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

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(45) **Date of Patent: Aug. 20, 2019**

(54) **WORK VEHICLE**

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Oct. 23, 2015 (JP) 2015-208832

(51) **Int. Cl.**
E02F 3/815 (2006.01)
B60R 1/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***E02F 9/264*** (2013.01); ***B60Q 1/04*** (2013.01); ***B60Q 1/24*** (2013.01); ***B60Q 1/2661*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC E02F 3/7609; E02F 3/7618; E02F 3/847; E02F 3/845; E02F 3/842; E02F 3/844;
(Continued)

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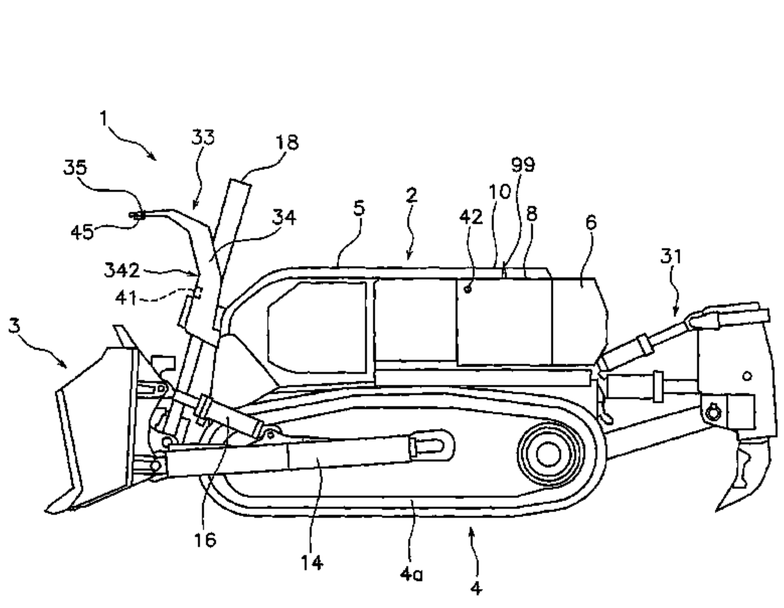
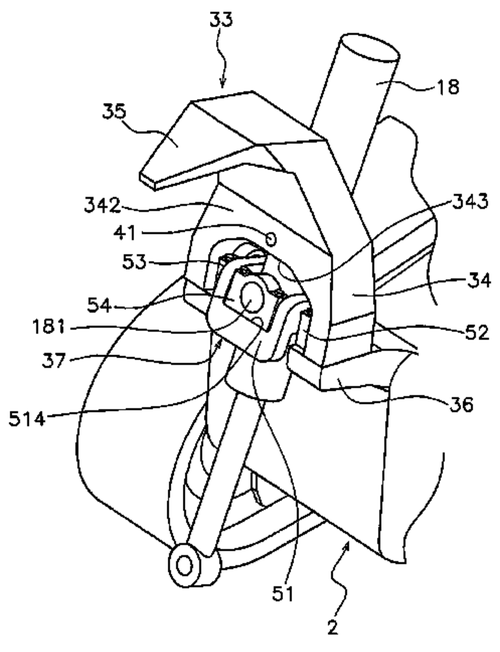
(74) *Attorney, Agent, or Firm* — Global IP Counselors, LLP

(57) **ABSTRACT**

A lift cylinder is attached to a center part of a vehicle body in a vehicle width direction. The lift cylinder causes a work implement to move up and down. A supporting member is attached to the center part of the vehicle body in the vehicle width direction and extends upward from the vehicle body. An imaging device is supported by the supporting member and captures images of a region in front of the vehicle body.
(Continued)





A penetrating part is formed in the supporting member. The lift cylinder is disposed through the penetrating part.

19 Claims, 23 Drawing Sheets

(51) **Int. Cl.**

E02F 9/26	(2006.01)
B60Q 1/04	(2006.01)
B60Q 1/24	(2006.01)
E02F 3/76	(2006.01)
E02F 3/84	(2006.01)
E02F 9/20	(2006.01)
G05D 1/00	(2006.01)
B60Q 1/26	(2006.01)
E02F 9/08	(2006.01)

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

CPC ***B60R 1/00*** (2013.01); ***E02F 3/7609*** (2013.01); ***E02F 3/7618*** (2013.01); ***E02F 3/842*** (2013.01); ***E02F 3/844*** (2013.01); ***E02F 3/847*** (2013.01); ***E02F 9/205*** (2013.01); ***E02F 9/261*** (2013.01); ***G05D 1/0038*** (2013.01); *E02F 3/7604* (2013.01); *E02F 9/0891* (2013.01); *G05D 2201/0202* (2013.01)

(58) **Field of Classification Search**

CPC E02F 9/2037; E02F 9/2041; E02F 9/262; E02F 9/264; E02F 9/205; E02F 9/261; G05D 1/0891; G05D 1/0038; G01S 19/14; B60Q 1/04; B60Q 1/24; B60Q 1/2661; B60R 1/00

USPC 37/347, 348, 231–235; 172/1–11, 830; 180/6.2; 701/50, 505

See application file for complete search history.

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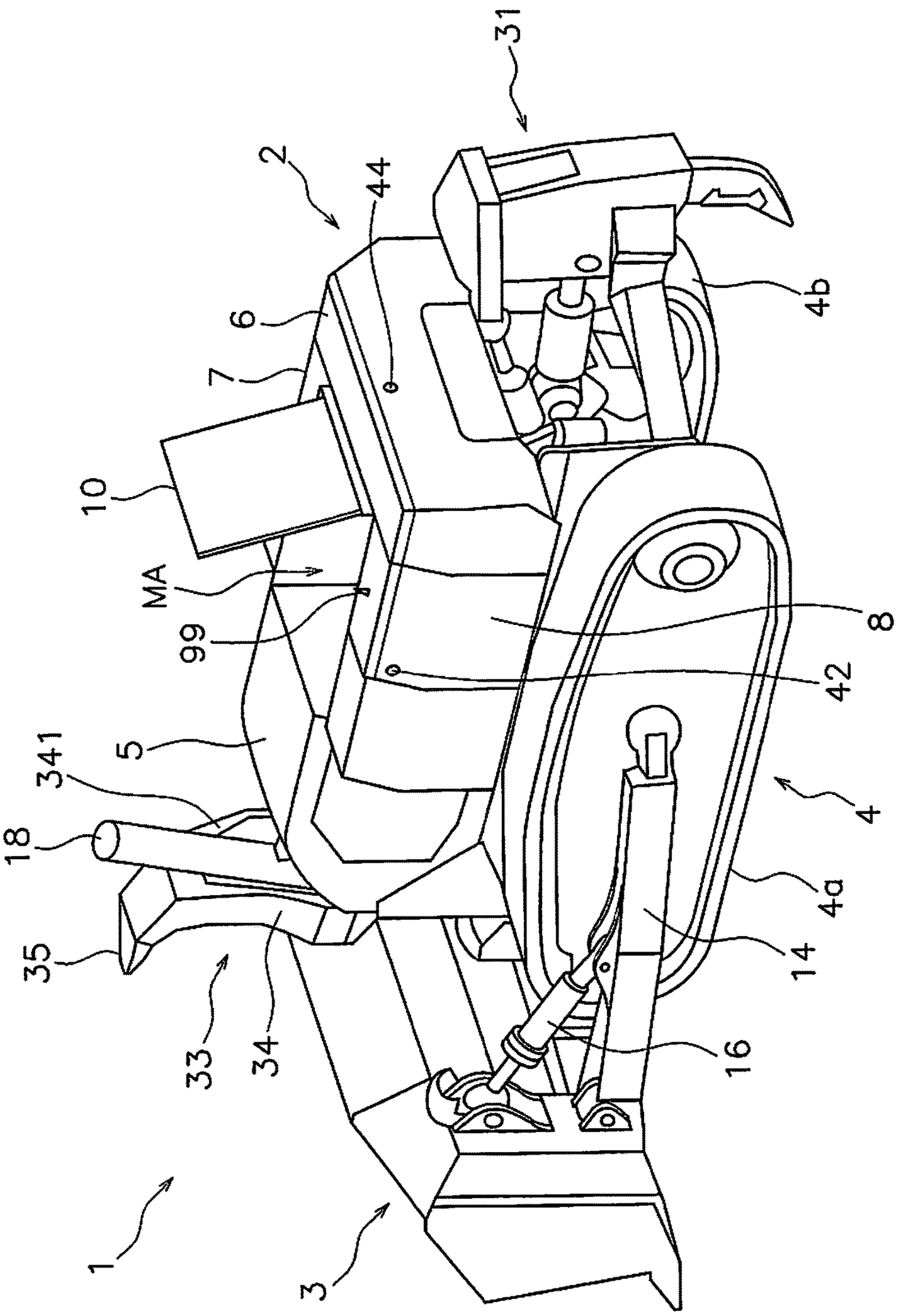


