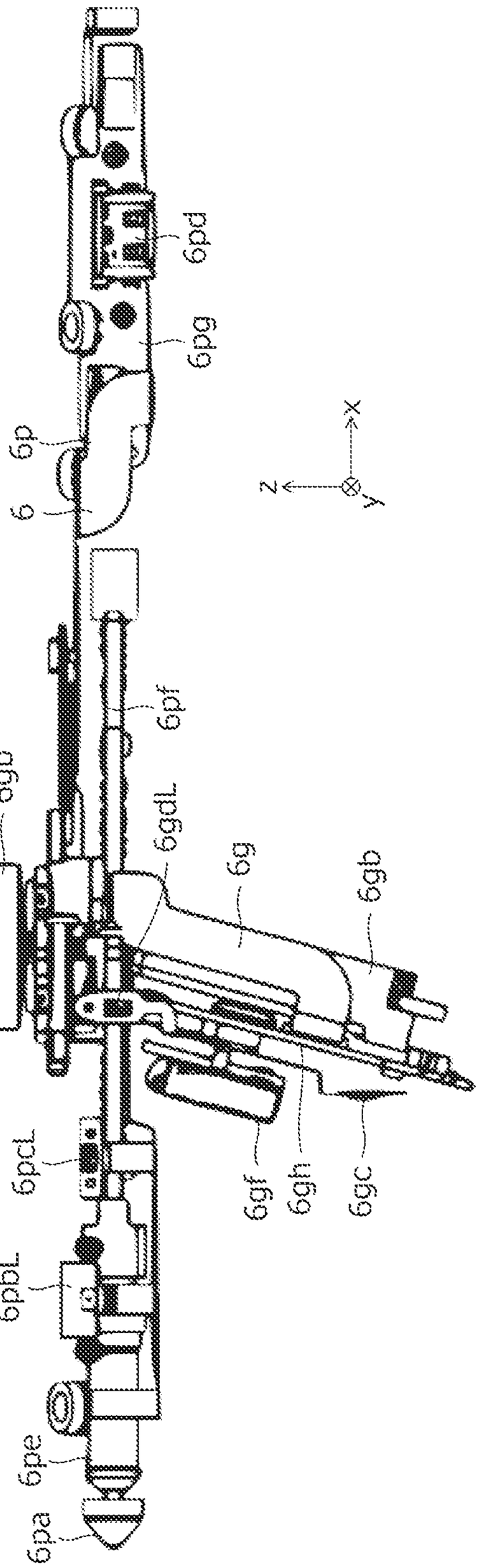

6pd
6pg
6p
6
X
Z
Y
6ga
6gb
6gdL
6g
6gb
6pcL
6gf
6gh
6gc
6pbL
6pe
6pa

FIG. 6A

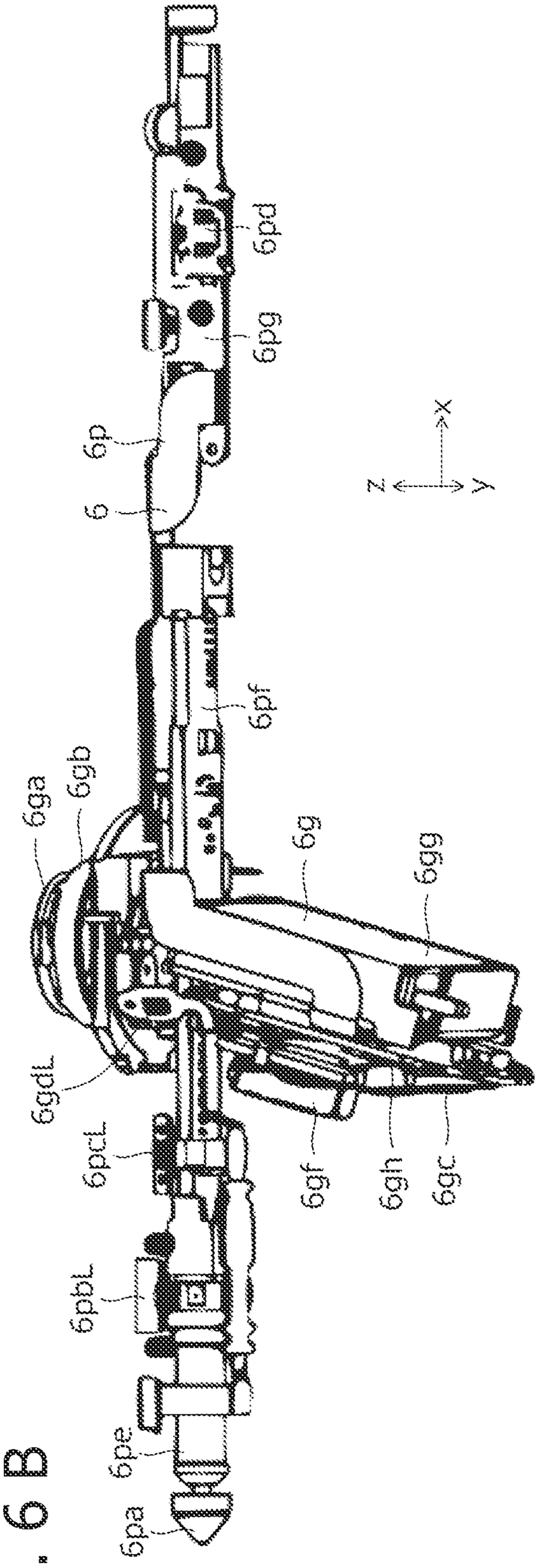
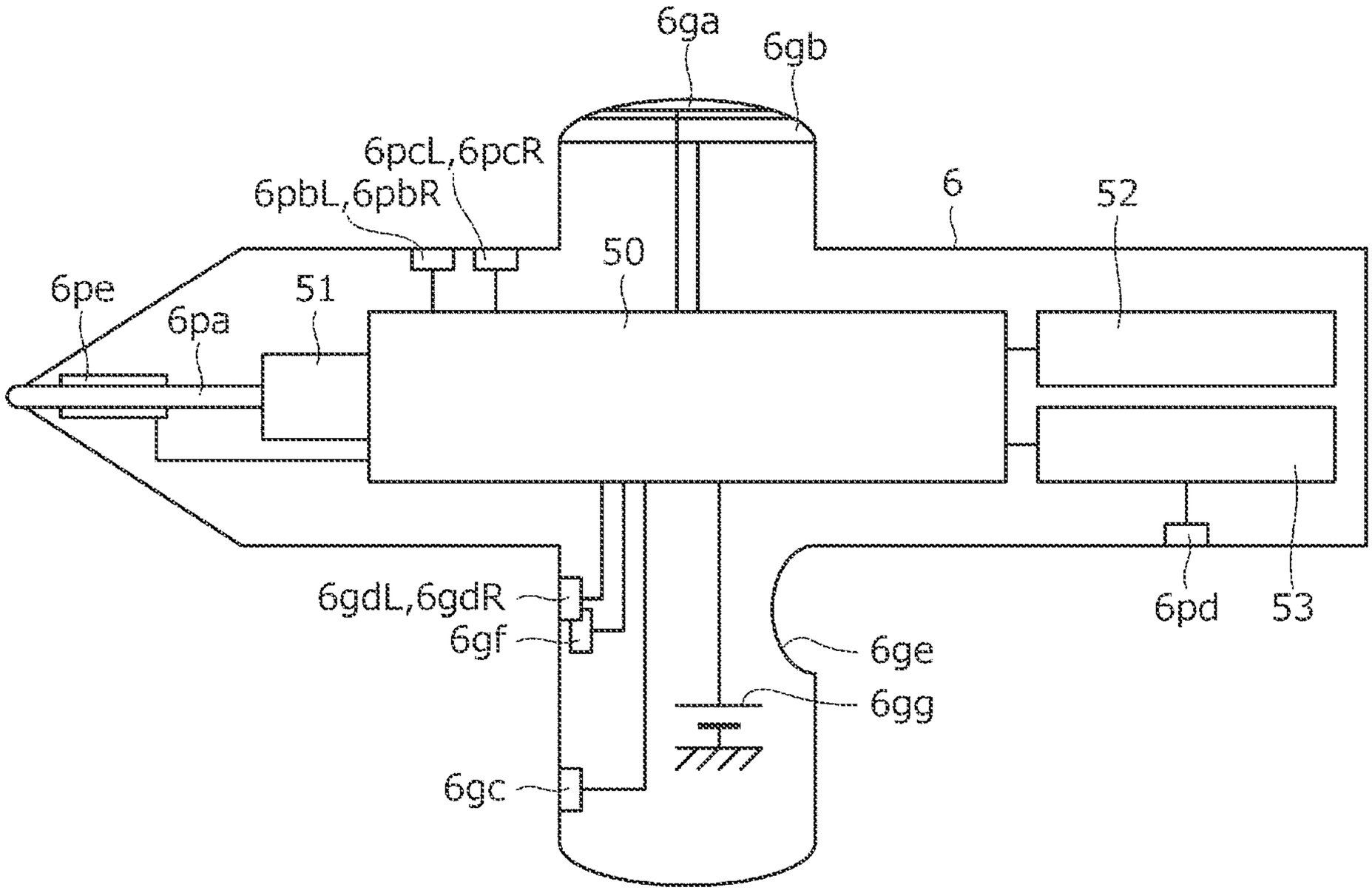