FIG. 1

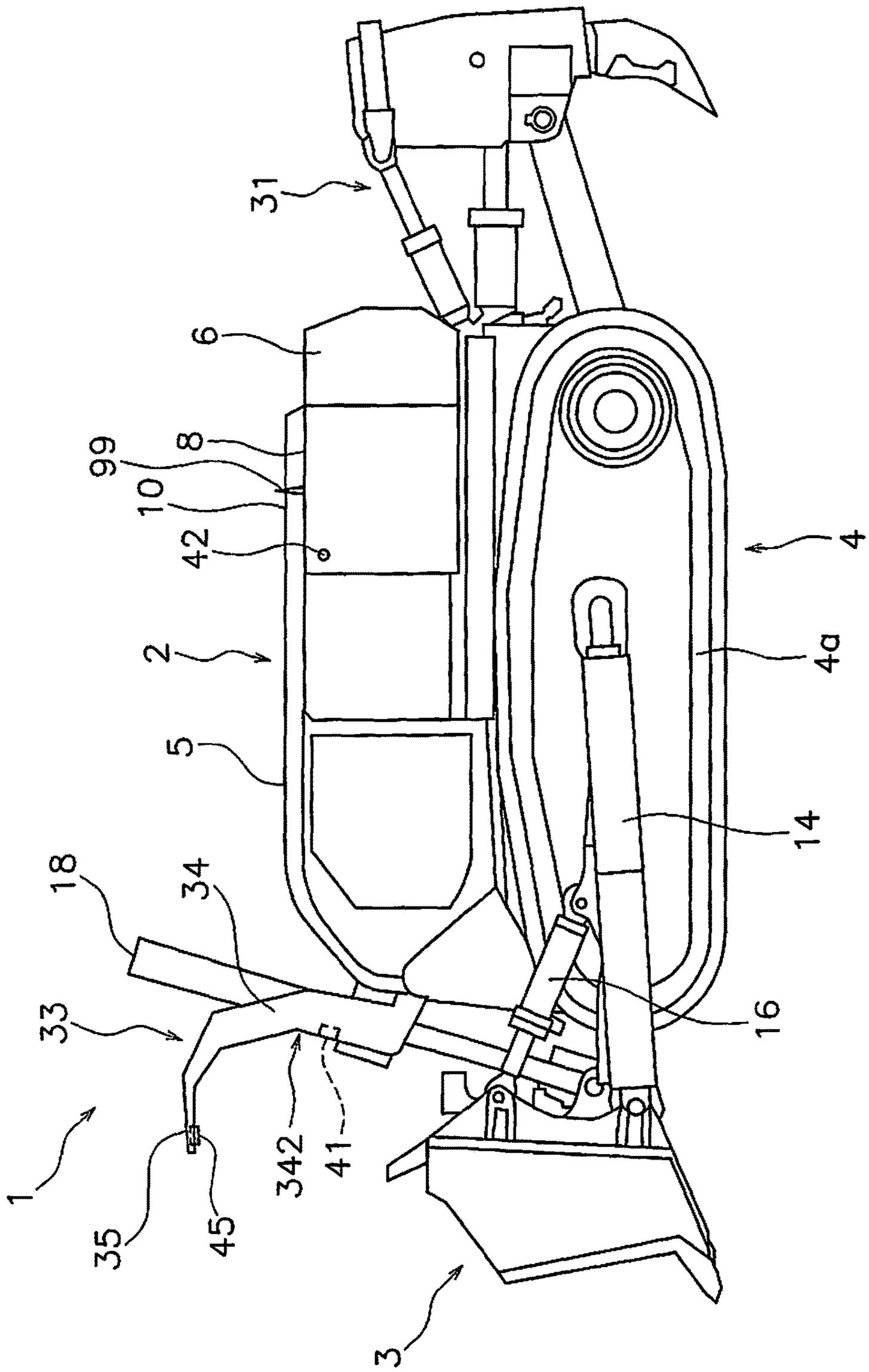


FIG. 2

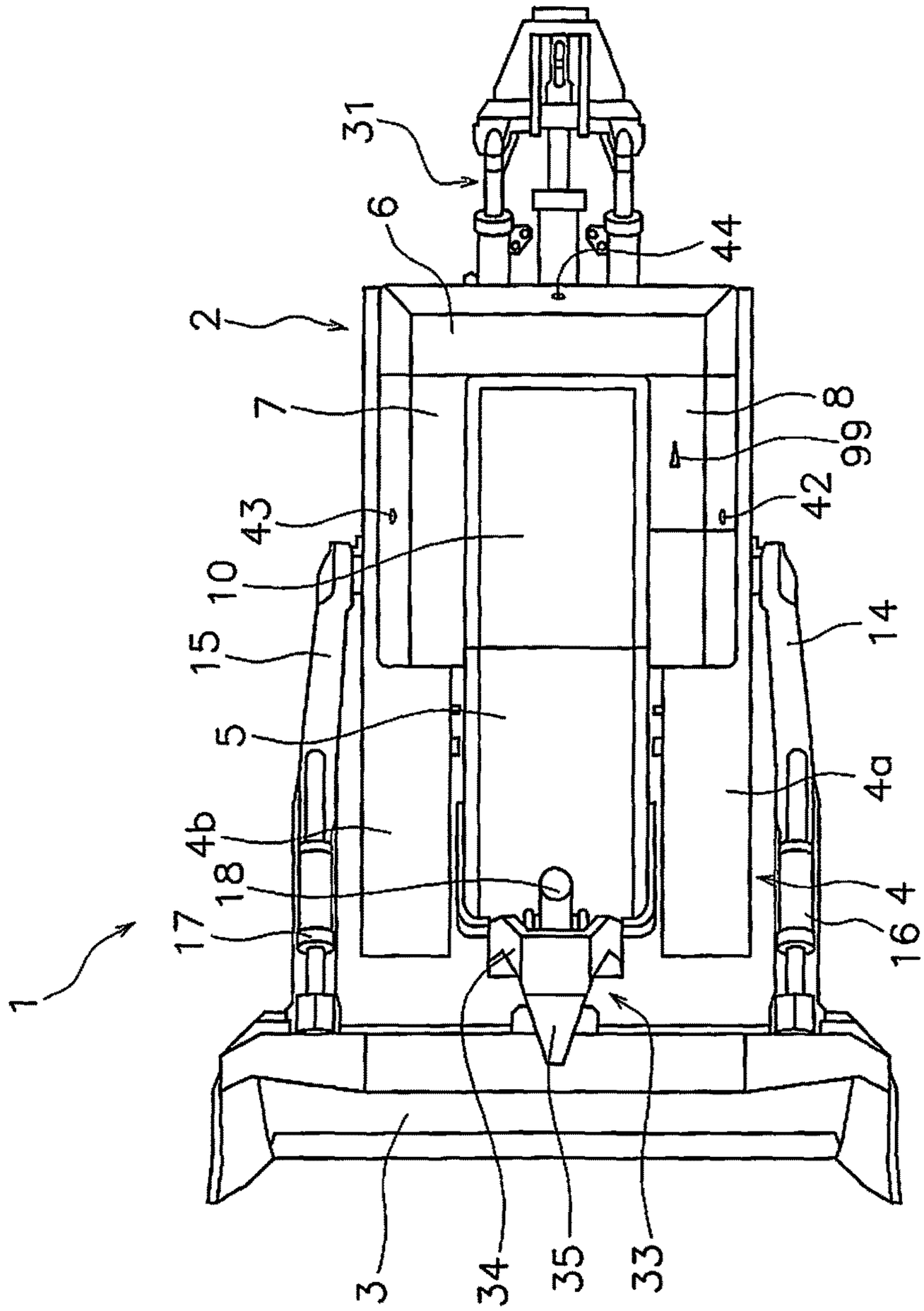
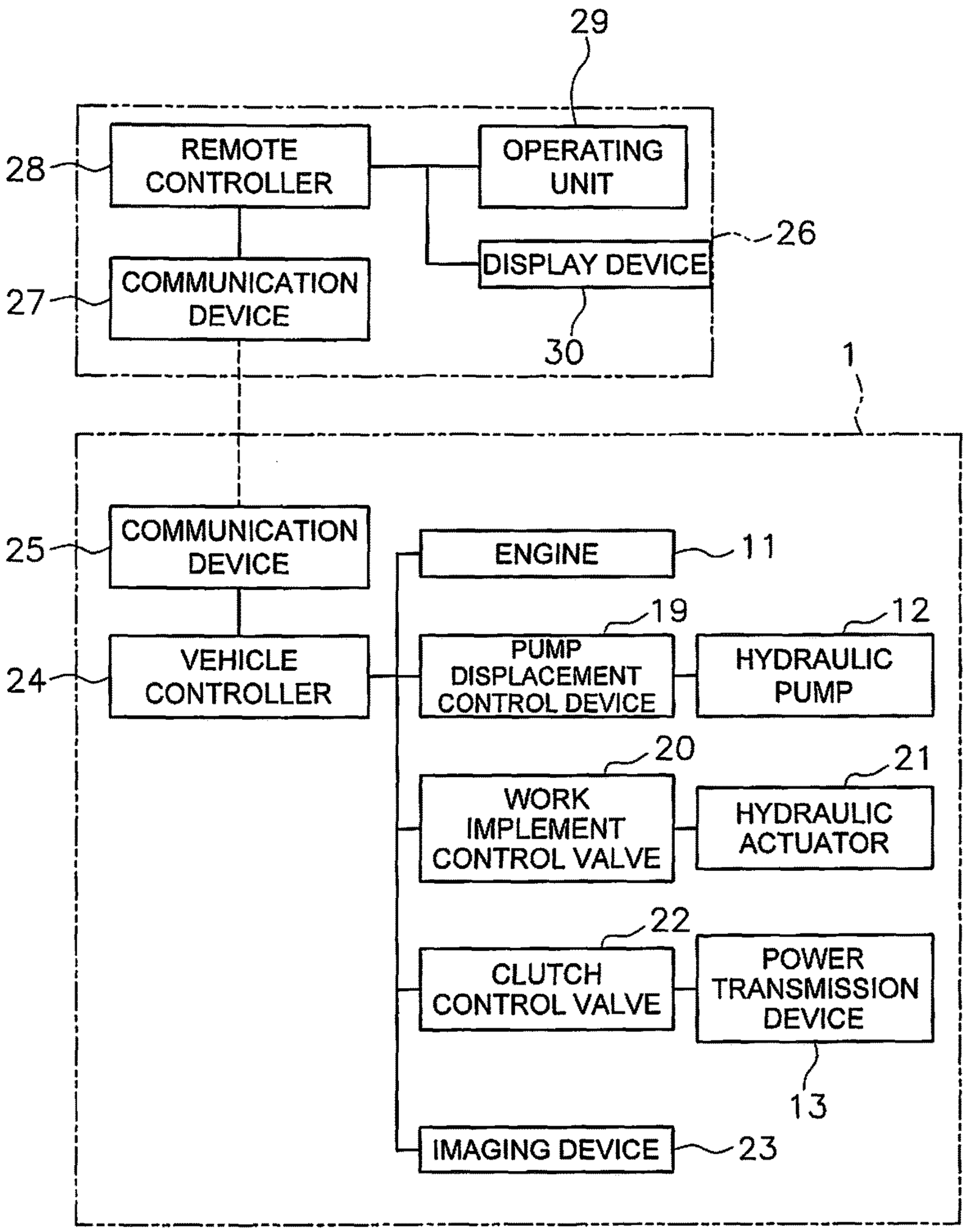


FIG. 3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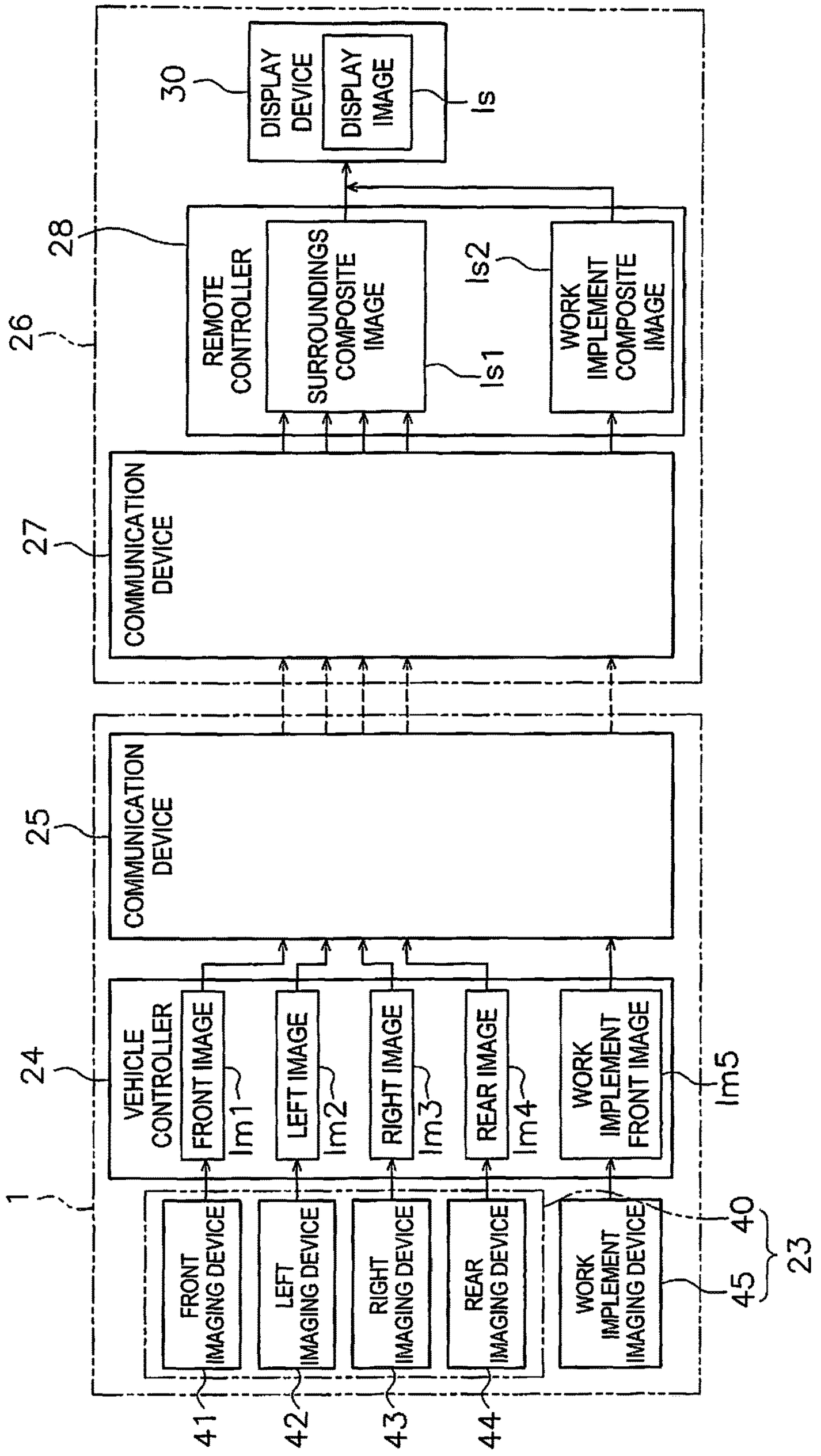
REMOTE CONTROLLER
OPERATING UNIT
26
DISPLAY DEVICE
27
COMMUNICATION DEVICE
30
1
25
COMMUNICATION DEVICE
ENGINE
11
19
12
24
VEHICLE CONTROLLER
PUMP DISPLACEMENT CONTROL DEVICE
HYDRAULIC PUMP
20
21
WORK IMPLEMENT CONTROL VALVE
HYDRAULIC ACTUATOR
22
CLUTCH CONTROL VALVE
POWER TRANSMISSION DEVICE
13
IMAGING DEVICE
23

FIG. 4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DISPLAY IMAGE
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Is1
Is2
WORK IMPLEMENT COMPOSITE IMAGE
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COMMUNICATION DEVICE
25
COMMUNICATION DEVICE
24
VEHICLE CONTROLLER
FRONT IMAGE
Im1
LEFT IMAGE
Im2
RIGHT IMAGE
Im3
REAR IMAGE
Im4
WORK IMPLEMENT FRONT IMAGE
Im5
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LEFT IMAGING DEVICE
RIGHT IMAGING DEVICE
REAR IMAGING DEVICE
WORK IMPLEMENT IMAGING DEVICE
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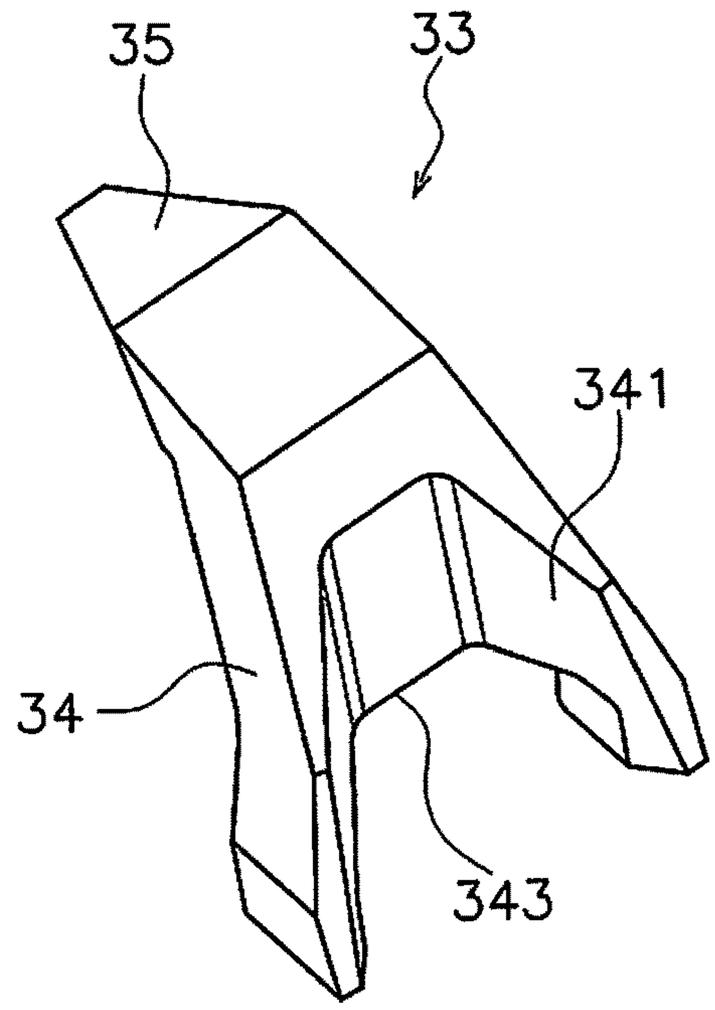
FIG. 5

FIG. 6



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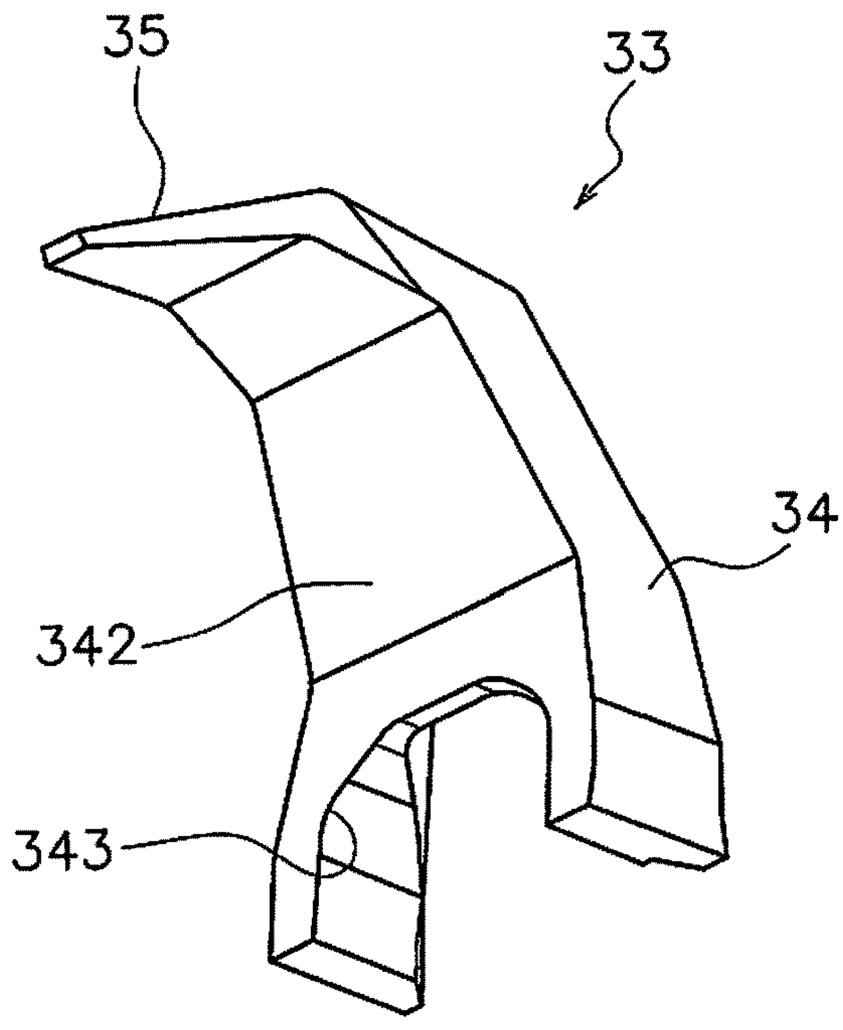

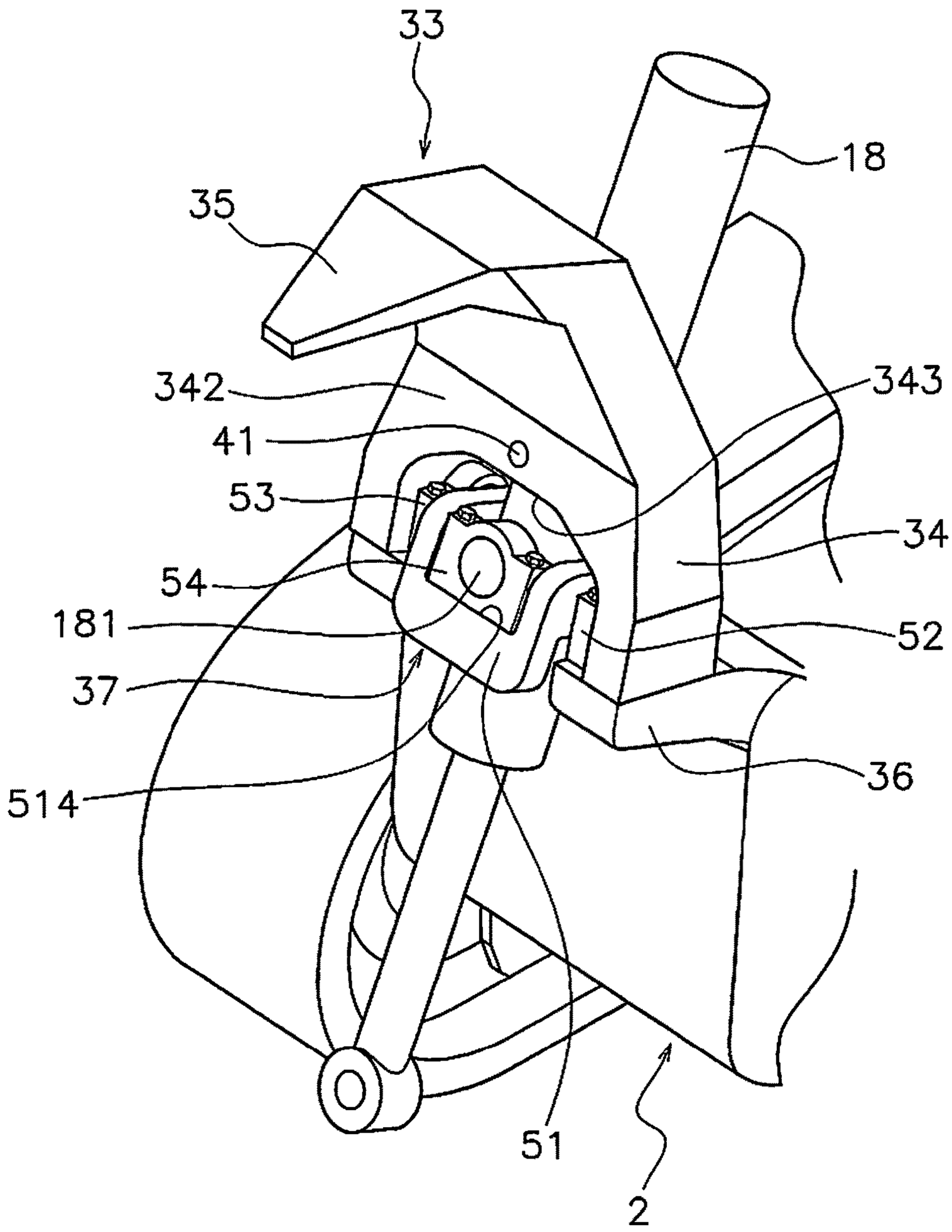

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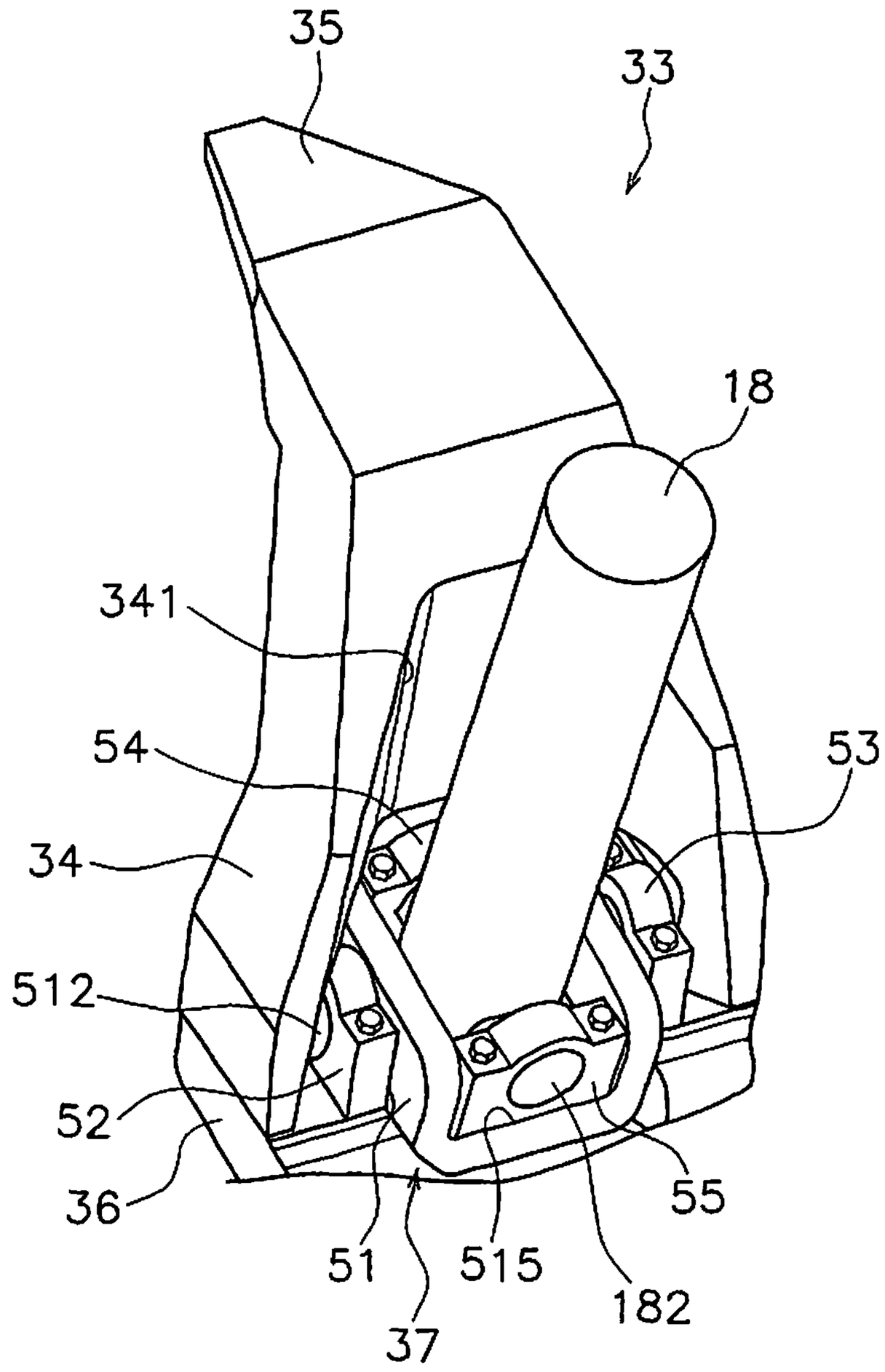

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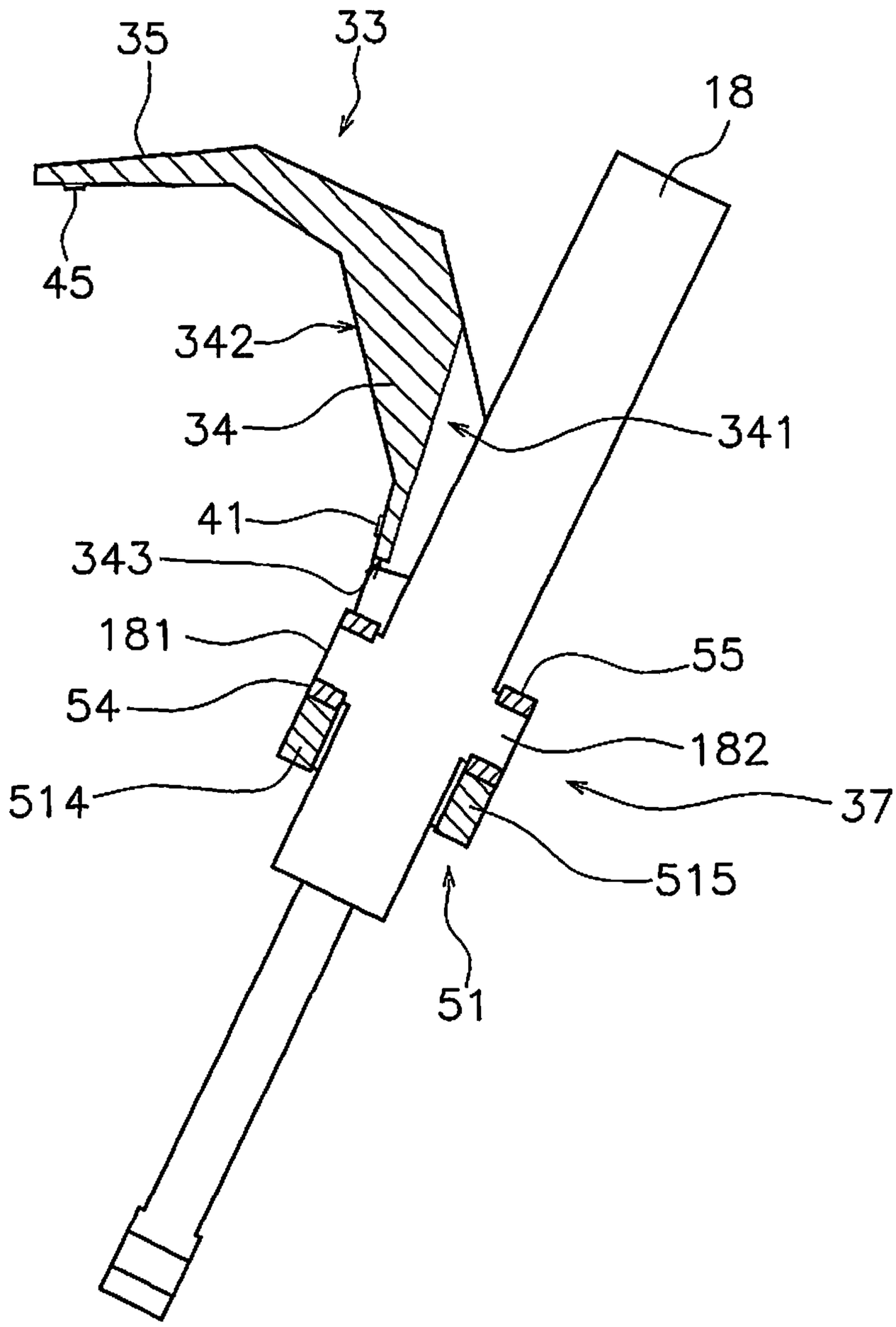

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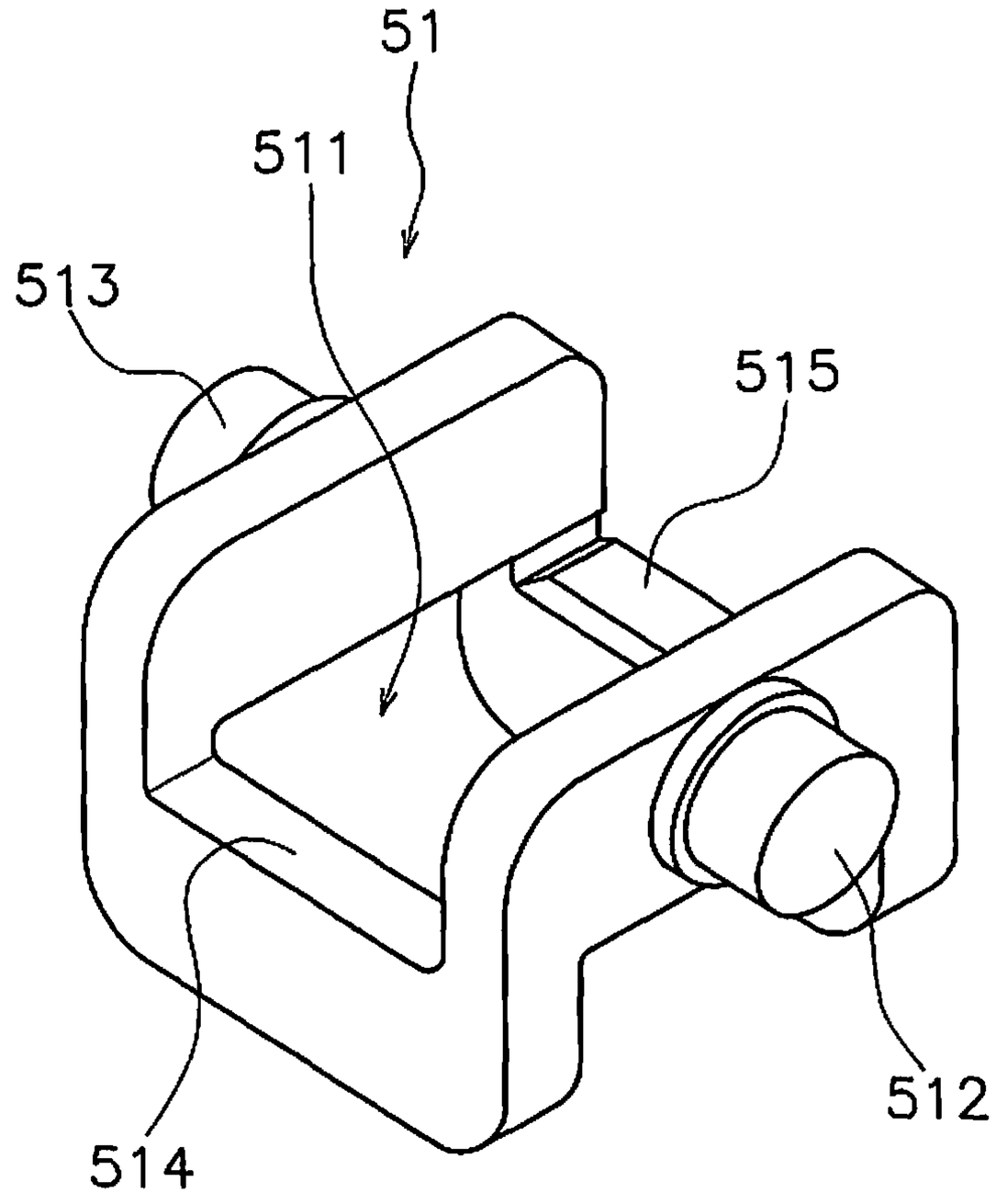