6pd
6pg
6p
6
X
Z
Y
6ga
6gb
6pf
6g
6gg
6gdL
6pcL
6gf
6gh
6gc
6pbL
6pe
6pa

FIG. 6B

FIG. 7


6ga
6gb
6pcL,6pcR
6pbL,6pbR
6
52
50
6pe
51
6pa
6gdL,6gdR
6gf
6pd
53
6ge
6gg
6gc

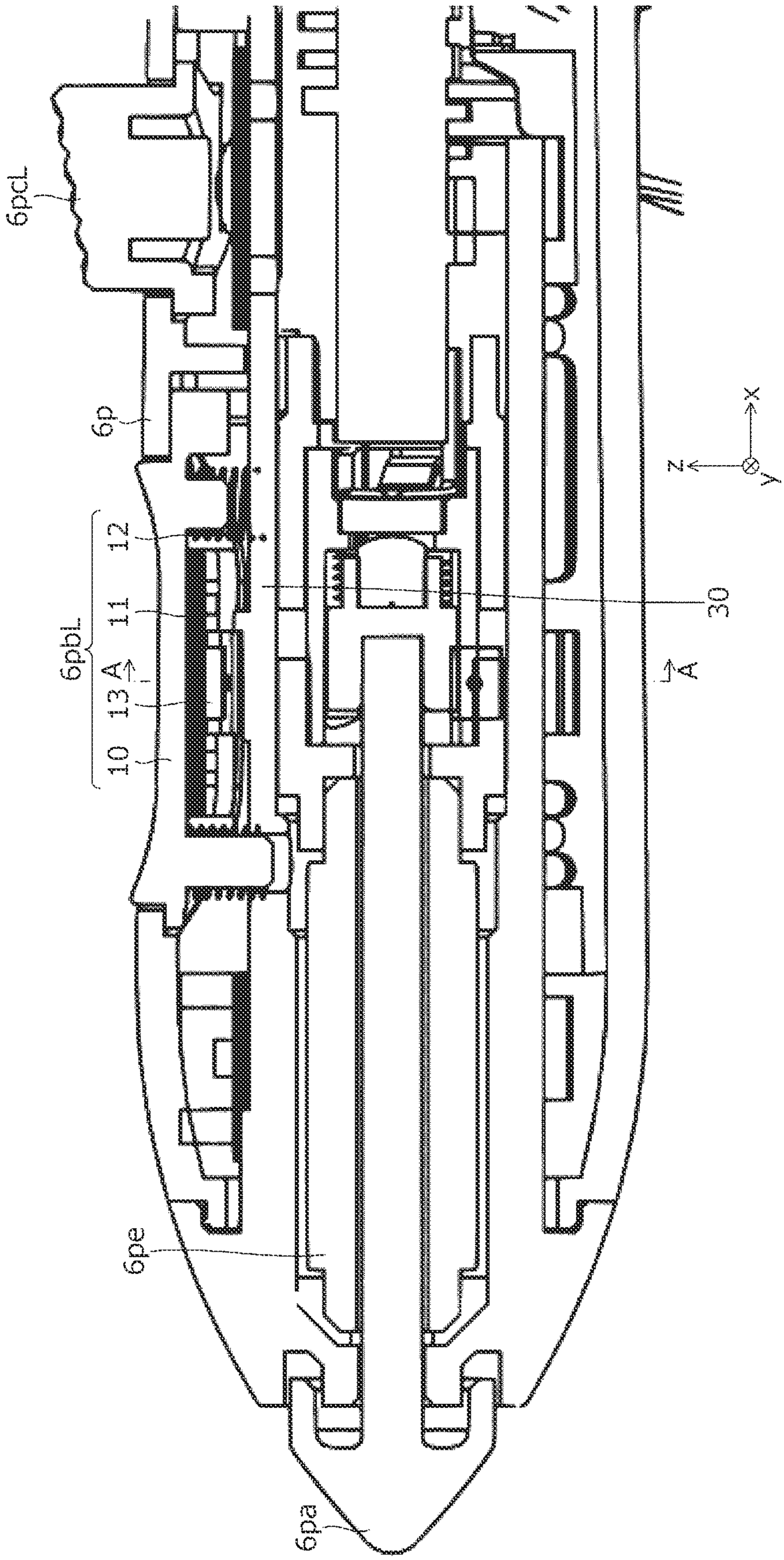


FIG. 8

FIG. 9

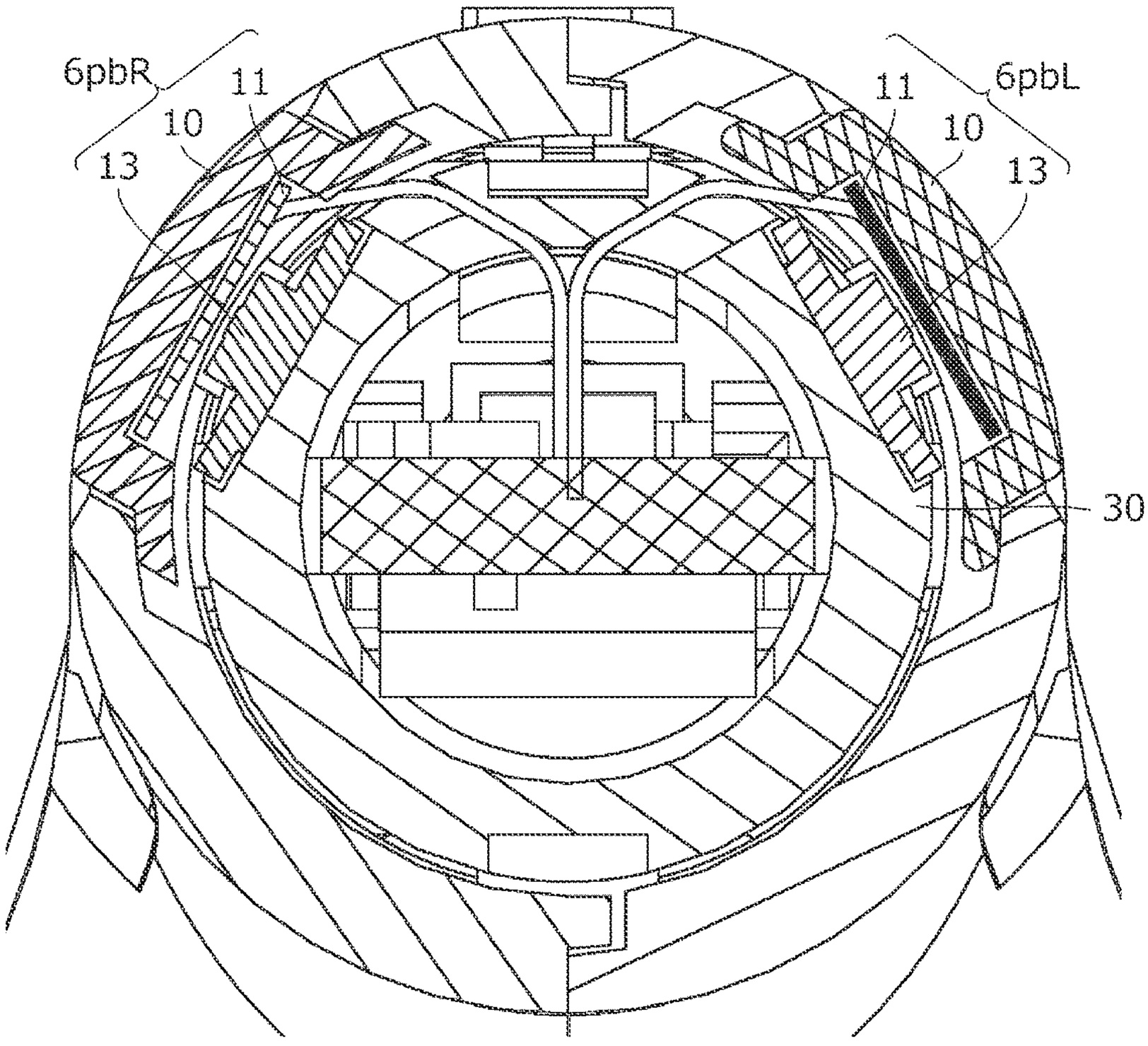


FIG. 10A

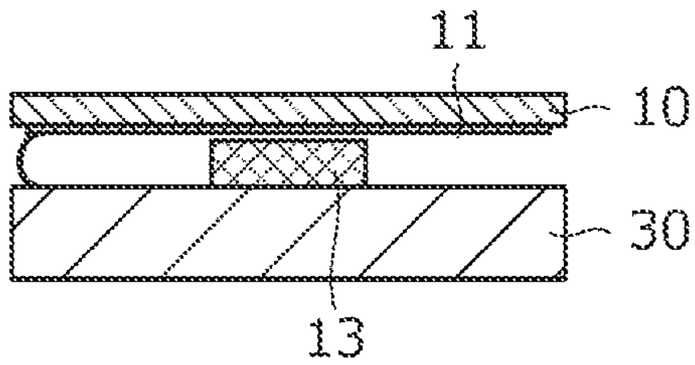


FIG. 10B

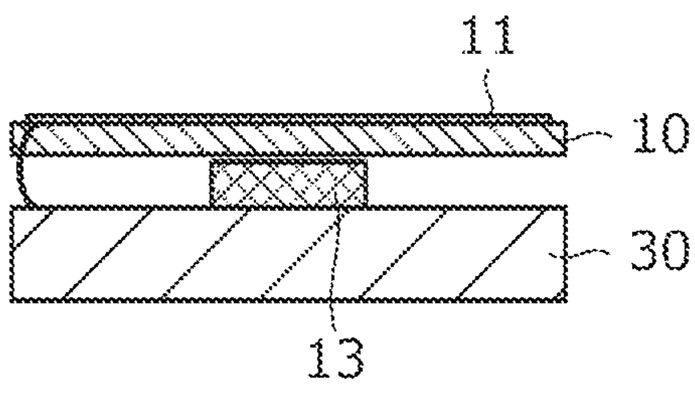


FIG. 10C

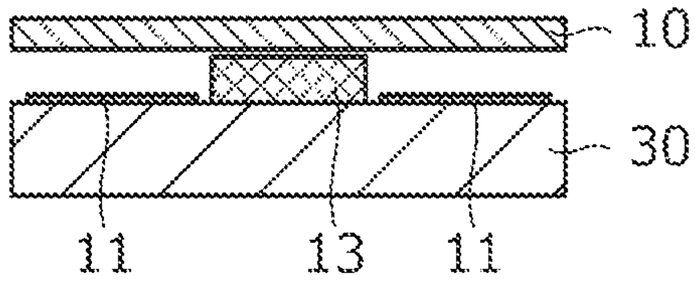


FIG. 10D

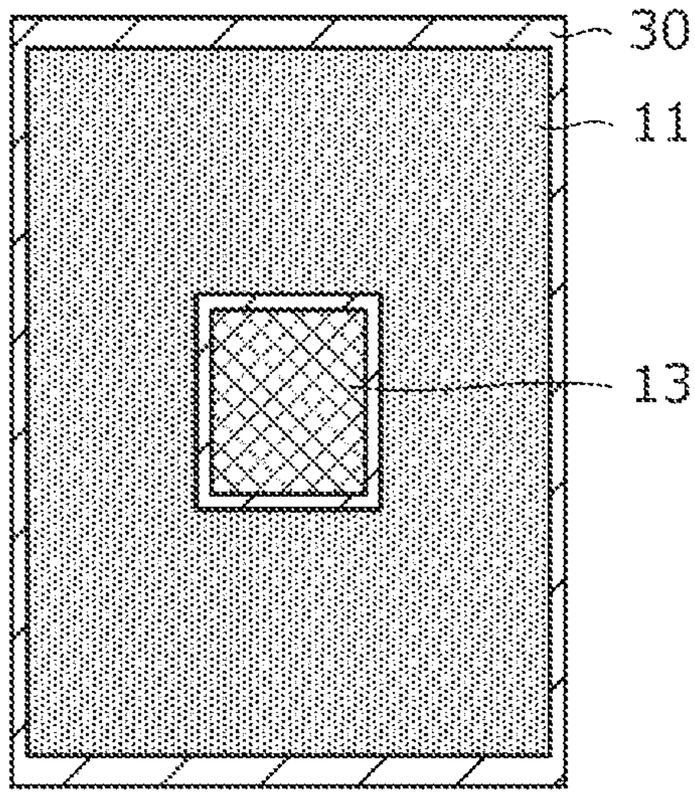


FIG. 11

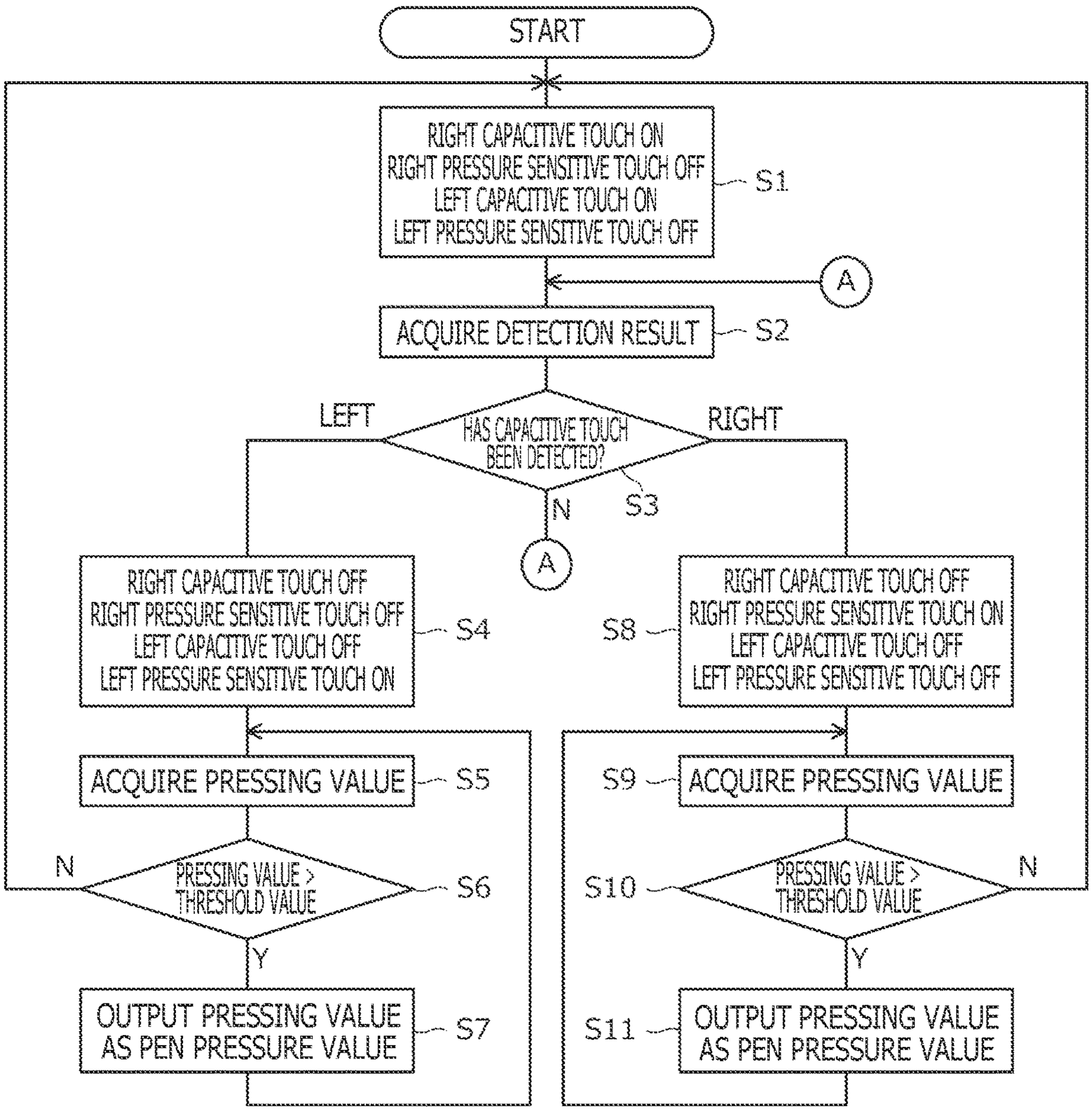

START
RIGHT CAPACITIVE TOUCH ON
RIGHT PRESSURE SENSITIVE TOUCH OFF
LEFT CAPACITIVE TOUCH ON
LEFT PRESSURE SENSITIVE TOUCH OFF
S1
A
ACQUIRE DETECTION RESULT
S2
LEFT
HAS CAPACITIVE TOUCH BEEN DETECTED?
RIGHT
S3
N
A
RIGHT CAPACITIVE TOUCH OFF
RIGHT PRESSURE SENSITIVE TOUCH OFF
LEFT CAPACITIVE TOUCH OFF
LEFT PRESSURE SENSITIVE TOUCH ON
S4
RIGHT CAPACITIVE TOUCH OFF
RIGHT PRESSURE SENSITIVE TOUCH ON
LEFT CAPACITIVE TOUCH OFF
LEFT PRESSURE SENSITIVE TOUCH OFF
S8
ACQUIRE PRESSING VALUE
S5
S9
ACQUIRE PRESSING VALUE
N
PRESSING VALUE > THRESHOLD VALUE
S6
S10
PRESSING VALUE > THRESHOLD VALUE
N
Y
Y
OUTPUT PRESSING VALUE AS PEN PRESSURE VALUE
S7
S11
OUTPUT PRESSING VALUE AS PEN PRESSURE VALUE