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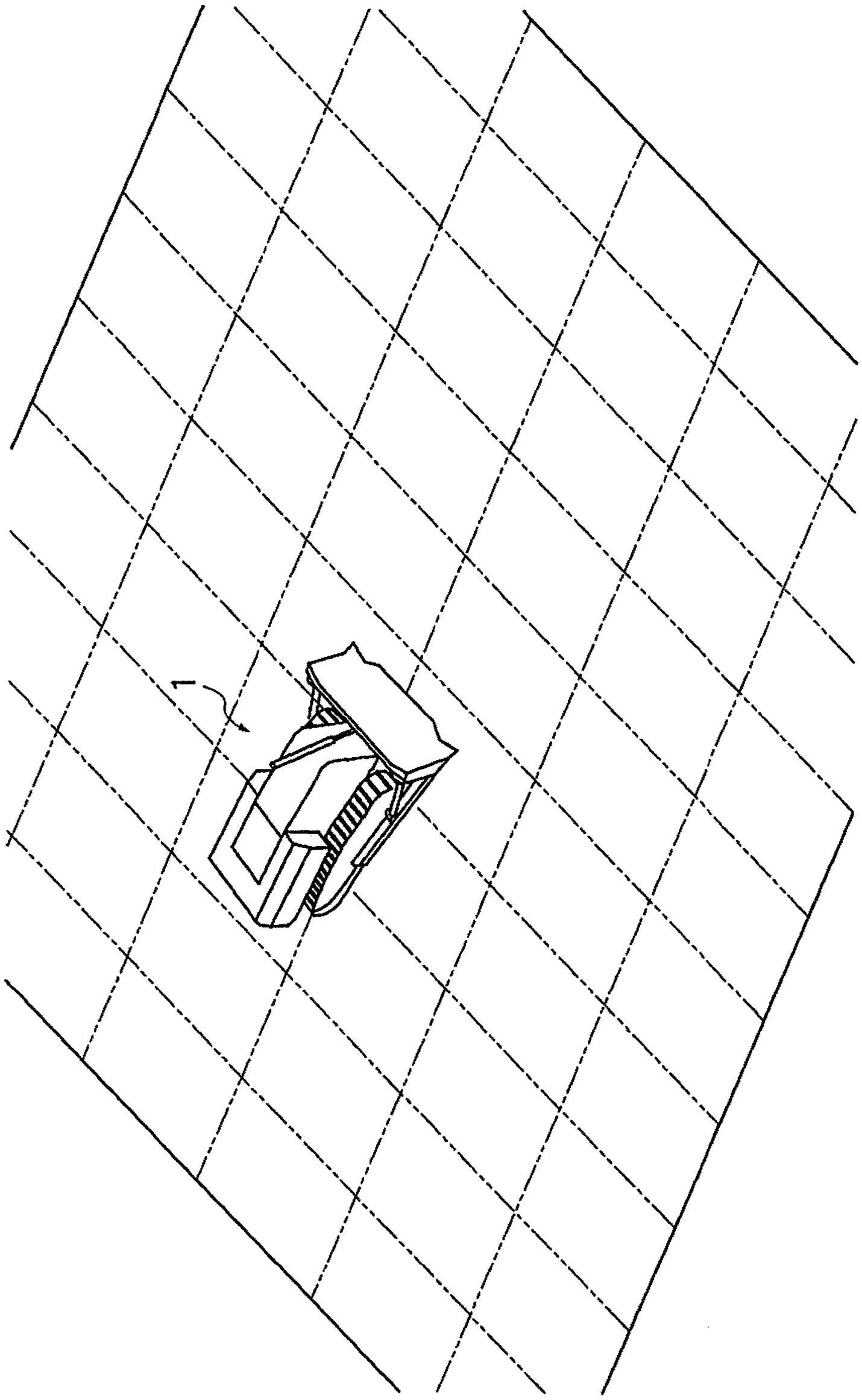
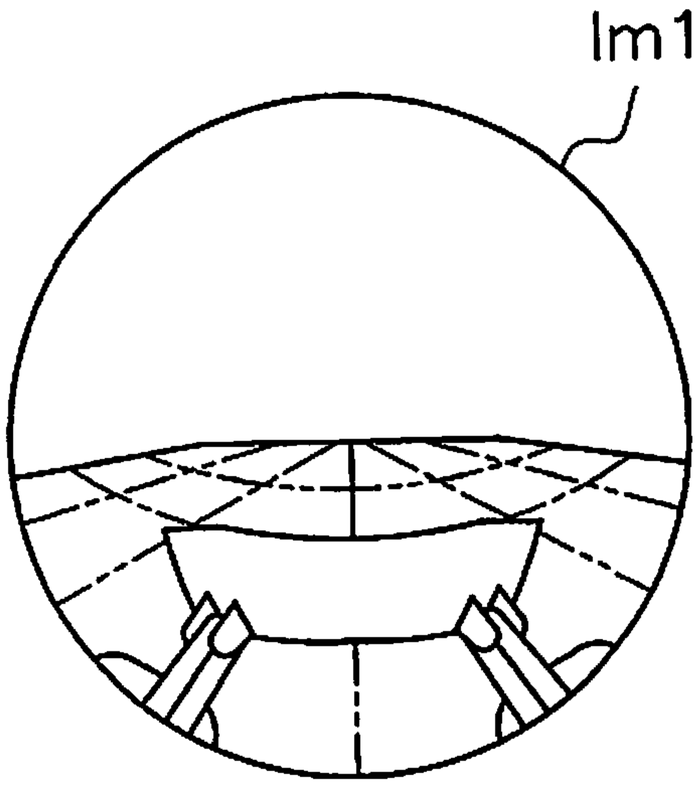


FIG. 12

FIG. 13A



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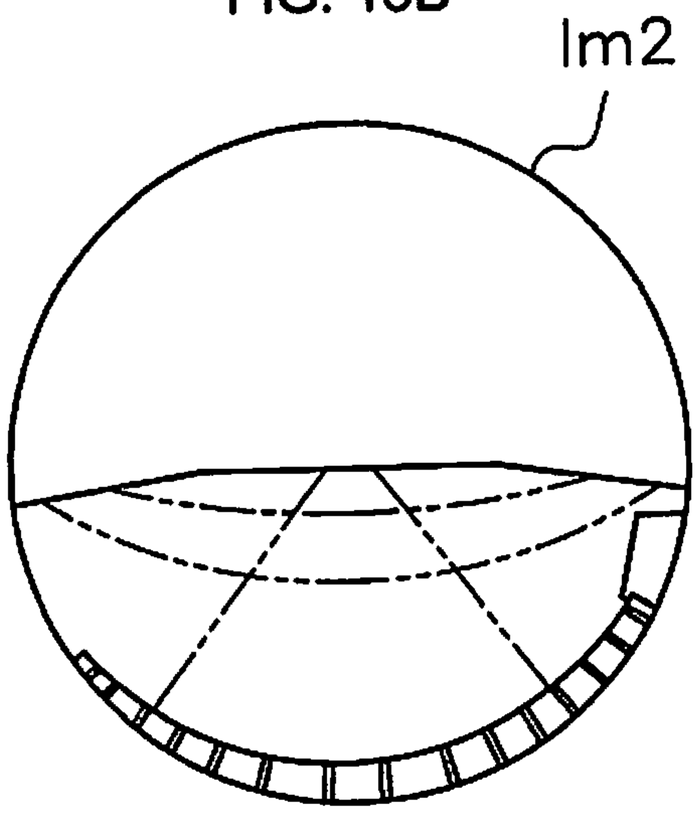


FIG. 13C

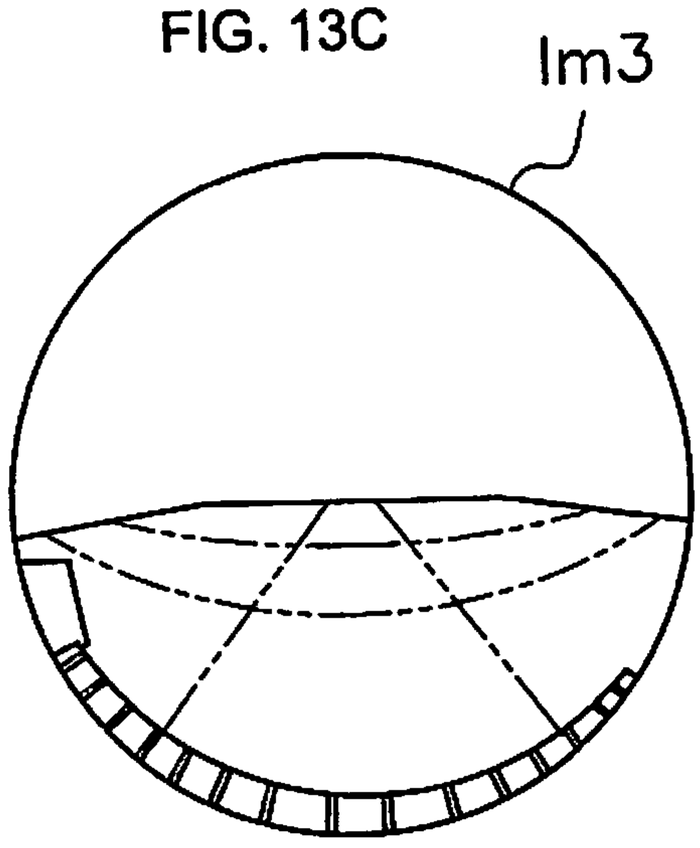
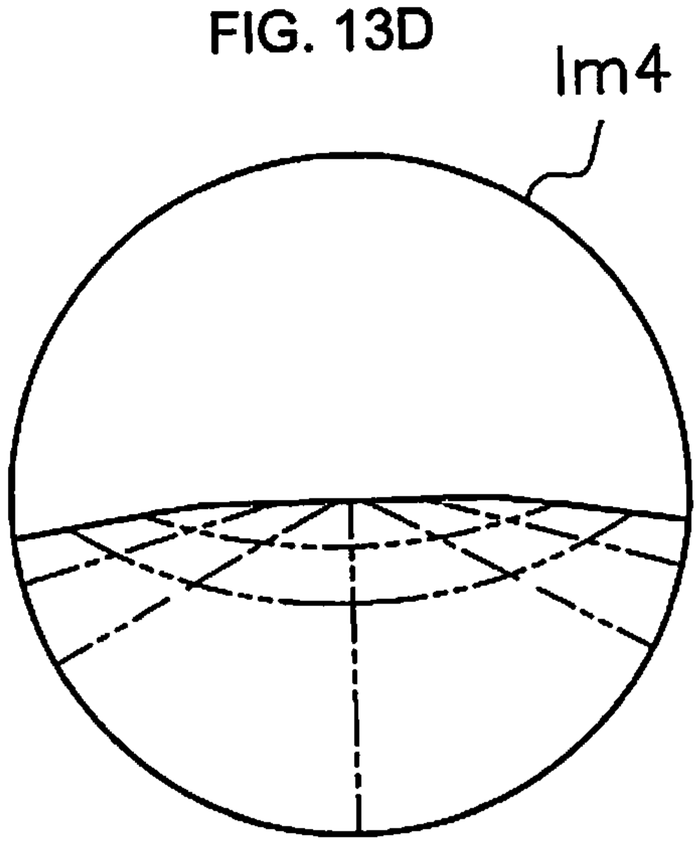


FIG. 13D



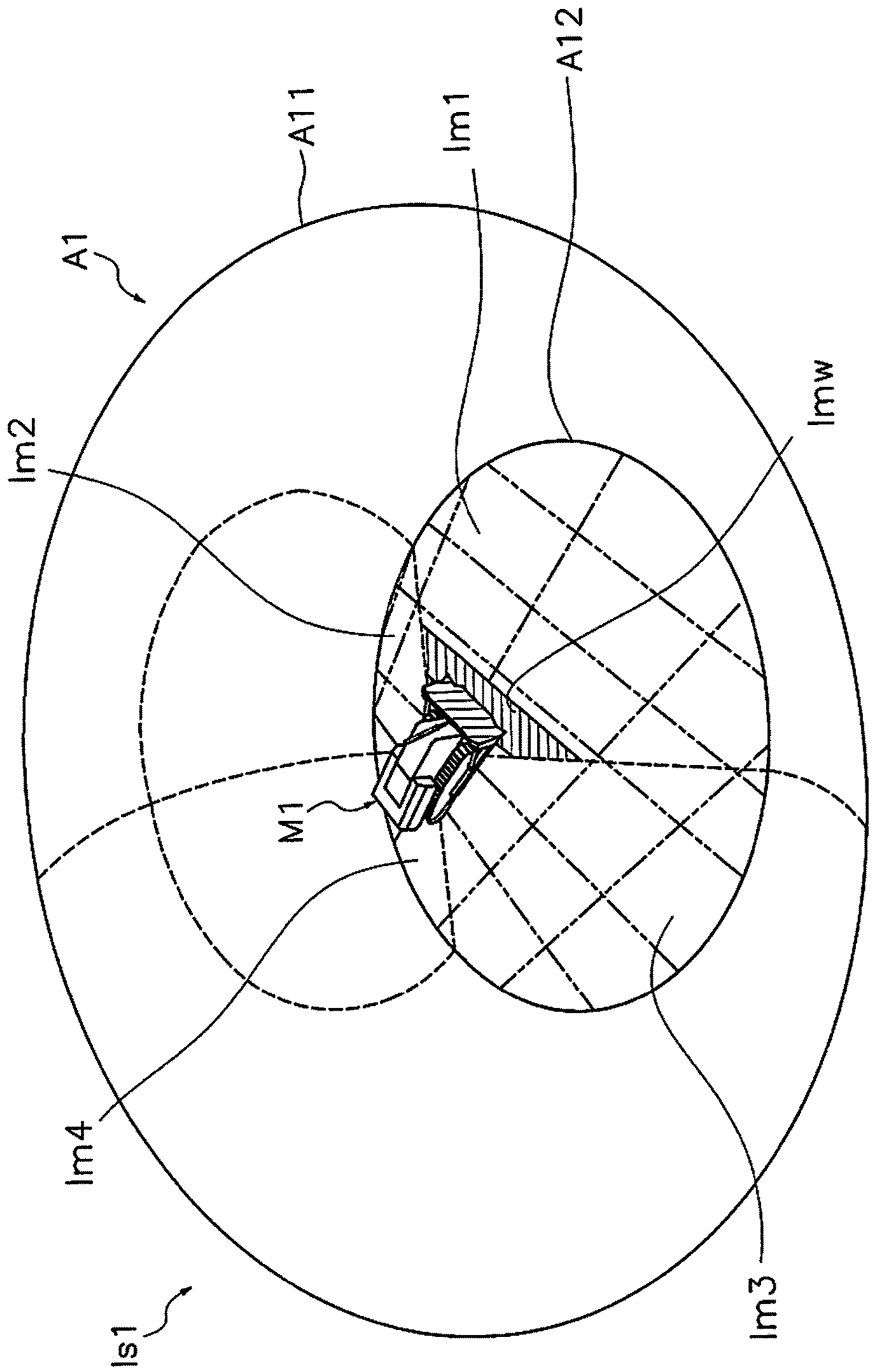
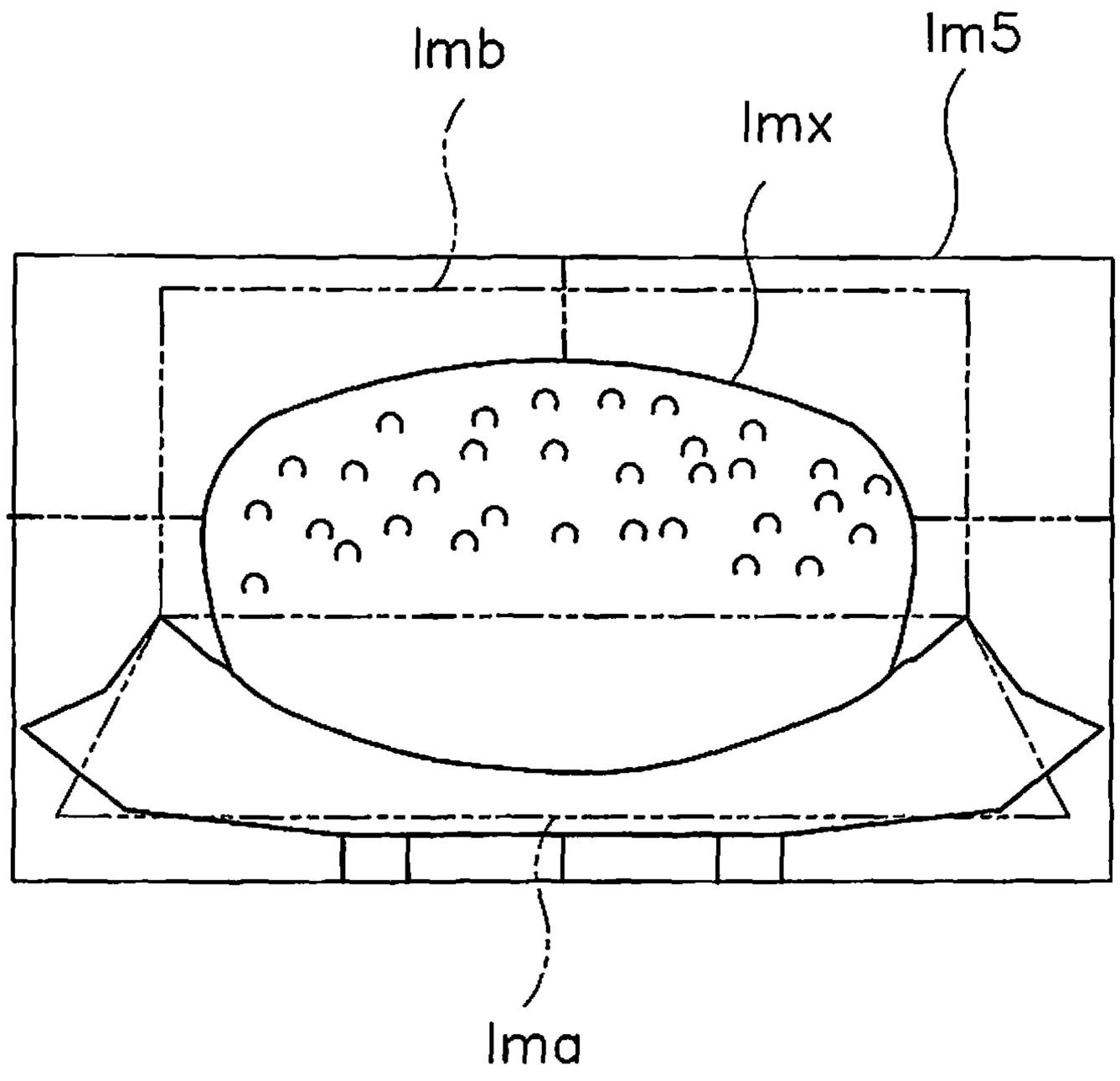


FIG. 14



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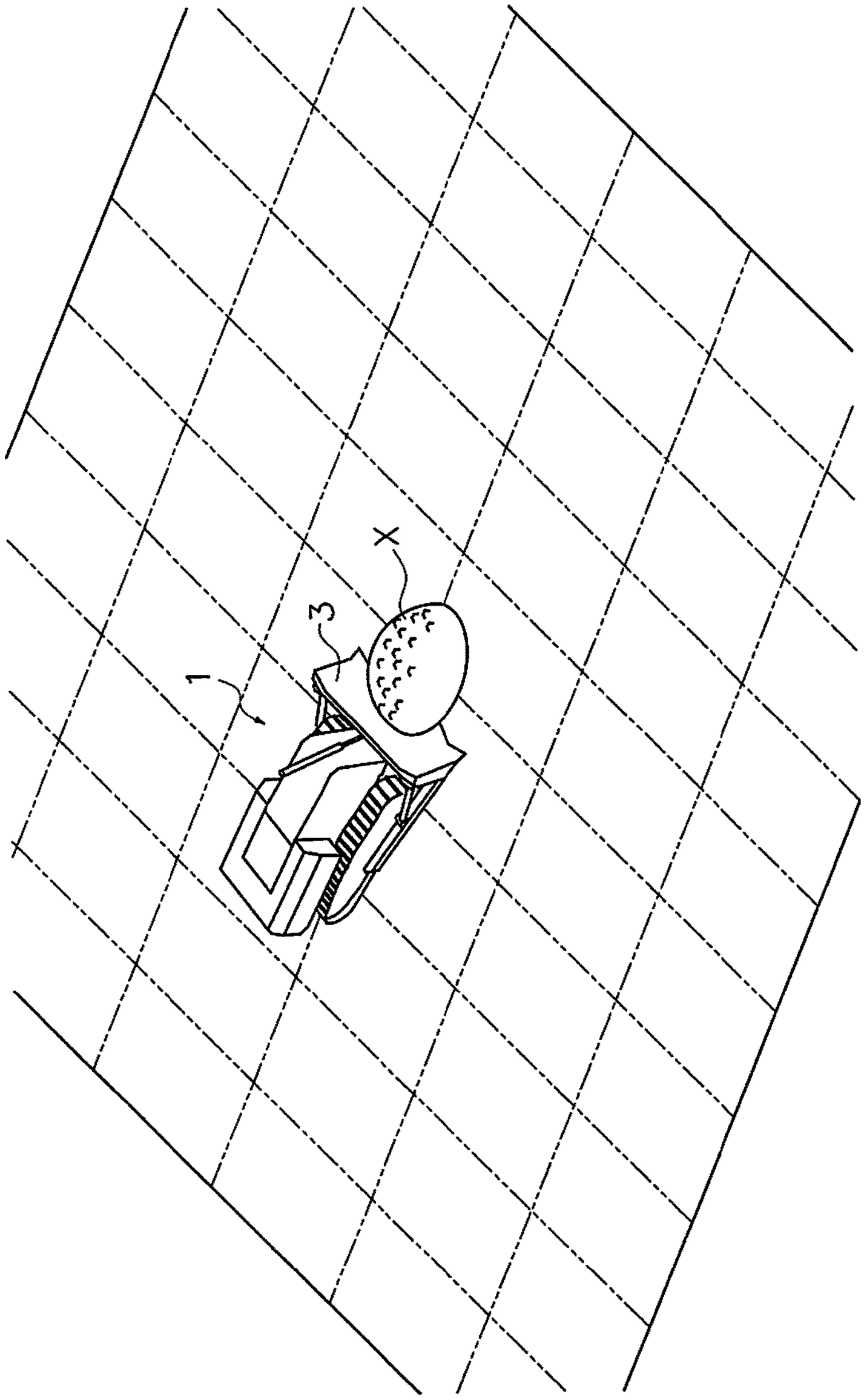