FIG. 12

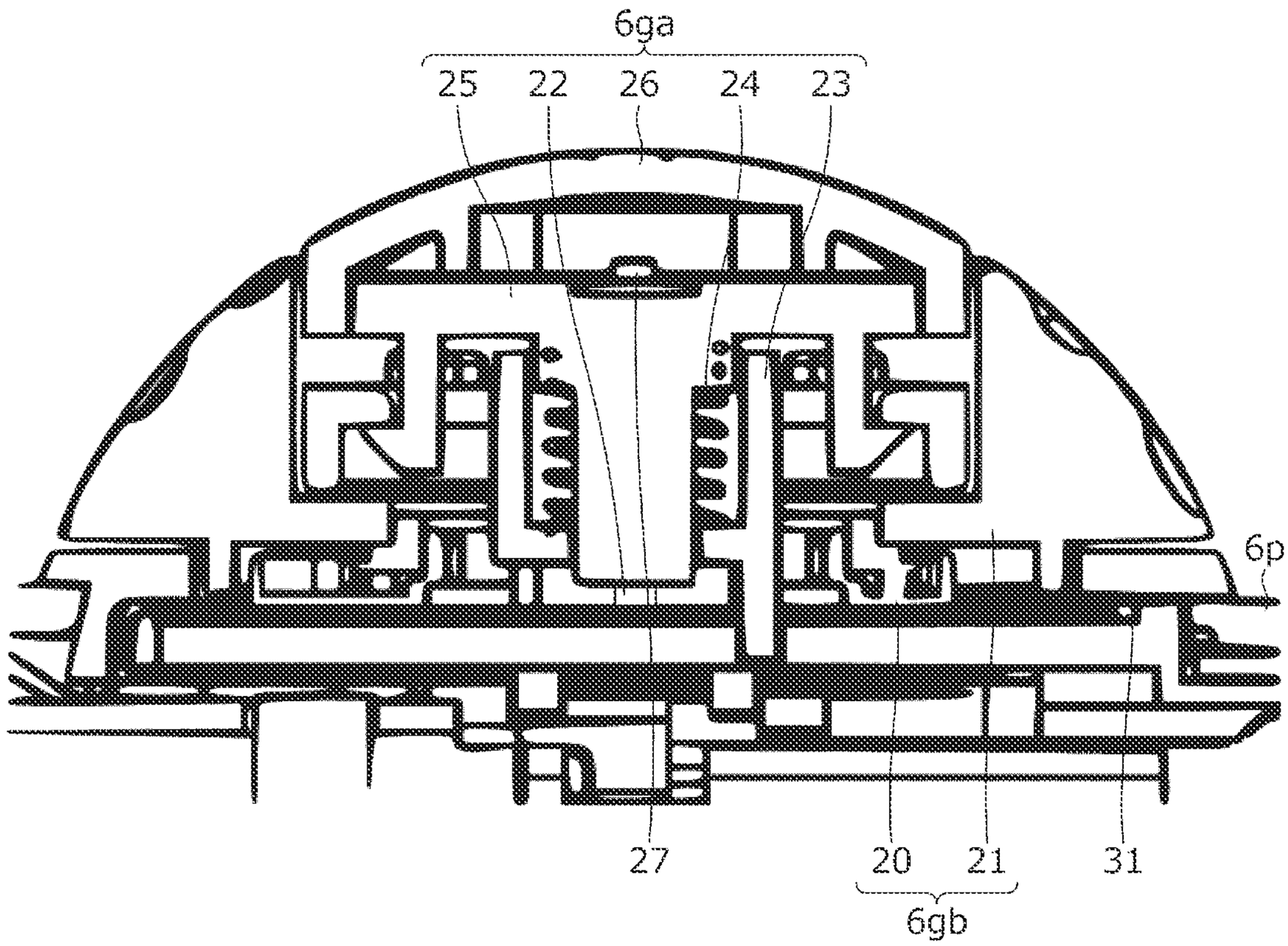


FIG. 13A

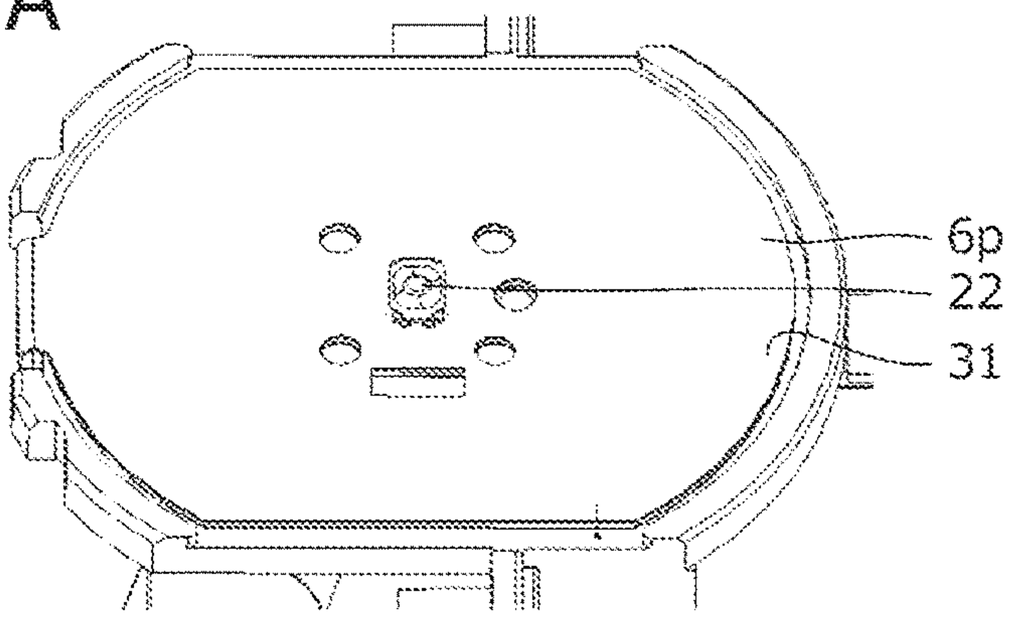


FIG. 13B

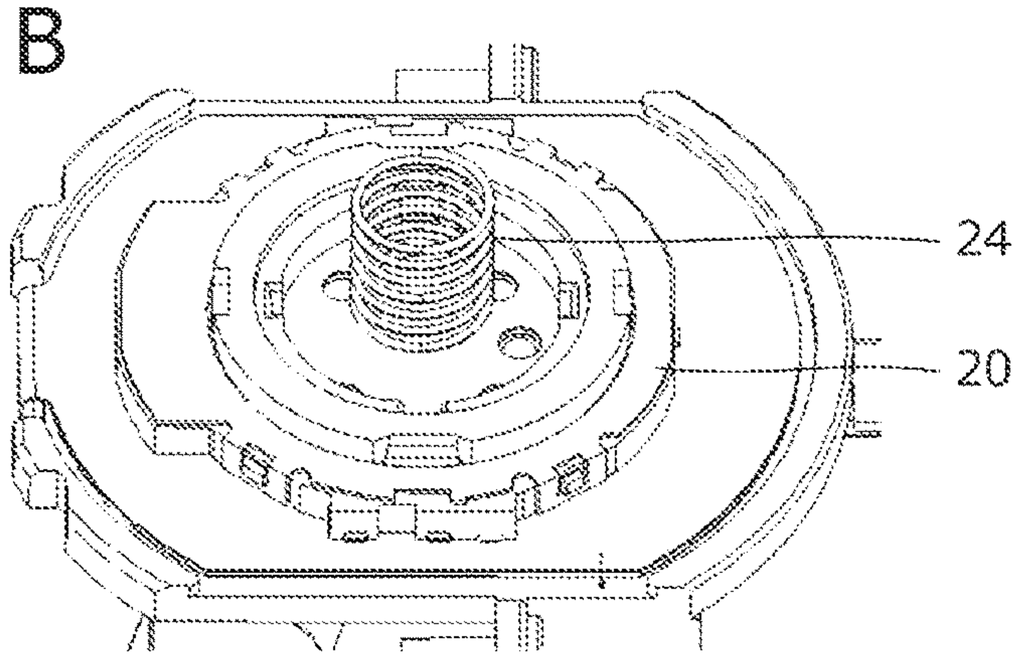


FIG. 13C

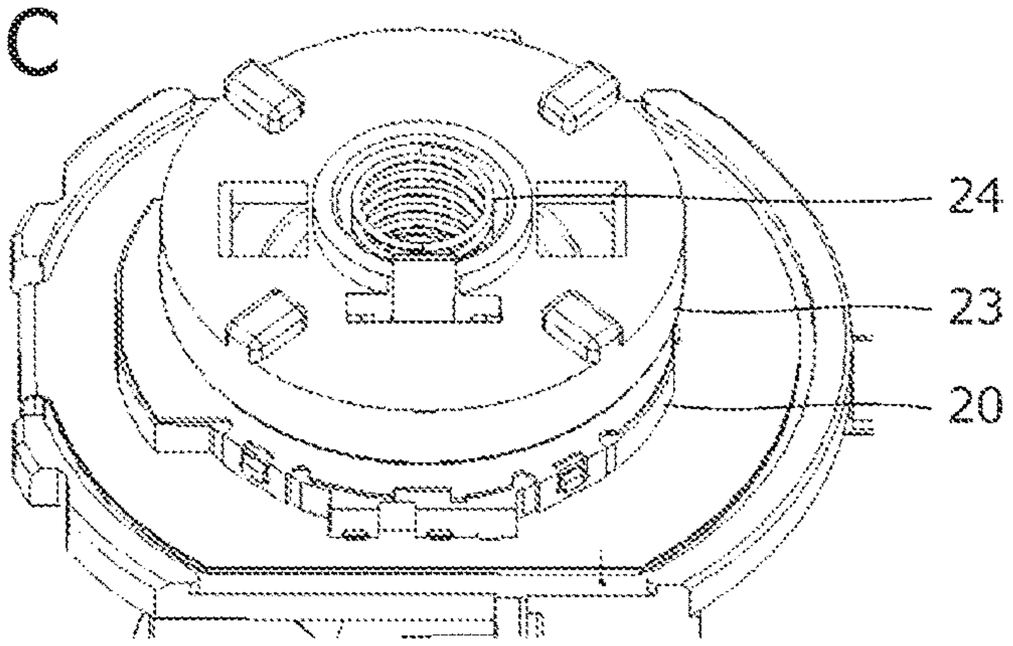
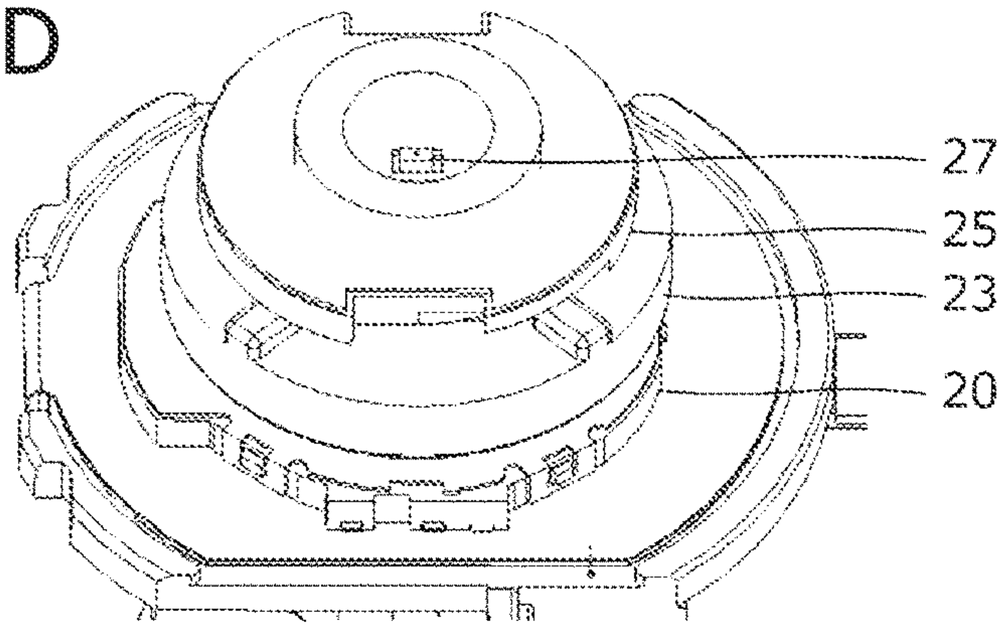


FIG. 13D



CONTROLLER AND COMPUTER

BACKGROUND

Technical Field

[0001] The present disclosure relates to a controller and a computer, and particularly to a controller used in a space configured by using an XR (Extended Reality) technology (hereinafter, such a space will be referred to as an "XR space") such as VR (Virtual Reality), AR (Augmented Reality), MR (Mixed Reality), or SR (Substitutional Reality) and a computer capable of communicating with such a controller.

Description of the Related Art

[0002] A pen-type controller is used by a user to indicate a position in the XR space. Patent Document 1 discloses an example of the pen-type controller.

[0003] A battery is incorporated in the pen-type controller in some cases. The electric power supplied from the battery is used to operate integrated circuits, to establish communication via short-distance wireless communication, and the like.

PRIOR ART DOCUMENT

Patent Document

[0004] Patent Document 1: PCT Patent Publication No. WO2019/220803 Specification.

BRIEF SUMMARY

Technical Problem

[0005] However, the pen-type controller incorporating a battery has a problem that the weight thereof is unbalanced, which causes the user to feel a sense of discomfort when the user uses the controller.

[0006] Therefore, one of the objects of the present disclosure is to provide a controller that can reduce a sense of discomfort felt by a user.

[0007] In addition, in the case where a pen-type controller is provided with a pressure pad, it is conceivable to provide a plurality of pressure pads.

[0008] Another object of the present disclosure is to provide a computer that operates based on information transmitted from a controller having a plurality of pressure pads.

Technical Solution

[0009] A controller according to a first aspect of the present disclosure is a controller including a pen part that is formed in a pen shape, a grip part that intersects an axial direction of the pen part, and a battery that is arranged in the grip part.

[0010] A computer according to a second aspect of the present disclosure is a computer that communicates with a controller including a pen part that is formed in a pen shape, a grip part that intersects an axial direction of the pen part, and a battery that is arranged in the grip part. The pen part has a first pressure pad including a first capacitive touch sensor and a first pressure sensitive sensor and a second pressure pad including a second capacitive touch sensor and a second pressure sensitive sensor. The computer includes a communication device that, in operation, receives information transmitted from the controller, and a processor. The processor, in operation, performs control, based on the information received by the communication device and detected by the first capacitive touch sensor or the second capacitive touch sensor, and outputs a pen pressure value that is the information received by the communication device and is related to a pressing value detected by the first pressure sensitive sensor the second pressure sensitive sensor.

Advantageous Effect

[0011] According to the first aspect of the present disclosure, it is possible to provide a controller that can reduce a sense of discomfort felt by a user.