FIG. 16

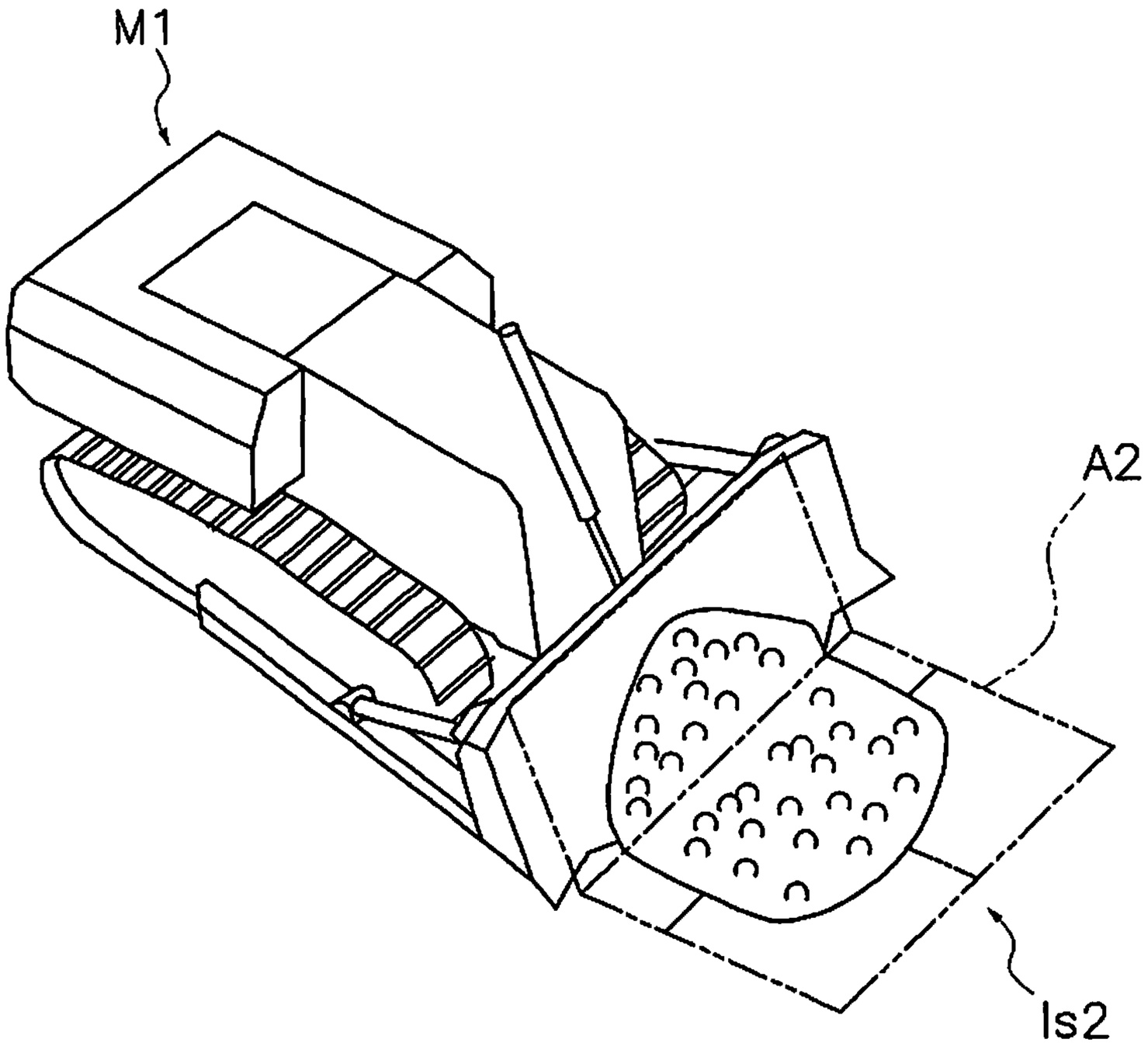


FIG. 17

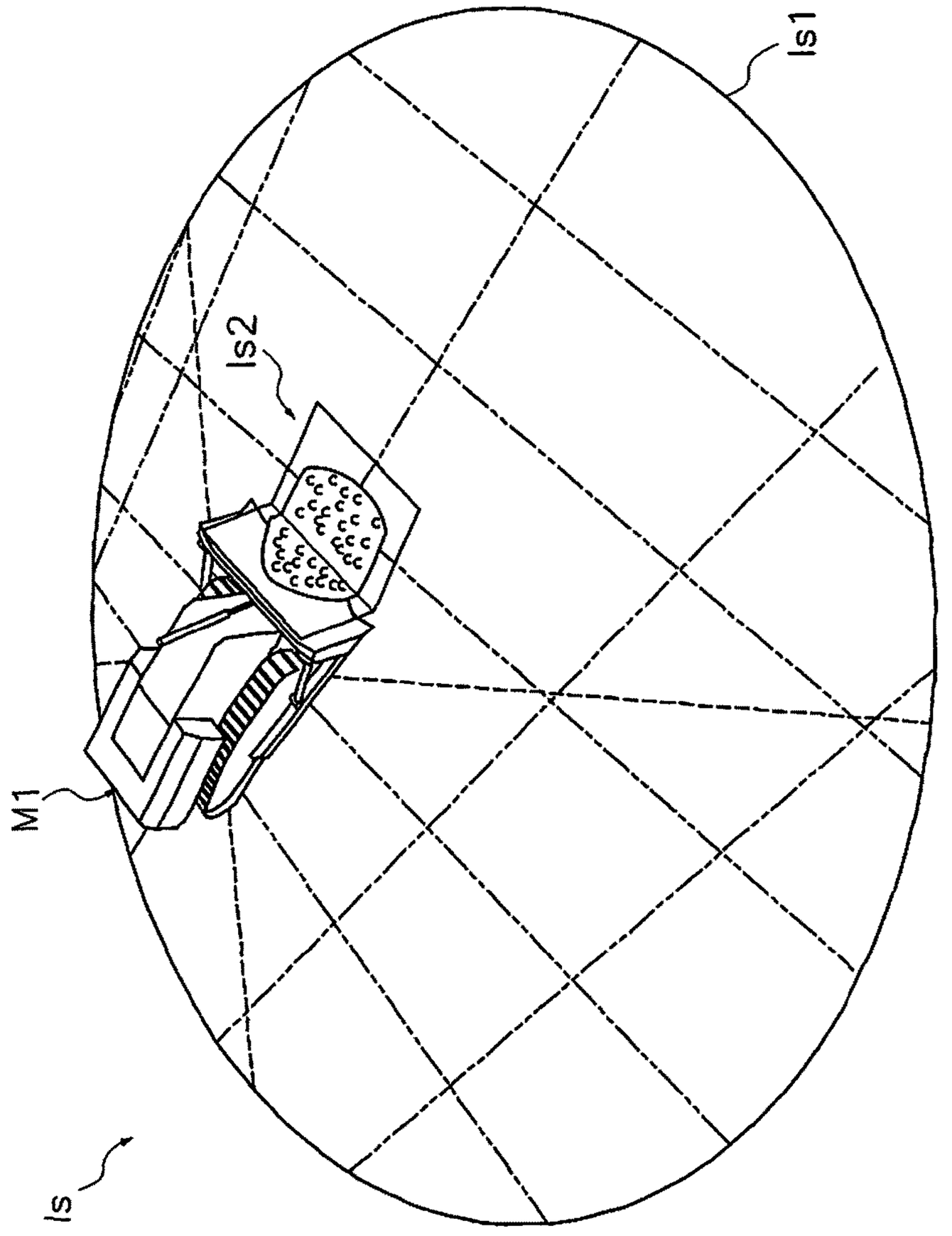
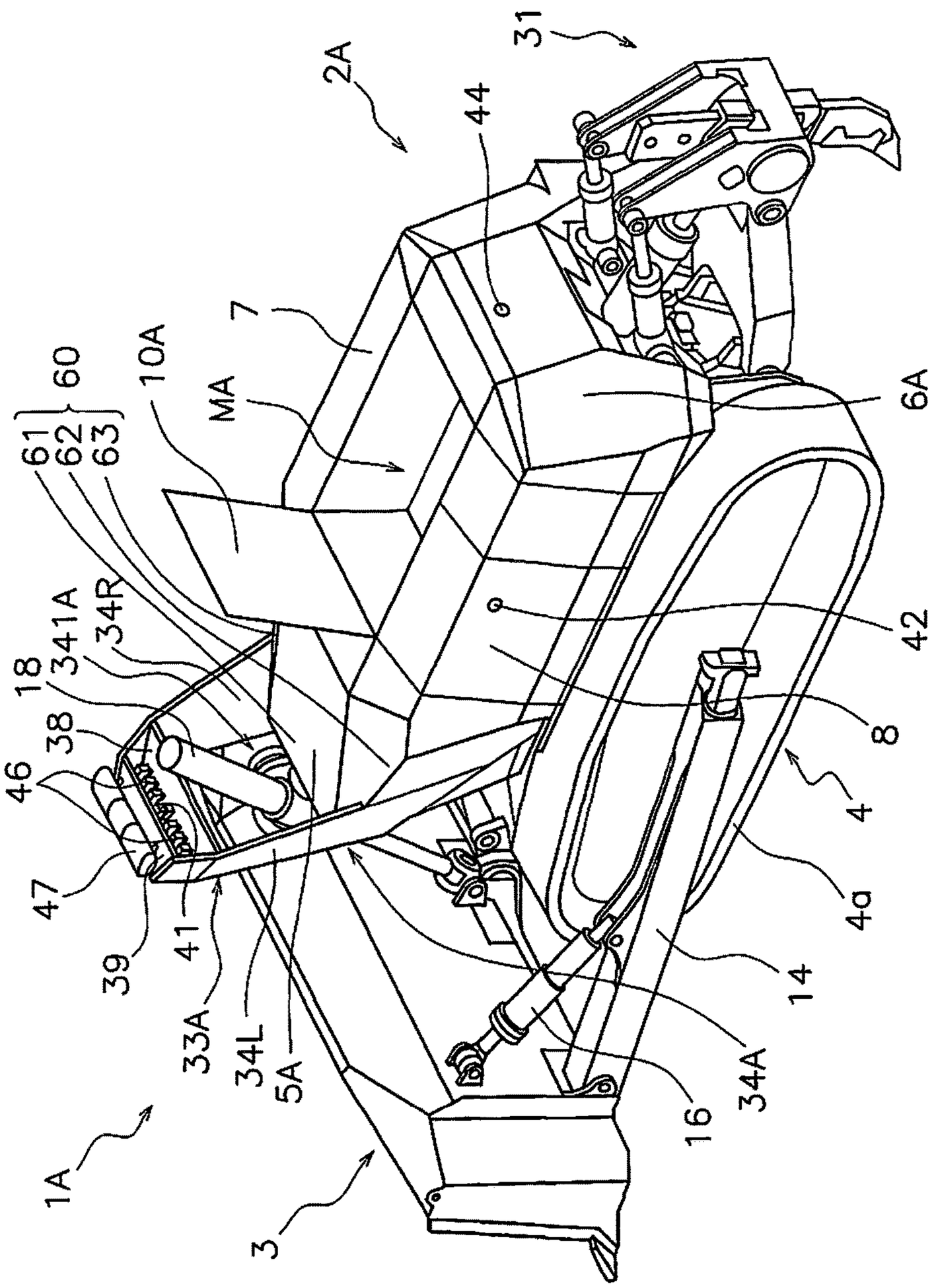


FIG. 18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5A
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34A

FIG. 19

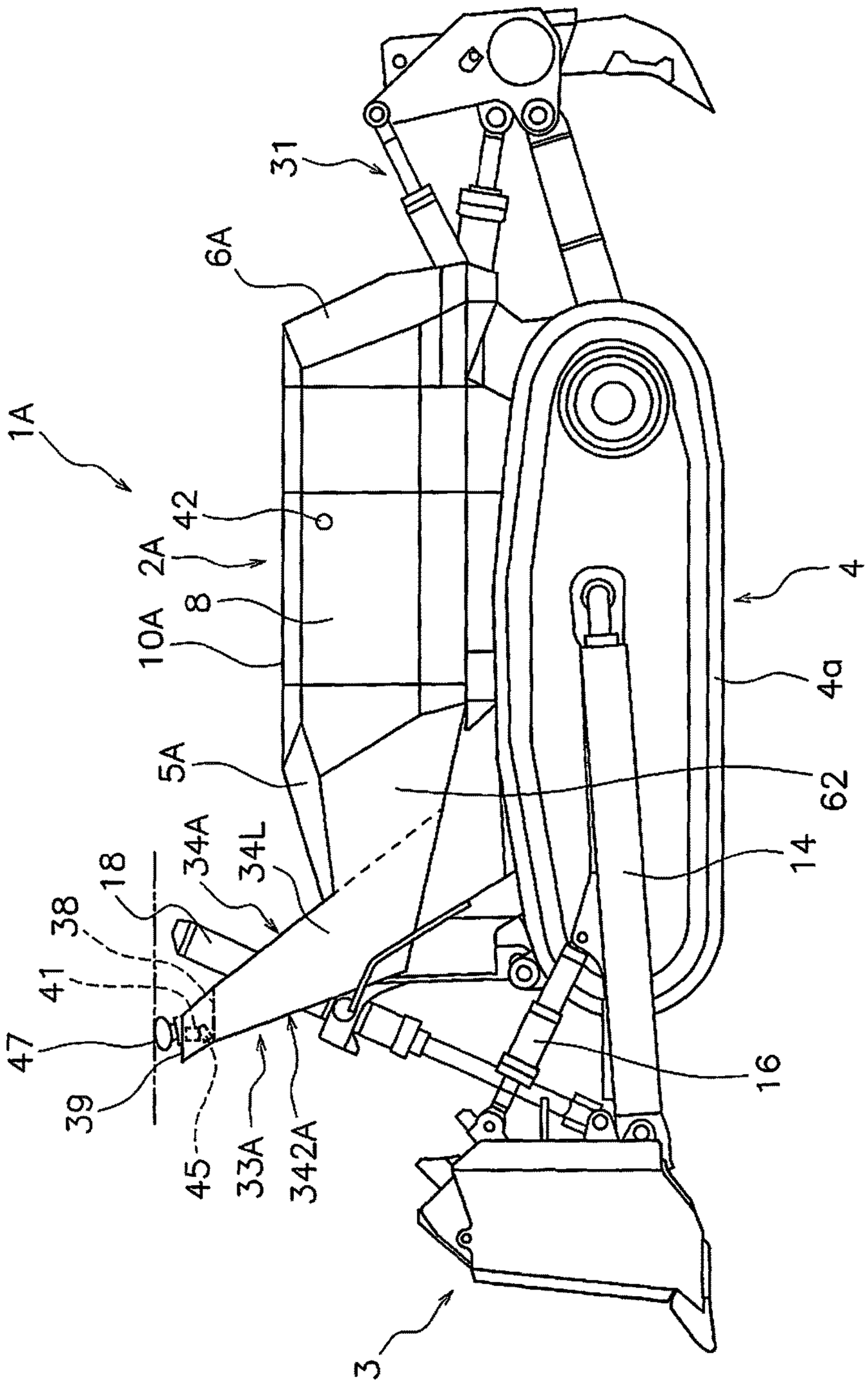
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FIG. 20

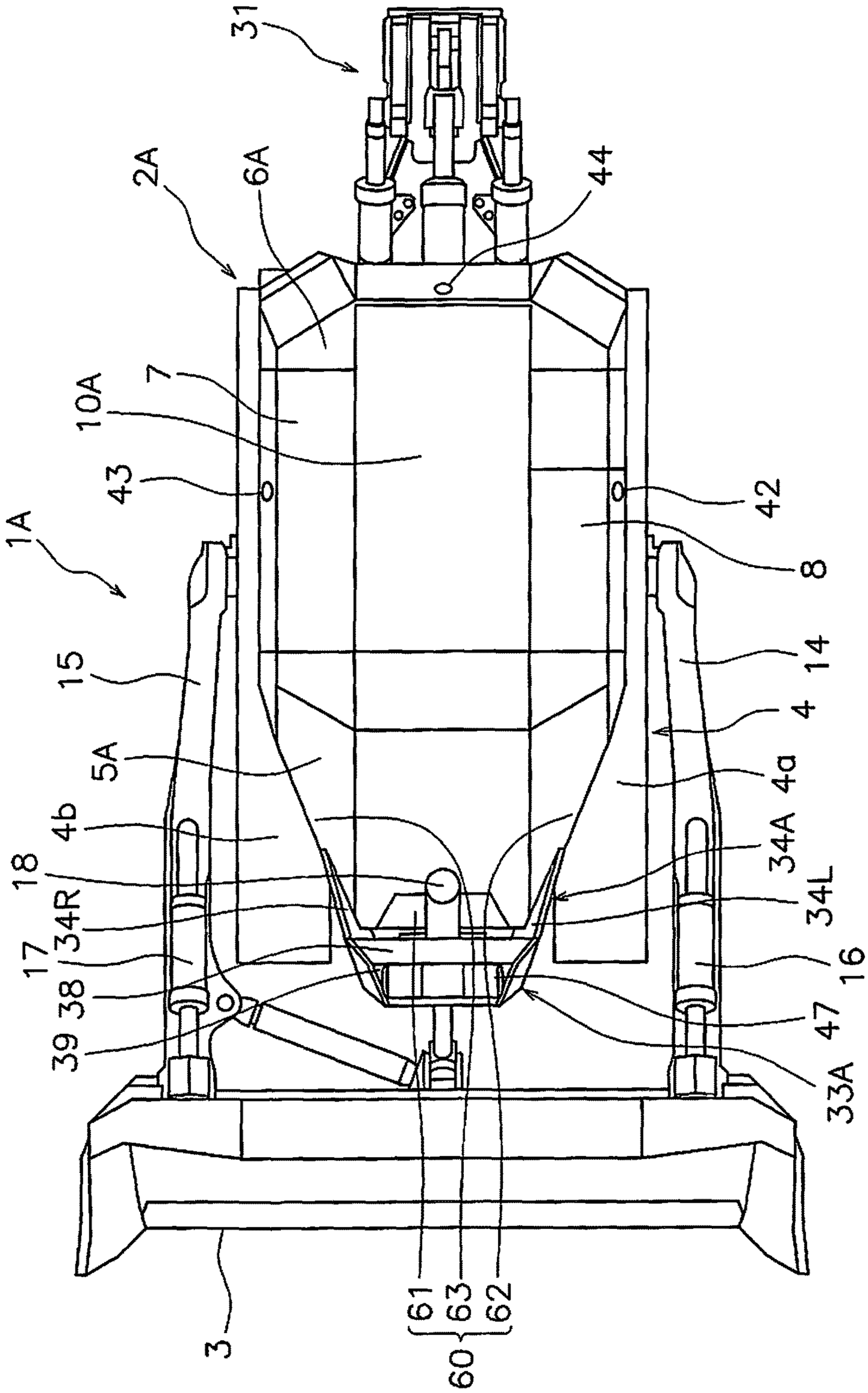
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FIG. 21