[0012] According to the second aspect of the present disclosure, it is possible to provide a computer that operates based on information transmitted from a controller having a plurality of pressure pads.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0013] FIG. **1** is a diagram for illustrating a use state of a tracking system **1** including a pen-type controller **6** with a grip according to an embodiment of the present disclosure.

[0014] FIG. **2** is a diagram for illustrating an example of a hardware configuration of a computer **2**.

[0015] FIG. **3** is a diagram for illustrating a state in which a user holds the controller **6** with the right hand.

[0016] FIG. **4**A and FIG. **4**B are perspective views of the controller **6** when viewed from angles different from each other.

[0017] FIG. **5** is a cross-sectional view of the controller **6** corresponding to an A-A line illustrated in FIG. **3**.

[0018] FIG. **6**A and FIG. **6**B are exploded perspective views each illustrating an internal structure of the controller **6** when viewed from angles different from each other.

[0019] FIG. **7** is a rough block diagram for illustrating functional blocks of the controller **6**.

[0020] FIG. **8** is a cross-sectional view of the controller **6** including a cross section of a pressure pad **6***pb*L.

[0021] FIG. **9** is a cross-sectional view of the controller **6** taken along an A-A line illustrated in FIG. **8**.

[0022] FIG. **10**A is a diagram for schematically illustrating a cross-sectional structure of the pressure pad **6***pb*L illustrated in FIG. **8**, FIG. **10**B is a diagram for schematically illustrating another example of the cross-sectional structure of the pressure pad **6***pb*L illustrated in FIG. **8**, FIG. **10**C is a diagram for schematically illustrating still another example of the cross-sectional structure of the pressure pad **6***pb*L illustrated in FIG. **8**, and FIG. **10**D is a plan view of the pressure pad **6***pb*L according to the example in FIG. **10**C.

[0023] FIG. **11** is a diagram for illustrating processing executed by the computer **2** having received, from a processing circuit **50**, information indicating detection results from the pressure pads **6***pb*L and **6***pb*R.

[0024] FIG. **12** is a cross-sectional view of a tactile top button **6***ga* and a dial button **6***gb*.

[0025] FIG. **13**A to FIG. **13**D are exploded perspective views each illustrating structures of the tactile top button **6***ga* and the dial button **6***gb*.

DETAILED DESCRIPTION

[0026] Hereinafter, an embodiment of the present disclosure will be described in detail with reference to the attached drawings.

[0027] FIG. **1** is a diagram for illustrating a use state of a tracking system **1** including a pen-type controller **6** with a grip according to the present embodiment. As illustrated in FIG. **1**, the tracking system **1** has a computer **2**, a position detection device **3**, three cameras **4***a* to **4***c*, and a head-mounted display **5** in addition to the controller **6**. The computer **2** and each of the position detection device **3**, the cameras **4***a* to **4***c*, the head-mounted display **5**, and the controller **6** are configured to be able to communicate with each other in a wired or wireless manner.

[0028] As illustrated in FIG. **1**, a user uses the tracking system **1** while sitting on a desk chair **61**, mounting the head-mounted display **5** on the head, and holding the controller **6** with the right hand. An XR space rendered by the computer **2** is displayed on a display surface of the head-mounted display **5**, and the user operates the controller **6** above a desk **60** while viewing this XR space. The controller **6** is a pen-type device with a grip attached to the pen, and controls (specifically, drawing, moving, and the like) a 3D (Three-dimensional) object displayed in the XR space. Further, the controller **6** is used to perform 2D input by using the position detection device **3**.

[0029] In the example of FIG. **1**, the computer **2** includes a notebook-type personal computer arranged in the center of the desk **60**. However, it is not necessary to arrange the computer **2** in the center of the desk **60**, and it is only necessary to arrange it at a position where it can communicate with the position detection device **3**, the cameras **4***a* to **4***c*, the head-mounted display **5**, and the controller **6**. In addition, the computer **2** can include various computers such as a desktop-type personal computer, a tablet-type personal computer, a smart phone, and a server computer, in addition to the notebook-type personal computer.

[0030] FIG. **2** is a diagram for illustrating an example of a hardware configuration of the computer **2**. As illustrated in FIG. **2**, the computer **2** has a CPU (Central Processing Unit) **101**, a storage device **102**, an input device **103**, an output device **104**, and a communication device **105**.

[0031] The CPU **101** is a processor that controls each unit of the computer **2** and that reads and executes various programs stored in the storage device **102**. The processing, to be described later, executed by the computer **2** is achieved by the CPU **101** executing the program stored in the storage device **102**.

[0032] The storage device **102** includes a main storage device such as a DRAM (Dynamic Random Access Memory) and an auxiliary storage device such as a hard disk. The storage device **102** is a device that stores various programs for executing the operating system and various applications of the computer **2** and data used by these programs.

[0033] The input device **103** is a device that accepts an input operation made by the user and that supplies it to the CPU **101**, and includes, for example, a keyboard, a mouse, and a touch panel. The output device **104** is a device that outputs the processing result from the CPU **101** to the user, and includes, for example, a display and a speaker. The communication device **105** is a device for communicating with external devices including the position detection device **3**, the cameras **4***a* to **4***c*, the head-mounted display **5**, and the controller **6**, and transmits and receives data to and from these devices under the control of the CPU **101**.

[0034] Described with reference to FIG. **1** again, the computer **2** periodically detects the position and tilt of each of the head-mounted display **5**, the controller **6**, and the position detection device **3** based on images captured by the cameras **4***a* to **4***c*, and thus tracks these movements. The detection of the position and tilt is specifically executed by using one or more LEDs (Light Emitting Diodes) attached to a surface of each of the head-mounted display **5**, the controller **6**, and the position detection device **3**. That is, the computer **2** is configured to detect the position and tilt of each device by detecting light emitted by these LEDs in the images captured by the cameras **4***a* to **4***c*.

[0035] The computer **2** performs processing of generating the XR space and the 3D object to be displayed therein, based on the movement of each device being tracked and the state of each switch or the like (described later) provided in the controller **6**, rendering the generated XR space and 3D object, and transmitting them to the head-mounted display **5**. The head-mounted display **5** displays the XR space including one or more 3D objects, by displaying the rendered image transmitted from the computer **2**.

[0036] In the example of FIG. **1**, the position detection device **3** includes a tablet arranged at a position corresponding to the front side of the computer **2** on an upper surface of the desk **60** when viewed from the user. However, it is not necessary to arrange the position detection device **3** at this position, and it is only necessary to arrange it within the reach of the user sitting on the desk chair **61**. In addition, the position detection device **3** and the computer **2** may be configured as, for example, an integrated device such as a tablet terminal.

[0037] The position detection device **3** has a function of periodically detecting the position of a pen tip of the controller **6** on a touch surface thereof and sequentially transmitting the detected position to the computer **2**. The computer **2** generates and renders stroke data configuring the 2D object or 3D object, based on the transmitted position. This rendering includes processing of controlling the thickness or transparency of the line to be drawn, according to a pen pressure value described later. Although the specific method of the position detection by the position detection device **3** is not limited to a particular one, it is preferable to use, for example, an active capacitive method or a capacitive induction method.

[0038] Each of the cameras **4***a* to **4***c* is an imaging device for capturing still images or moving images, and is configured to sequentially supply the captured images to the computer **2**. The camera **4***a* is arranged at a position opposite to the user across the desk **60**, the camera **4***b* is arranged above the left side of the user, and the camera **4***c* is arranged above the right side of the user, in such directions that images of the upper surface of the desk **60** can be captured.

[0039] FIG. **3** is a diagram for illustrating a state in which the user holds the controller **6** with the right hand. In addition, FIG. **4**A and FIG. **4**B are perspective views of the controller **6** when viewed from angles different from each other, FIG. **5** is a cross-sectional view of the controller **6** corresponding to an A-A line illustrated in FIG. **3**, FIG. **6**A and FIG. **6**B are exploded perspective views each illustrating an internal structure of the controller **6** when viewed from angles different from each other, and FIG. **7** is a rough block diagram for illustrating functional blocks of the con-

troller **6**. Hereinafter, the configuration of the controller **6** will be described in detail with reference to these drawings.

[0040] First, as illustrated in FIG. **4**A and FIG. **4**B, the controller **6** has a pen part **6***p* formed in a pen shape and a grip part **6***g* fixed to the pen part **6***p* such that the longitudinal direction thereof intersects the axial direction of the pen part **6***p*. When holding the controller **6**, the user holds the controller **6** in such a manner that the grip part **6***g* is gripped by the thumb, the index finger, and the middle finger as illustrated in FIG. **3**. Hereinafter, the axial direction of the pen part **6***p* is referred to as an x direction, a direction that extends in a plane formed by the x direction and the longitudinal direction of the grip part **6***g* and that is perpendicular to the x direction is referred to as a z direction, and a direction perpendicular to each of the x direction and the z direction is referred to as a y direction.

[0041] As illustrated in FIG. **4**A and FIG. **4**B, a nib **6***pa* is provided at a pen tip of the pen part **6***p*, and left and right pressure pads **6***pb*L and **6***pb*R, left and right shift buttons **6***pc*L and **6***pc*R, and a USB (Universal Serial Bus) connector **6***pd* are provided on side surfaces. In addition, the grip part **6***g* is provided with a tactile top button **6***ga*, a dial button **6***gb*, a grab button **6***gc*, left and right tactile buttons **6***gd*L and **6***gd*R, and a recess portion **6***ge*. Besides these, as illustrated in FIG. **5**, FIG. **6**A, and FIG. **6**B, a pen tip electrode **6***pe*, a printed circuit board assembly **6***pf*, and a flexible printed circuit board **6***pg* are arranged inside the pen part **6***p*, and a haptic element **6***gf*, a battery **6***gg*, and a main board **6***gh* are arranged inside the grip part **6***g*. Among these components, the printed circuit board assembly **6***pf* is a core component of the controller **6**, and the controller **6** is manufactured by mounting other components on the printed circuit board assembly **6***pf* as a finished product.

[0042] In addition, as illustrated in FIG. **7**, the controller **6** functionally has a processing circuit **50**, a pen pressure sensor **51**, a wireless communication circuit **52**, and a power supply circuit **53**. Among these, the processing circuit **50** includes integrated circuits mounted in the printed circuit board assembly **6***pf*, and the wireless communication circuit **52** and the power supply circuit **53** include integrated circuits mounted on the flexible printed circuit board **6***pg*.