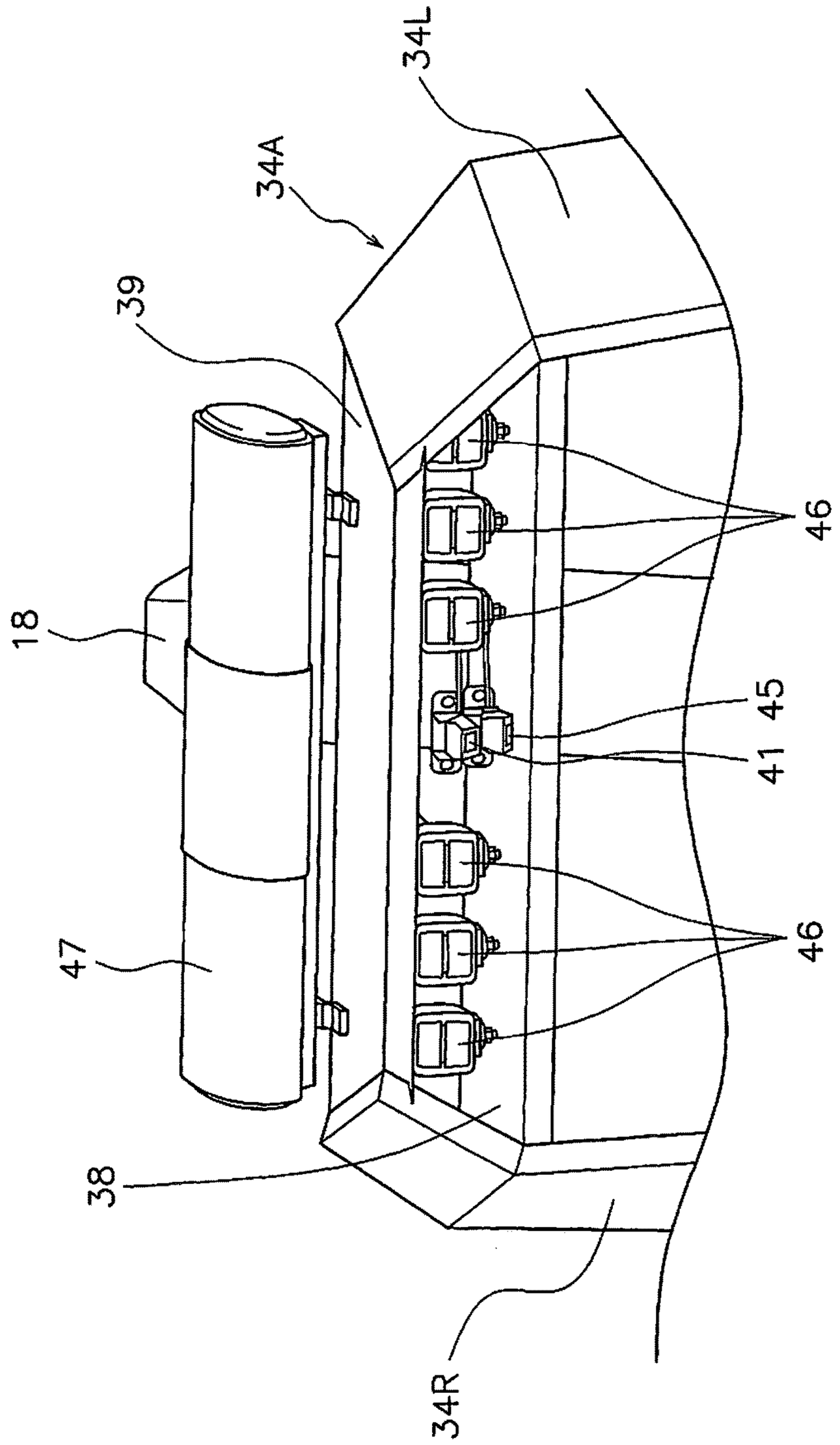

FIG. 22

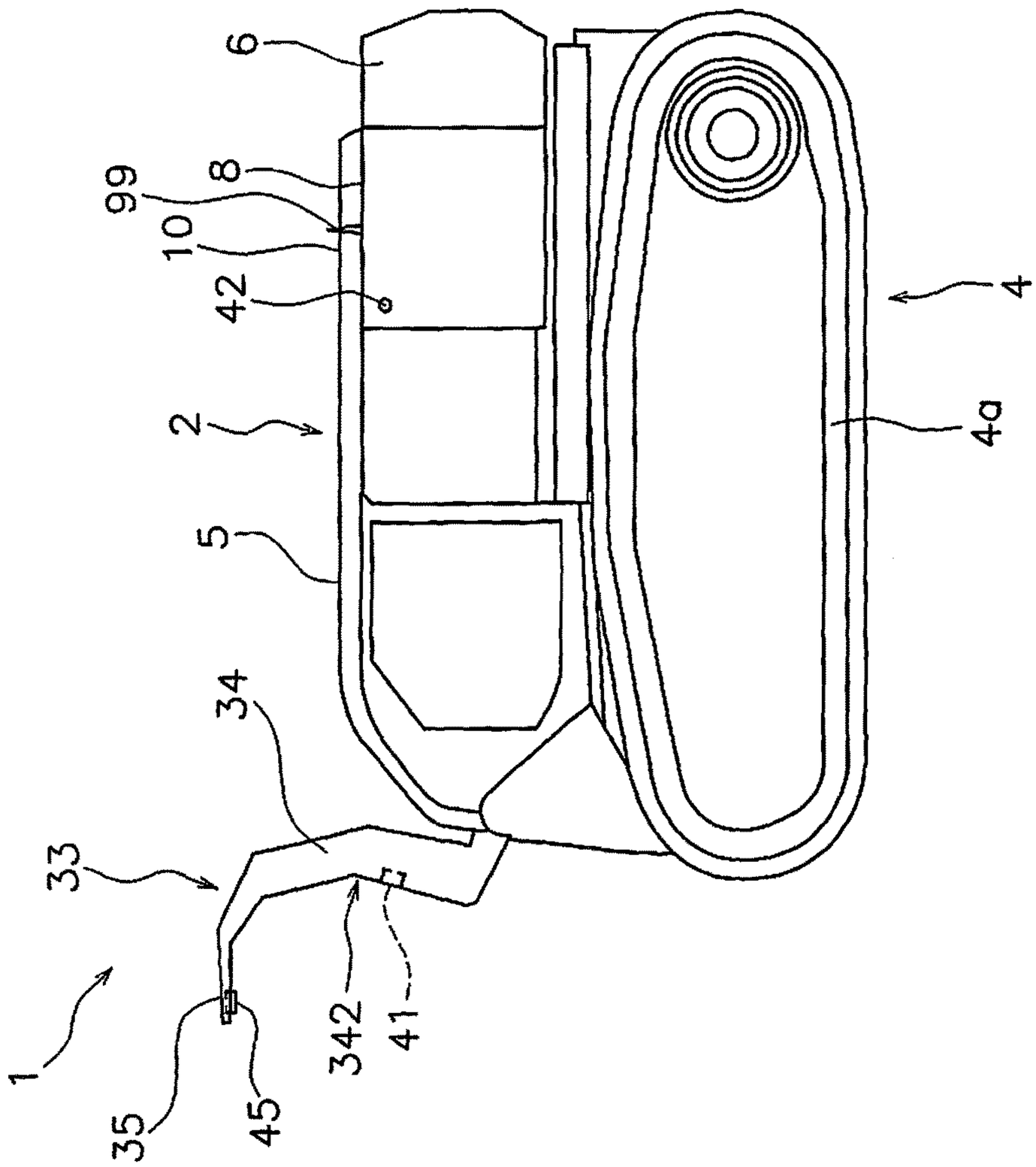

FIG. 23

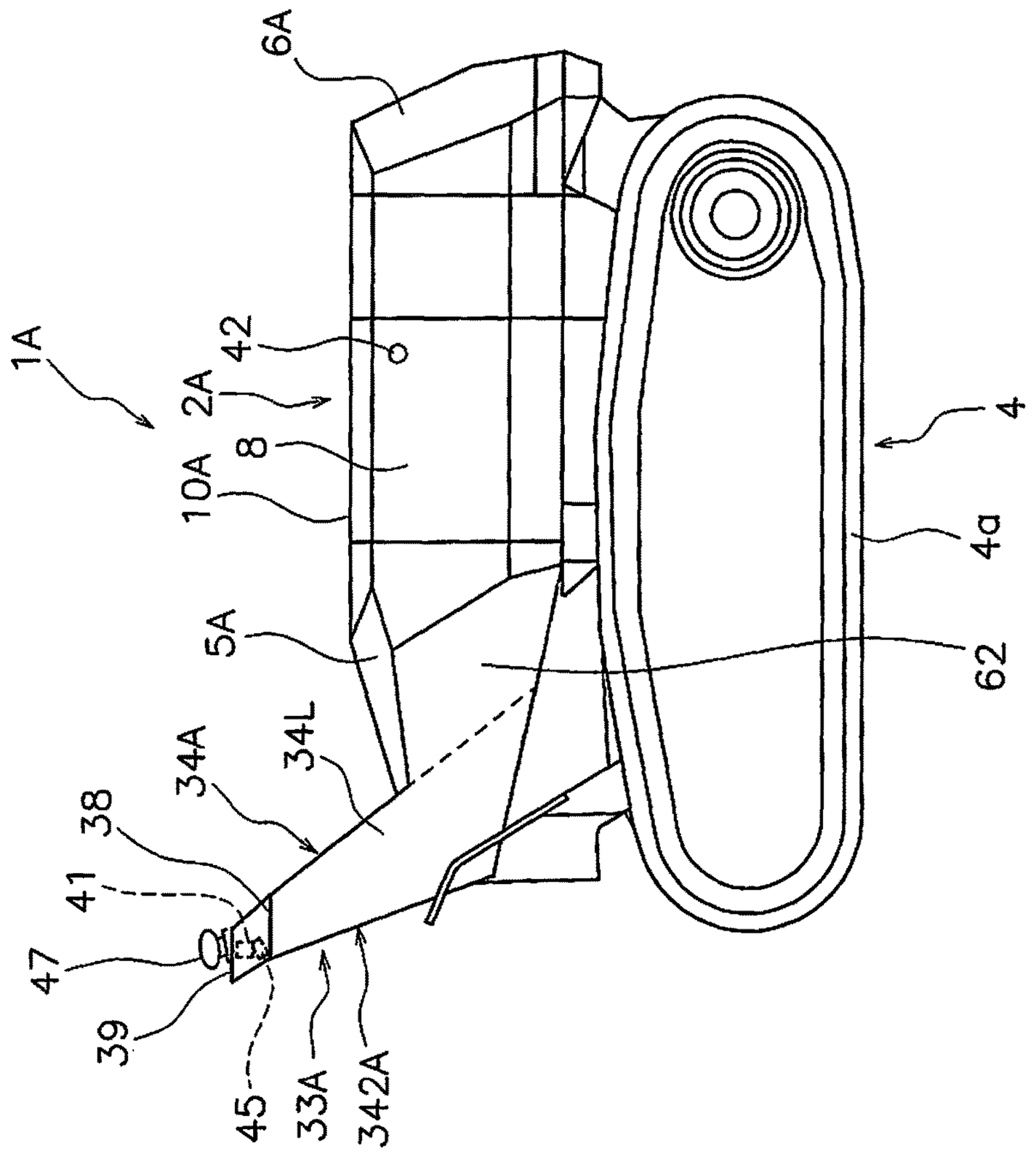

FIG. 24

WORK VEHICLE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a U.S. National stage application of International Application No. PCT/JP2016/054469, filed on Feb. 16, 2016. This U.S. National stage application claims priority under 35 U.S.C. § 119(a) to Japanese Patent Application No. 2015-033294, filed in Japan on Feb. 23, 2015 and to Japanese Patent Application No. 2015-208832, filed in Japan on Oct. 23, 2015, the entire contents of which are hereby incorporated herein by reference.

BACKGROUND

Field of the Invention

The present invention relates to a work vehicle.

Description of the Related Art

A work vehicle includes an actuator for driving a work implement. For example, a pair of left and right lift cylinders are provided on both sides of a vehicle body for causing a work implement to move up and down (see Japanese Patent Laid-open No. 2007-077722).

SUMMARY

However, when the work implement is used for carrying out work, such as excavating, the load applied to the work implement is transmitted to the vehicle body of the work vehicle through the lift cylinders. When the pair of lift cylinders are disposed away from each other to the left and right, different loads of different sizes may be applied to the vehicle body from each of the lift cylinders.

In order to improve the load balance, a lift cylinder may be disposed in the center of the work vehicle. However, in this case, it is difficult to recognize a region in front of the work vehicle due to the lift cylinder.

An object of the present invention is to provide a work vehicle in which it is possible to easily recognize the conditions of a region in front of the work vehicle and in which it is possible to improve the balance of the load applied to the vehicle body from the work implement.

A work vehicle according to a first aspect of the present invention includes a vehicle body, a work implement, a lift cylinder, an imaging device, and a supporting member. The work implement is disposed in front of the vehicle body. The lift cylinder is attached to a center part of a vehicle body in the vehicle width direction. The lift cylinder causes the work implement to move up and down. The supporting member is attached to the center part of the vehicle body in the vehicle width direction and extends upward from the vehicle body. The imaging device is supported by the supporting member and captures images of a region in front of the vehicle body. A penetrating part is formed in the supporting member. The lift cylinder is disposed through the penetrating part.

In the work vehicle according to the first aspect, images of the region in front of the vehicle body can be captured by the imaging device. As a result, the conditions of the region in front of the vehicle body can be easily recognized. Further, the lift cylinder is attached to the center part of a vehicle body in the vehicle width direction. As a result, the balance of the load applied to the vehicle body from the work implement can be improved in comparison to when a pair of lift cylinder are disposed away from each other to the left and right.

The operator of the work vehicle is able to recognize the conditions in front of the work vehicle due to the images captured by the imaging device. As a result, there is no problem with a decrease in forward visibility even when the lift cylinder and the supporting member are attached to the center part of the vehicle body in the vehicle width direction. Furthermore, the lift cylinder is disposed in the penetrating part of the supporting member. As a result, interference of the lift cylinder with regard to the supporting member is avoided and the supporting member and the lift cylinder can be disposed in a compact manner.

The vehicle body may have a mounting member. The lift cylinder may be attached to the mounting member. The supporting member may be attached to the mounting member. In this case, the supporting member and the lift cylinder can be disposed in a compact manner. Further, the supporting member can be firmly supported.

The vehicle body may have a universal joint for supporting the lift cylinder so as to allow rotational movement to the front and rear and to the left and right. The supporting member may be attached to the mounting member via the universal joint. In this case, the movements of the lift cylinder are absorbed by the universal joint. As a result, the load applied to the vehicle body from the lift cylinder can be reduced even further.

The supporting member may have a pillar part that extends upward from the vehicle body, and a holding part that extends toward the front from the pillar part. The imaging device may have a work implement imaging device supported by the holding part. In this case, the conditions in front of the work implement can be recognized easily due to the work implement imaging device capturing images of the region in front of the work implement.

A work vehicle according to a second aspect of the present invention includes a vehicle body, a work implement, a lift cylinder, an imaging device, and a supporting member. The work implement is disposed in the front of the vehicle body. The lift cylinder is attached to a center part of a vehicle body in the vehicle width direction. The lift cylinder causes the work implement to move up and down. The supporting member is attached to the center part of the vehicle body in the vehicle width direction and extends upward from the vehicle body. The imaging device is supported by the supporting member and captures images of a region in front of the vehicle body. A penetrating part is formed in the supporting member. The lift cylinder is disposed through the penetrating part.

The supporting member has a pillar part that extends upward from the vehicle body, and a first beam part that extends in the vehicle width direction form the pillar part. The penetrating part is formed by the pillar part and the first beam part. The lift cylinder is disposed through the penetrating part.