[0043] The processing circuit **50** is a circuit that functions as a central processing unit of the controller **6**. The processing circuit **50** has a function of acquiring the respective states (the operation states and the detection states) of the pressure pads **6***pb*L and **6***pb*R, the shift buttons **6***pc*L and **6***pc*R, the tactile top button **6***ga*, the dial button **6***gb*, the grab button **6***gc*, the tactile buttons **6***gd*L and **6***gd*R, and the pen pressure sensor **51** and supplying the acquired states to the position detection device **3** or the computer **2** through the pen tip electrode **6***pe* or the wireless communication circuit **52**, a function of receiving a signal transmitted by the position detection device **3** or the computer **2** through the pen tip electrode **6***pe* or the wireless communication circuit **52**, and a function of performing processing according to the signal received from the position detection device **3** or the computer **2**. The processing according to the signal received from the position detection device **3** or the computer **2** includes processing of generating and returning a signal according to the received signal and control of the haptic element **6***gf*. The processing circuit **50** also controls the lighting state of each of one or more LEDs attached to the surface of the controller **6**.

[0044] The wireless communication circuit **52** is a circuit that performs wireless communication such as Bluetooth (registered trademark) and wireless LAN (Local Area Network). The processing circuit **50** uses this wireless communication circuit **52** to communicate with the computer **2** illustrated in FIG. **1**.

[0045] The nib **6***pa* is a roughly rod-shaped member configuring the pen tip and is arranged such that the tip end thereof slightly protrudes from a casing of the pen part **6***p* while being energized toward the tip end direction. The rear end of the nib **6***pa* abuts against the pen pressure sensor **51**. When the user presses the tip end of the nib **6***pa* against the touch surface of the position detection device **3**, the nib **6***pa* moves rearward. The pen pressure sensor **51** is a sensor that detects the pressure being applied to the tip end of the nib **6***pa*, by detecting this movement, and notifies the processing circuit **50** of the detected pressure value as a "pen pressure value."

[0046] The pen tip electrode **6***pe* is a conductor arranged to surround the nib **6***pa* as illustrated in FIG. **5**, FIG. **6**A, and FIG. **6**B, and is electrically connected to the processing circuit **50** as illustrated in FIG. **7**. The processing circuit **50** executes transmission and reception of signals to and from the position detection device **3** via the pen tip electrode **6***pe*. The position detection device **3** detects the position of the nib **6***pa* on the touch surface by using the signals thus transmitted and received, and acquires the above pen pressure value from the processing circuit **50**.

[0047] The USB connector **6***pd* is a connector to which a USB cable can be connected, and is connected to the processing circuit **50** and the power supply circuit **53**. The processing circuit **50** is configured to update its own firmware by firmware from the outside through the USB cable. Meanwhile, the power supply circuit **53** is configured to charge the battery **6***gg* by electric power supplied from the outside through the USB cable. The power supply circuit **53** and the battery **6***gg* are connected to each other by wiring extending from the flexible printed circuit board **6***pg* to the main board **6***gh*. The charged battery **6***gg* supplies operating electric power to the respective parts in the controller **6** including the processing circuit **50** and the haptic element **6***gf*.

[0048] In the case of a conventional pen-type controller, the battery **6***gg* is provided at a position in the pen part **6***p*. However, in the controller **6** according to the present embodiment, the battery **6***gg* is provided at a position in the grip part **6***g* as illustrated in FIG. **5**. In other words, the battery **6***gg* is arranged on the lower side (the end side which corresponds to one of the opposite ends of the grip part **6***g* in the longitudinal direction and which is farther from the axial direction of the pen part **6***p* when viewed from the printed circuit board assembly **6***pf*) of the printed circuit board assembly **6***pf* arranged in the pen part **6***p*. Further, in other words, the battery **6***gg* is arranged between the haptic element **6***gf* and the recess portion **6***ge*. By adopting such an arrangement, the pen part **6***p* that is positioned on the upper side of the grip part **6***g* gripped by the user can be made lighter than the conventional one, and thus, a sense of discomfort caused in the case where the user grips the grip part **6***g* and operates the controller **6** can be reduced.

[0049] Each of the pressure pads **6***pb*L and **6***pb*R is a device having a touch sensor for detecting a finger of the user touching the surface and the position of the finger on the surface, and a pressure sensitive sensor for detecting the

pressure being applied to the surface. The specific structures of the pressure pads **6***pb*L and **6***pb*R will be described in detail later with reference to FIG. **8**. The detection results from the pressure pads **6***pb*L and **6***pb*R are supplied to the computer **2** through the processing circuit **50** and used for various types of processing. In a specific example, the pressure detected by the pressure sensitive sensor is used for selection and drawing on the application. For example, it is used to control the thickness or transparency of the line to be drawn, according to the pressure, as if it were the pen pressure value described above. Meanwhile, information indicating the presence or absence of touch detected by the touch sensor is used to perform on/off determination of the output of the pressure sensitive sensor and light double-tap.

[0050] As illustrated in FIG. **4**A, the pressure pads **6***pbL* and **6***pbR* are arranged at positions closer to the pen tip than the grip part **6***g* on the upper surface of the pen part **6***p* in a symmetrical manner across the xz plane. As can be understood from FIG. **3**, the user holding the controller **6** with the right hand operates the pressure pad **6***pbL* with the thumb and the pressure pad **6***pbR* with the index finger.

[0051] The shift buttons **6***pc*L and **6***pc*R, the grab button **6***gc*, and the tactile buttons **6***gd*L and **6***gd*R are each a switch that can be turned on and off. Each of the shift buttons **6***pc*L and **6***pc*R is assigned to the menu of the application. The grab button **6***gc* is used to grab and move an object. Each of the tactile buttons **6***gd*L and **6***gd*R is used for button assistance such as the right button of a mouse. The processing circuit **50** is configured to also detect the operation states of these switches and supply information based on the detected states to the computer **2** or the position detection device **3**. Each of the computer **2** and the position detection device **3** performs processing according to the information thus supplied.

[0052] As illustrated in FIG. **4**A, the shift buttons **6***pc*L and **6***pc*R are arranged at positions between the pressure pads **6***pbL* and **6***pbR* and the grip part **6***g* on the upper surface of the pen part **6***p* in a symmetrical manner across the xz plane. In addition, the grab button **6***gc* is arranged at a position in the vicinity of the lower end of the side surface of the grip part **6***g* on the pen-tip side. In addition, the tactile buttons **6***gd*L and **6***gd*R are arranged at positions overlapping the pen part **6***p* on the side surface of the grip part **6***g* on the pen-tip side when viewed in the z direction, in a symmetrical manner across the xz plane. As can be understood from FIG. **3**, the user holding the controller **6** with the right hand performs the pressing operation of the grab button **6***gc* with the middle finger, the pressing operation of the tactile button **6***gd*R with the index finger, and the pressing operation of the tactile button **6***gd*L with the thumb.

[0053] The tactile top button **6***ga* is a switch that functions as a power supply button by a long press. In addition, the dial button **6***gb* is a ring-shaped member configured to be rotatable, and is configured to output the amount of rotation as the operation state. This amount of rotation is used, for example, to rotate the object being selected. The specific structures of the tactile top button **6***ga* and the dial button **6***gb* will be described in detail later with reference to FIG. **12** and FIG. **13**. The processing circuit **50** is configured to also detect the operation states of the tactile top button **6***ga* and the dial button **6***gb* and to supply information based on the detected states to the computer **2** or the position detection device **3**. Each of the computer **2** and the position detection device **3** performs processing according to the information thus supplied.

[0054] As illustrated in FIG. **4**A, the dial button **6***gb* is arranged at the upper end (the end which corresponds to one of the opposite ends of the grip part **6***g* in the longitudinal direction and which is closer to the axial direction of the pen part **6***p*) of the grip part **6***g*, and the tactile top button **6***ga* is arranged at the hollow portion of the dial button **6***gb*. As can be understood from FIG. **3**, the user holding the controller **6** with the right hand performs the rotary operation of the dial button **6***gb* and the pressing operation of the tactile top button **6***ga* with the thumb. However, since the tactile top button **6***ga* and the dial button **6***gb* are located at positions where the user must intentionally lift the thumb up to the upper end of the grip part **6***g* to operate them, they are exposed without being hidden by the hand of the user in a normal state.

[0055] As illustrated in FIG. **3**, the recess portion **6***ge* is a portion that exactly fits a portion ranging from the base of the index finger to the base of the thumb in the case where the user grips the controller **6**, and is formed to open toward the pen end of the pen part **6***p*. With the recess portion **6***ge* provided in the controller **6**, the fatigue of the user using the controller **6** is reduced.

[0056] The haptic element **6***gf* illustrated in FIG. **5**, FIG. **6**A, FIG. **6**B, and FIG. **7** is an element that performs an operation for haptics, and includes, for example, a vibrating element. As illustrated in FIG. **5**, the haptic element **6***gf* is arranged in the grip part **6***g* in the vicinity of the portion gripped by the user. In other words, the haptic element **6***gf* is provided in the grip part **6***g* at a position adjacent to the pen part **6***p*. The recess portion **6***ge* is positioned on the opposite side of the grip part **6***g* when viewed from the haptic element **6***gf*, which makes it possible to give haptics to the middle finger of the user as can be understood from FIG. **3**.

[0057] FIG. **8** is a cross-sectional view of the controller **6** including a cross section of the pressure pad **6***pb*L. In addition, FIG. **9** is a cross-sectional view of the controller **6** taken along an A-A line illustrated in FIG. **8**, and FIG. **10**A is a diagram for schematically illustrating the cross-sectional structure of the pressure pad **6***pbL* illustrated in FIG. **8**. The cross-sectional structure of the pressure pad **6***pbL* will be described below with reference to these drawings. The pressure pad **6***pb*R also has a similar structure as can be understood from FIG. **9**.

[0058] As illustrated in FIG. **8**, FIG. **9**, and FIG. **10**A, the pressure pad **6***pbL* has a configuration in which a surface member **10**, a capacitive touch sensor **11**, a pressure sensitive sensor **13**, and an elastic body **12** are arranged on an installation table **30** fixed to the casing of the pen part **6***p*. As illustrated in FIG. **9**, the installation table **30** has a cylindrical shape, and the pressure pad **6***pbL* is arranged on the outer peripheral surface thereof. It should be noted that the illustration of the elastic body **12** is omitted in FIG. **10**A. The same applies to FIG. **10**B to FIG. **10**D to be described later.

[0059] The surface member **10** is formed of, for example, plastic and is a member whose surface is formed into such a shape that can easily be pressed by the user. The capacitive touch sensor **11** is a self-capacitive or mutual capacitive touch sensor, and is mounted on a rigid flexible board or a film pasted to the lower surface (inner surface) of the surface member **10** in the example of FIG. **10**A. It should be noted

that the capacitive touch sensor **11** may be formed by printing conductive ink on the lower surface of the surface member **10**. The capacitive touch sensor **11** detects a finger of the user touching the surface of the surface member **10** and the position of the finger on the surface of the surface member **10**.

[0060] The elastic body **12** is an elastic member with one end fixed to the surface member **10** and the other end fixed to the installation table **30**, and typically includes a spring as illustrated in FIG. **8**. However, the elastic body **12** may include other kinds of elastic bodies such as rubber. The pressure sensitive sensor **13** is a sensor whose resistance value changes according to the pressing force, and is fixed to the surface (outer peripheral surface) of the installation table **30**. Specifically, as the pressure sensitive sensor **13**, it is possible to use both a sensor with a stroke (a sensor whose shape changes when being pressed) and a sensor without a stroke (a sensor whose shape does not change when being pressed), and it is particularly preferable to use the sensor without a stroke from the viewpoint of preventing the controller **6** itself from moving according to the movement of the finger.

[0061] The surface member **10**, the capacitive touch sensor **11** (and the rigid flexible board or the like), and the pressure sensitive sensor **13** are fixed to one another. They are configured to be movable in the normal direction of the surface of the surface member **10** within a predetermined range, and are energized outwards by the elastic body **12**. With the energizing, in the case where no force is applied to the surface of the surface member **10**, a gap is formed between the pressure sensitive sensor **13** and the installation table **30**. On the other hand, when the user presses the surface member **10** and the pressure sensitive sensor **13** moves downward, the pressure sensitive sensor **13** is pressed by the installation table **30**, and the resistance value of the pressure sensitive sensor **13** changes.

[0062] The processing circuit **50** illustrated in FIG. **7** acquires the detection result from the pressure pad **6***pb*L, by acquiring the detection result from the capacitive touch sensor **11** and the resistance value (hereinafter, referred to as a "pressing value") of the pressure sensitive sensor **13**. Then, the processing circuit **50** generates information indicating the acquired detection result and supplies the generated information to the computer **2**.

[0063] FIG. **10**B is a diagram for schematically illustrating another example of the cross-sectional structure of the pressure pad **6***pb*L. As illustrated in FIG. **10**B, the rigid flexible board or film on which the capacitive touch sensor **11** is mounted may be pasted to the upper surface (outer surface) of the surface member **10**. In addition, the capacitive touch sensor **11** may be formed by printing conductive ink on the upper surface of the surface member **10**.

[0064] FIG. **10**C is a diagram for schematically illustrating still another example of the cross-sectional structure of the pressure pad **6***pb*L. FIG. **10**D is a plan view of the pressure pad **6***pb*L according to the example of FIG. **10**C. It should be noted that the illustration of the surface member **10** is omitted in FIG. **10**D. In this example, the rigid flexible board or film on which the capacitive touch sensor **11** is mounted is formed in a square shape and is pasted to the upper surface of the installation table **30** such that the pressure sensitive sensor **13** is positioned in a central hollow portion. With such a configuration, the capacitive touch sensor **11** can be used even in the case where it is difficult to arrange the capacitive touch sensor **11** on the surface of the surface member **10**. Even in this case, the capacitive touch sensor **11** may be formed by printing conductive ink on the upper surface of the installation table **30**.

[0065] The processing circuit **50** of the controller **6** transmits information detected by the pressure pads **6***pbL* and **6***pb*R, that is, information detected by the capacitive touch sensor **11** of the pressure pad **6***pb*R, information detected by the pressure sensitive sensor **13** of the pressure pad **6***pb*R, information detected by the capacitive touch sensor **11** of the pressure pad **6***pb*L, or information detected by the pressure sensitive sensor **13** of the pressure pad **6***pb*L, to the computer **2** through the wireless communication circuit **52**. Then, based on the information detected by the capacitive touch sensor **11** of the pressure pad **6***pbR* or the information detected by the pressure sensitive sensor **13** of the pressure pad **6***pbR*, the computer **2** outputs the pen pressure value related to the information detected by the pressure sensitive sensor **13** of the pressure pad **6***pbR* or outputs the pen pressure value related to the information detected by the pressure sensitive sensor **13** of the pressure pad **6***pb*L. An example of processing executed by the computer **2** having received, from the processing circuit **50**, information indicating the detection results from the pressure pads **6***pbL* and **6***pbR* will be described below.

[0066] FIG. **11** is a diagram for illustrating an example of processing executed by the computer **2** having received, from the processing circuit **50**, information indicating the detection results from the pressure pads **6***pbL* and **6***pb*R. It should be noted that the processing illustrated in FIG. **11** is preferably executed by a device driver of the controller **6** operating in the computer **2**. However, it may be executed by a program, such as an application, other than the device driver.

[0067] In FIG. **11**, "right capacitive touch" refers to a touch operation detected by the capacitive touch sensor **11** of the pressure pad **6***pb*R, "right pressure sensitive touch" refers to a pressing operation detected by the pressure sensitive sensor **13** of the pressure pad **6***pb*R, "left capacitive touch" refers to a touch operation detected by the capacitive touch sensor **11** of the pressure pad **6***pb*L, and "left pressure sensitive touch" refers to a pressing operation detected by the pressure sensitive sensor **13** of the pressure pad **6***pb*L. As illustrated in FIG. **11**, the computer **2** first turns on the right capacitive touch and the left capacitive touch (a state in which input of the corresponding information from the processing circuit **50** is accepted) and turns off the right pressure sensitive touch and the left pressure sensitive touch (a state in which input of the corresponding information from the processing circuit **50** is ignored) (S**1**).

[0068] The computer **2** acquires the detection result from the capacitive touch sensor **11** of each of the pressure pads **6***pbL* and **6***pb*R, by referring to the information supplied from the processing circuit **50** (S**2**). Then, it is determined whether or not the right capacitive touch or the left capacitive touch has been detected, by referring to the acquired detection results (S**3**).

[0069] At S**3**, the computer **2** which determines that neither the right capacitive touch nor the left capacitive touch has been detected returns to S**2** to continue the processing. On the other hand, the computer **2** which determines that the left capacitive touch has been detected turns off the right capacitive touch and the left capacitive touch, while turning on the left pressure sensitive touch (S**4**). Then, the pressing

value of the pressure sensitive sensor **13** of the pressure pad **6***pbL* is acquired by referring to the information supplied from the processing circuit **50** (S**5**), and it is determined whether or not the acquired pressing value exceeds a predetermined threshold value (S**6**). The computer **2** which determines that the acquired pressing value exceeds the threshold value outputs the acquired pressing value to the application as a pen pressure value (S**7**), and then returns to S**5** to acquire the next pressing value. On the other hand, the computer **2** which determines at S**6** that the acquired pressing value does not exceed the threshold value returns to S**1** to repeat the processing.

[0070] In the case where it is determined at S**3** that the right capacitive touch has been detected, the processing of the computer **2** is similar to that in a case where the left capacitive touch has been detected, except for the difference between the left and right. Specifically, the computer **2** turns off the right capacitive touch and the left capacitive touch, while turning on the right pressure sensitive touch (S**8**). Then, by referring to the information supplied from the processing circuit **50**, the pressing value of the pressure sensitive sensor **13** of the pressure pad **6***pbR* is acquired (S**9**), and it is determined whether or not the acquired pressing value exceeds the predetermined threshold value (S**10**). The computer **2** which determines that the acquired pressing value exceeds the threshold value outputs the acquired pressing value to the application as a pen pressure value (S**11**), and then returns to S**9** to acquire the next pressing value. On the other hand, the computer **2** which determines at S**10** that the acquired pressing value does not exceed the threshold value returns to S**1** to repeat the processing.

[0071] When the computer **2** performs the above processing, it is possible to activate one of the pressure sensitive sensors **13** of the pressure pads **6***pbL* and **6***pbR* which is touched first by the user, while inactivating the other pressure sensitive sensor **13**, so that the user can operate the controller **6** having the pressure pads **6***pbL* and **6***pbR* without stress. Specifically, in the case where the pressure sensitive sensor **13** without a stroke is used as described above, the pressure sensitive sensor **13** reacts in some cases even if the user does not consciously press it. This is stressful for the user. However, according to the processing described with reference to FIG. **11**, the capacitive touch sensor **11** detects one of the pressure pads **6***pbL* and **6***pbR* which is touched first by the user, and the pressure sensitive sensor **13** of only the detected one is activated, so that the reaction of the pressure sensitive sensor **13** as described above can be suppressed and the stress of the user can be reduced.

[0072] FIG. **12** is a cross-sectional view of the tactile top button **6***ga* and the dial button **6***gb*. In addition, FIG. **13**A to FIG. **13**D are exploded perspective views each illustrating the structures of the tactile top button **6***ga* and the dial button **6***gb*. Referring first to FIG. **12**, the tactile top button **6***ga* and the dial button **6***gb* are arranged on an installation table **31** having a flat surface fixed to the casing of the pen part **6***p*. The dial button **6***gb* includes an encoder **20** and a rotating body **21**, and the tactile top button **6***ga* has a tactile switch **22**, a cover **23**, an elastic body **24**, a pusher **25**, and a lens **26**. An LED **27** which is one of the one or more LEDs (one or more LEDs to be detected by the computer **2**) described above is installed on the upper surface of the pusher **25**.

[0073] The rotating body **21** is a ring-shaped member arranged with the center portion of the installation table **31** as its center, and is configured to be rotatable around the center by user operation. The encoder **20** is a device for detecting the amount of rotation of the rotating body **21**, and includes a circular member arranged to surround the center of the installation table **31** as illustrated in FIG. **13**B. The outer periphery of the encoder **20** engages with the inner periphery of the rotating body **21**, and the encoder **20** is configured to detect the amount of rotation of the rotating body **21** through this engagement. The cover **23** is a member covering the upper surface of the encoder **20** and is fixed to the installation table **31** and the encoder **20**.

[0074] The tactile switch **22** is a switch that can be turned on and off by being pressed, and is arranged in the center of the approximately circular installation table **31** as illustrated in FIG. **13**A. The elastic body **24** is an elastic member with one end fixed to the upper surface of the cover **23** and the other end fixed to the lower surface of the pusher **25**, and typically includes a spring as illustrated in FIG. **13**B. However, the elastic body **24** may include other kinds of elastic bodies such as rubber.

[0075] The pusher **25** is a hard member for transmitting the pressing force on the surface of the lens **26** to the tactile switch **22**. In addition, the lens **26** is a hemispherical member including a transparent and hard material, and forms the upper surface of the tactile top button **6***ga*. The lens **26** includes a transparent material such that the LED **27** arranged under the lens **26** can be viewed from the outside of the controller **6**, thereby allowing the computer **2** to check the light of the LED **27** in the images captured by the cameras **4***a* to **4***c*.

[0076] The pusher **25** and the lens **26** are fixed to each other, are configured to be movable in the normal direction of the installation table **30** in a predetermined range, and are energized outwards by the elastic body **24**. With this energizing force, in the case where no force is applied to the lens **26**, the tactile switch **22** is in a state where it is not pressed by the pusher **25**. On the other hand, when the user presses the lens **26** to move the lens **26** and the pusher **25** downward, the tactile switch **22** is pressed by the pusher **25**, and the on/off state of the tactile switch **22** is switched.

[0077] The processing circuit **50** illustrated in FIG. **7** acquires the operation states of the tactile top button **6***ga* and the dial button **6***gb* by acquiring the amount of rotation detected by the encoder **20** and the on/off state of the tactile switch **22**. Then, the processing circuit **50** generates information indicating the acquired operation states and supplies the generated information to the computer **2**.

[0078] As described above, according to the pen-type controller **6** with a grip according to the present embodiment, the battery **6***gg*, which is a heavy component, is arranged in the grip part **6***g* instead of the pen part **6***p*. Therefore, the balance of weight is improved, and it becomes possible to reduce a sense of discomfort felt by the user when the user operates the controller **6** by gripping the grip part **6***g*.

[0079] In addition, according to the pen-type controller **6** with a grip according to the present embodiment, since the haptic element **6***gf* is provided on the opposite side of the grip part **6***g* when viewed from the recess portion **6***ge*, haptics can preferably be given to the middle finger of the user.

[0080] In addition, according to the pen-type controller **6** with a grip according to the present embodiment, since the pressure pads **6***pbL* and **6***pbR* including the capacitive touch

sensors **11** and the pressure sensitive sensors **13** are provided, it becomes possible to detect a finger of the user touching the surfaces of the pressure pads **6***pbL* and **6***pb*R, the position of the finger on the surfaces, and the pressure applied to the surfaces of the pressure pads **6***pbL* and **6***pb*R, and use the results of the detection to render a 3D object.

[0081] In addition, according to the pen-type controller **6** with a grip according to the present embodiment, since the tactile top button **6***ga* is provided at the upper end of the grip part **6***g*, which is exposed without being hidden by the hand of the user in a normal state, and the LED **27** is arranged therein, it becomes possible to reduce the possibility that the computer **2** fails to track the controller **6**.

[0082] In addition, according to the tracking system **1** according to the present embodiment, since one of the pressure sensitive sensors **13** of the pressure pads **6***pbL* and **6***pbR* which is touched first by the user can be activated while the other pressure sensitive sensor **13** can be inactivated, the user can operate the controller **6** having the pressure pads **6***pbL* and **6***pbR* without stress.

[0083] Although the preferred embodiment of the present disclosure has been described above, it is obvious that the present disclosure is not limited to such an embodiment at all and can be carried out in various forms without deviating from the gist thereof.

DESCRIPTION OF REFERENCE SYMBOLS

[0084] **1**: Tracking system
[0085] **2**: Computer
[0086] **3**: Position detection device
[0087] **4***a* to **4***c*: Camera
[0088] **5**: Head-mounted display
[0089] **6**: Pen-type controller with grip
[0090] **6***g*: Grip part
[0091] **6***ga*: Tactile top button
[0092] **6***gb*: Dial button
[0093] **6***gc*: Grab button
[0094] **6***gd*L and **6***gd*R: Tactile button
[0095] **6***ge*: Recess portion
[0096] **6***gf*: Haptic element
[0097] **6***gg*: Battery
[0098] **6***gh*: Main board
[0099] **6***p*: Pen part
[0100] **6***pa*: Nib
[0101] **6***pbL* and **6***pb*R: Pressure pad
[0102] **6***pc*L and **6***pc*R: Shift button
[0103] **6***pd*: USB connector
[0104] **6***pe*: Pen tip electrode
[0105] **6***pf*: Printed circuit board assembly
[0106] **6***pg*: Flexible printed circuit board
[0107] **10**: Surface member
[0108] **11**: Capacitive touch sensor
[0109] **12**: Elastic body
[0110] **13**: Pressure sensitive sensor
[0111] **20**: Encoder
[0112] **21**: Rotating body
[0113] **22**: Tactile switch
[0114] **23**: Cover
[0115] **24**: Elastic body
[0116] **25**: Pusher
[0117] **26**: Lens
[0118] **30**, **31**: Installation table
[0119] **50**: Processing circuit
[0120] **51**: Pen pressure sensor
[0121] **52**: Wireless communication circuit
[0122] **53**: Power supply circuit
[0123] **60**: Desk
[0124] **61**: Desk chair
[0125] **101**: CPU
[0126] **102**: Storage device
[0127] **103**: Input device
[0128] **104**: Output device
[0129] **105**: Communication device

[0130] The various embodiments described above can be combined to provide further embodiments. All of the U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications referred to in this specification and/or listed in the Application Data Sheet are incorporated herein by reference, in their entirety. Aspects of the embodiments can be modified, if necessary to employ concepts of the various patents, applications and publications to provide yet further embodiments.

[0131] These and other changes can be made to the embodiments in light of the above-detailed description. In general, in the following claims, the terms used should not be construed to limit the claims to the specific embodiments disclosed in the specification and the claims, but should be construed to include all possible embodiments along with the full scope of equivalents to which such claims are entitled. Accordingly, the claims are not limited by the disclosure.

1. A controller that communicates with a computer configured to control a three-dimensional object in an extended reality space and that is operated away from a surface to input a line of the three-dimensional object, the controller comprising:

a pen part that is formed in a pen shape;

a first pressure pad that, in operation, detects a first pressure that is transmitted to the computer, wherein the computer is configured to control a thickness of the line of the three-dimensional object in the extended reality space based on the first pressure, the first pressure changing according to an operation made in mid-air by a user to change the thickness of the line of the three-dimensional object in a state where the user grips the pen part with a first finger and a second finger in a pinching manner; and

a second pressure pad that, in operation, detects a second pressure that is transmitted to the computer configured to control the thickness of the line of the three-dimensional object in the extended reality space based on the second pressure, the second pressure changing according to the operation made in mid-air by the user to change the thickness of the line of the three-dimensional object in the state where the user grips the pen part with the first finger and the second finger in the pinching manner,

wherein the first pressure pad is provided at a position touching the first finger of the user, and the second pressure pad is provided at a position touching the second finger of the user.

2. The controller according to claim **1**, comprising:

a grip part that intersects an axial direction of the pen part; and

a battery that is arranged in the grip part along a longitudinal direction of the grip part.

3. The controller according to claim **2**,
wherein the grip part has a first portion including a first end adjacent to the pen part and a second portion including a second end away from the pen part, and
wherein the battery is arranged in the second portion of the grip part.
4. The controller according to any one of claim **2**,
wherein the pen part has a circuit, and
wherein the battery, in operation, supplies electric power to the circuit.
5. The controller according to claim **2**,
wherein the grip part has a button that operable by the user, and
wherein the button includes:
a tactile switch that, in operation, is turned on and off, and
a light emitting diode which, in operation, detects the controller by the computer.
6. The controller according to claim **5**,
wherein an upper surface of the button includes a transparent member, and
wherein the light emitting diode is arranged under the transparent member.
7. The controller according to claim **2**, further comprising:
a haptic element,
wherein the haptic element is arranged in the grip part.
8. The controller according to claim **7**,
wherein the haptic element is arranged in the grip part in a vicinity of a portion gripped by the user.
9. The controller according to claim **7**,
wherein the haptic element is arranged in the grip part at a position adjacent to the pen part.
10. The controller according to any one of claim **7**,
wherein the grip part has a first side surface positioned on a pen tip side of the pen part and a second side surface positioned on a pen rear side of the pen part, and
wherein the haptic element is arranged in a vicinity of the first side surface.
11. The controller according to claim **10**,
wherein the grip part has a recess portion provided in a vicinity of the second side surface.
12. The controller according to claim **11**,
wherein the battery is arranged between the haptic element and the recess portion.
13. The controller according to claim **7**,
wherein the grip part has a first portion including a first end adjacent to the pen part and a second portion including a second end away from the pen part, and
wherein the haptic element is arranged in the second portion of the grip part.
14. The controller according to claim **1**,
wherein the first pressure pad includes a first capacitive touch sensor and a first pressure sensitive sensor, and
wherein the second pressure pad includes a second capacitive touch sensor and a second pressure sensitive sensor.
15. The controller according to claim **1**,
wherein, when the user grips the pen part with a plurality of fingers, a thumb of the user comes into contact with the first pressure pad, and an index finger of the user comes into contact with the second pressure pad.
16. The controller according to claim **1**, comprising:
a first communication device that, in operation, transmits the first pressure detected by the first pressure pad or the second pressure detected by the second pressure pad.
17. The controller according to claim **16**,
wherein the first communication device, in operation, transmits the first pressure detected by the first pressure pad or the second pressure detected by the second pressure pad, to the computer configured to control the thickness of the line of the three-dimensional object in the extended reality space based on the first pressure detected by the first pressure pad or the second pressure detected by the second pressure pad.
18. The controller according to claim **16**, further comprising:
a pen pressure sensor that, in operation, detects a third pressure applied to a pen tip of the pen part; and
a second communication device that, in operation, transmits the third pressure detected by the pen pressure sensor, wherein the second communication device is different from the first communication device.
19. A computer that communicates with a controller including a pen part that is formed in a pen shape, a first pressure pad that includes a first capacitive touch sensor and a first pressure sensitive sensor provided in the pen part, and a second pressure pad that includes a second capacitive touch sensor and a second pressure sensitive sensor provided in the pen part, the computer comprising:
a communication device that, in operation, receives information transmitted from the controller; and
a processor,
wherein the processor, in operation, controls, based on the information received by the communication device and detected by the first capacitive touch sensor or the second capacitive touch sensor, outputting of a pen pressure value that is related to a pressing value detected by the first pressure sensitive sensor or the second pressure sensitive sensor.

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