In the work vehicle according to the second aspect, images of the region in front of the vehicle body can be captured by the imaging device. As a result, the conditions of the region in front of the vehicle body can be easily recognized. Further, the lift cylinder is attached to the center part of the vehicle body in the vehicle width direction. As a result, the balance of the load applied to the vehicle body from the work implement can be improved in comparison to when a pair of lift cylinder are disposed away from each other to the left and right.

The operator of the work vehicle is able to recognize conditions in front of the work vehicle due to the images captured by the imaging device. As a result, there is no problem with a decrease in forward visibility even if the lift cylinder is attached to the center part of the vehicle body in the vehicle width direction. Furthermore, the lift cylinder is disposed in the penetrating part of the supporting member. As a result, interference of the lift cylinder on the supporting member is avoided.

The imaging device may have a work implement imaging device supported by the first beam part. In this case, the conditions in front of the work implement can be recognized easily due to the work implement imaging device capturing images of the region in front of the work implement.

The vehicle body in the work vehicle of either of the first aspect or the second aspect may have a mounting member. The lift cylinder may be attached to the mounting member. The supporting member may be attached to the mounting member in the work vehicle of the first aspect. In this case, the supporting member and the lift cylinder can be disposed in a compact manner. Further, the supporting member can be firmly supported.

The vehicle body in the work vehicle of either of the first aspect or the second aspect may have a universal joint for supporting the lift cylinder so as to allow rotational movement to the front and rear and to the left and right. The supporting member may be attached to the mounting member via the universal joint. In this case, the movements of the lift cylinder are absorbed by the universal joint. As a result, the load applied to the vehicle body from the lift cylinder can be reduced even further.

The front surface of the pillar part in the work vehicle of either of the first aspect or the second aspect may be inclined toward the front and upward from the vehicle body. In this case, the mobility range of the work implement disposed in front of the pillar part can be increased.

The holding part in the work vehicle of the first aspect may have a shape that is tapered toward the front. As a result, the load of the supporting member on an attachment part of the vehicle body can be reduced.

The work vehicle of the second aspect may further include a headlight supported by the first beam part. As a result, work efficiency can be improved at night or in dark areas.

The work vehicle of the second aspect may further include a rotating lamp. The supporting member may have a second beam part that extends from a right pillar part and a left pillar part to the inside in the vehicle width direction above the first beam part. The rotating lamp may be supported by the second beam part. As a result, the visibility of the rotating lamp is improved because the rotating lamp is disposed in a high position.

The upper end of the rotating lamp may be positioned higher than the upper end of the lift cylinder. As a result, the visibility of the rotating lamp is improved because the rotating lamp is not shielded by the lift cylinder.

The vehicle body in the work vehicle of either of the first aspect or the second aspect may have a universal joint and a mounting member. The universal joint supports the lift cylinder so as to allow rotational movement to the front and rear and to the left and right. The mounting member has the lift cylinder attached thereto via the universal joint. In this case, the movements of the lift cylinder are absorbed by the universal joint. As a result, the load applied to the vehicle body from the lift cylinder can be reduced even further.

The imaging device in either of the work vehicle of the first aspect or the second aspect may have a front imaging device disposed in front of the lift cylinder. In this case, the conditions of the region in front of the lift cylinder can be recognized easily.

The lift cylinder may overlap the supporting member as seen in a side view of the vehicle in the either of the work vehicle of the first aspect or the second aspect. In this case, the supporting member and the lift cylinder can be disposed in a compact manner.

The work vehicle may further include a communication device and a controller in the work vehicle of either of the first aspect or the second aspect. The communication device communicates with an external remote operating device. The communication device transmits image data captured by the imaging device to the remote operating device. The communication device receives operation signals for operating the work vehicle from the remote operating device. The controller controls the work vehicle on the basis of the operation signals from the remote operating device.

In this case, the operator of the work vehicle is able to remotely operate the work vehicle with the remote operating device while viewing the images captured by the imaging device.

According to the present invention, a work vehicle can be provided in which it is possible to easily recognize conditions of a region in front of the work vehicle and in which it is possible to improve the balance of the load applied to the vehicle body from the work implement.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view of a work vehicle according to a first exemplary embodiment.

FIG. **2** is a side view of the work vehicle according to the first exemplary embodiment.

FIG. **3** is a plan view of the work vehicle according to the first exemplary embodiment.

FIG. **4** is a block diagram illustrating a control system of the work vehicle.

FIG. **5** is a block diagram illustrating a configuration and a processing flow for generating a display image.

FIG. **6** is a rear perspective view of a supporting member according to the first exemplary embodiment.

FIG. **7** is a front perspective view of the supporting member according to the first exemplary embodiment.

FIG. **8** is a front perspective view illustrating the structure in the vicinity of the supporting member and the lift cylinder according to the first exemplary embodiment.

FIG. **9** is a rear perspective view illustrating the structure in the vicinity of the supporting member and the lift cylinder according to the first exemplary embodiment.

FIG. **10** is a cross-sectional view of the supporting member and the lift cylinder according to the first exemplary embodiment.

FIG. **11** is a perspective view of a joint body.

FIG. **12** is a perspective view illustrating actual conditions of the work vehicle.

FIGS. **13**A-**13**D illustrate examples of images captured by a surroundings imaging device mounted on the work vehicle illustrated in FIG. **4**.

FIG. **14** illustrates an example of a surroundings composite image.

FIG. **15** illustrates an example of an image at the front of a work implement.

FIG. **16** is a perspective view illustrating actual conditions of the work vehicle.

FIG. **17** illustrates processing for generating a work implement composite image.

FIG. **18** illustrates an example of a display image.

FIG. **19** is a perspective view of the work vehicle according to a second exemplary embodiment.

FIG. **20** is a side view of the work vehicle according to the second exemplary embodiment.

FIG. **21** is a plan view of the work vehicle according to the second exemplary embodiment.

FIG. **22** is an enlarged perspective view in the vicinity of the upper end of the supporting member according to the second exemplary embodiment.

FIG. **23** is a side view of the work vehicle according to a first modified example.

FIG. **24** is a side view of the work vehicle according to a second modified example.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

First Exemplary Embodiment

The following is a description of a work vehicle according to the present exemplary embodiment with reference to the drawings. FIG. **1** is a perspective view of a work vehicle **1** according to the first exemplary embodiment. FIG. **2** is a side view of the work vehicle **1** according to the present exemplary embodiment. FIG. **3** is a plan view of the work vehicle **1** according to the present exemplary embodiment. The work vehicle **1** is a bulldozer according to the present exemplary embodiment. The work vehicle **1** is a vehicle that is not provided with an operator's cab. As discussed below, the work vehicle **1** can be operated remotely. The work vehicle **1** includes a vehicle body **2** and a work implement **3**.

The vehicle body **2** has a travel device **4** and an engine compartment **5**. The travel device **4** is a device for causing the work vehicle **1** to travel. The travel device **4** has crawler belts **4***a* and **4***b*. The crawler belt **4***a* is mounted on the left side part of the vehicle body **2**. The crawler belt **4***b* is mounted on the right side part of the vehicle body **2**. The work vehicle **1** travels due to the crawler belts **4***a* and **4***b* being driven.

The front signifies the direction in which the lift cylinder is disposed on the vehicle body **2** in the present exemplary embodiment, and the rear signifies the opposite direction. Left and right signify the left and right directions when facing the above-mentioned direction toward the front.

The engine compartment **5** is disposed on a front part of the vehicle body **2**. An engine **11** (see FIG. **4**) is disposed inside the engine compartment **5**.

The vehicle body has a rear compartment **6**, a right compartment **7**, and a left compartment **8**. The engine compartment **5**, the rear compartment **6**, the right compartment **7**, and the left compartment **8** are disposed so as to surround a maintenance area MA. The engine compartment **5** is disposed in front of the maintenance area MA. The rear compartment **6** is disposed behind the maintenance area MA. The right compartment **7** is disposed to the right of the maintenance area MA. The left compartment **8** is disposed to the left of the maintenance area MA.

For example, the rear compartment **6** is a fuel tank. The rear compartment **6** may be configured to house the fuel tank. A cooling device, such as a radiator, is disposed in the right compartment **7**. A hydraulic fluid tank is disposed in the left compartment **8**. However, the items housed in the compartments **6-8** are not limited to the above items and may be changed.

A lid member **10** is disposed above the maintenance area MA. The lid member **10** is disposed so as to be able to open and close the maintenance area MA. The lid member **10** is depicted while open in FIG. **1** and the lid member **10** is depicted while closed in FIGS. **2** and **3**.

Doors (not illustrated) for opening and closing the engine compartment and the right compartment **7** are provided facing the maintenance area MA on the engine compartment **5** and on the right compartment **7**. A worker is able to access the inside of the engine compartment **5** or the inside of the right compartment **7** from the maintenance area MA by opening the door on the engine compartment **5** or on the right storing part **7**.

The work implement **3** is disposed in front of the vehicle body **2**. The work implement **3** is disposed in front of the engine compartment **5**. In the present exemplary embodiment, the work implement **3** is a blade. The work implement **3** is supported by a left arm **14** and a right arm **15**. The left arm **14** is mounted on a left side part of the vehicle body **2**. The right arm **15** is mounted on a right side part of the vehicle body **2**.

A left tilt cylinder **16**, a right tilt cylinder **17**, and a lift cylinder **18** are attached to the work implement **3**. The left tilt cylinder **16** is attached to the left side part of the vehicle body **2**. The right tilt cylinder **17** is attached to the right side part of the vehicle body **2**. The left tilt cylinder **16** and the right tilt cylinder **17** are driven by hydraulic fluid from a hydraulic pump **12**. The left tilt cylinder **16** and the right tilt cylinder **17** cause the work implement **3** to move to the left or right.

The lift cylinder **18** is attached to the center part of the vehicle body **2** in the vehicle width direction. The lift cylinder **18** is attached to the vehicle body **2** while being inclined in the front-back direction of the vehicle body **2**. Only one lift cylinder **18** is provided in the work vehicle **1**. The lift cylinder **18** is disposed in front of the engine compartment **5**. The lift cylinder **18** is disposed behind the work implement **3**. The lift cylinder **18** is driven by hydraulic fluid from the hydraulic pump **12**. The lift cylinder **18** causes the work implement **3** to move up and down.

The work vehicle **1** includes a ripper device **31**. The ripper device **31** is disposed behind the vehicle body **2**. The ripper device **31** is attached to the vehicle body **2**. The ripper device may be omitted.

FIG. **4** is a block diagram of a control system of the work vehicle **1**. As illustrated in FIG. **4**, the work vehicle **1** has the hydraulic pump **12** and a pump displacement controller **19**. The hydraulic pump **12** is driven by the engine **11** to discharge hydraulic fluid. The hydraulic pump **12** is a variable displacement pump and the pump displacement controller **19** controls the discharge displacement of the hydraulic pump **12**.

The work vehicle **1** has a work implement control valve **20** and a hydraulic actuator **21**. The hydraulic actuator **21** is driven by hydraulic fluid discharged from the hydraulic pump **12**. For example, the hydraulic actuator **21** includes the above-mentioned lift cylinder **18** and the left and right tilt cylinders **16** and **17**. The work implement control valve **20** controls the supply and exhaust of the hydraulic fluid to and from the hydraulic actuator **21**.

The work vehicle **1** has a power transmission device **13** and a clutch control valve **22**. The power transmission device **13** includes, for example, a transmission and a torque converter. The clutch control valve **22** controls the switching of a speed change clutch, a forward/reverse travel clutch, and a steering clutch and the like included in the power transmission device **13**.

The work vehicle **1** has an imaging device **23**. The imaging device **23** acquires images of the surroundings of the work vehicle **1**. The imaging device is described in detail below.

The work vehicle **1** includes a vehicle controller **24** and a communication device **25**. The communication device **25** is connected to an antenna **99** (see FIG. **1**) mounted on the vehicle body **2**. The communication device **25** carries out wireless communication with a communication device **27** of a remote operating device **26**. For example, the remote operating device **26** is disposed inside a management center away from the work site where the work vehicle **1** is used. Alternatively, the remote operating device **26** may be portable and may be disposed at the work site.

The vehicle controller **24** is configured with a computation device, such as a CPU, and a memory, such as a RAM or a ROM, or with a storage device, such as a hard disk. The vehicle controller **24** is programmed to control the work vehicle **1** on the basis of operation signals from the remote operating device **26**. Moreover, the vehicle controller **24** acquires image data acquired by the imaging device **23** through a wire or wirelessly. The vehicle controller **24** transmits the image data captured by the imaging device **23** to the communication device **27** of the remote operating device **26** via the communication device **25**.

The remote operating device **26** has a remote controller **28** and an operating unit **29**. The remote controller **28** is configured with a computation device, such as a CPU, and a memory such, as a RAM or a ROM, or with a storage device, such as a hard disk.

The operating member **29** is operated by an operator for operating the work vehicle **1**. For example, the operating unit **29** includes an acceleration operating device for adjusting the output of the engine **11**. The operating unit **29** includes a work implement operating device for operating the work implement **3**. The operating unit **29** includes a steering operating device for changing the traveling direction of the work vehicle **1** to the right and left. The remote controller **28** transmits operation signals indicating the operating contents from the operating unit **29** to the communication device **25** of the work vehicle **1** via the communication device **27**.

The remote operating device **26** has a display device **30**. The display device **30** is configured with a display, such as a CRT, an LCD, an OELD, or the like. However, the display device **30** is not limited to the afore-mentioned displays and may be another type of display.

The communication device **27** of the remote operating device **26** receives the image data captured by the imaging device **23** from the communication device **25** of the work vehicle **1**. The remote controller **28** is programmed to generate a display image indicating the surroundings of the work vehicle **1** and display the display image on the display device **30** on the basis of the image data captured by the imaging device **23**.

The operator operates the operating unit **29** while viewing the display image. As a result, the operation signals are transmitted from the communication device **27** of the remote operating device **26** and the communication device **25** of the work vehicle **1** receives the operation signals from the remote operating device **26**. The vehicle controller **24** controls the above-mentioned engine **11**, the pump displacement controller **19**, the work implement control valve **20**, and the clutch control valve **22** and the like on the basis of the operation signals. As a result, the operator is able to operate the work vehicle **1** remotely.

Next, a configuration and processing for generating the display image will be explained in detail. FIG. **5** is a block diagram illustrating a configuration and a processing flow for generating the display image. As illustrated in FIG. **5**, the imaging device **23** mounted on the work vehicle **1** has a surroundings imaging device **40** and a work implement imaging device **45**. The surroundings imaging device **40** captures images of the surroundings of the vehicle body **2**. That is, the surroundings imaging device **40** captures images of the regions in the front and back and left and right of the vehicle body **2**. The work implement imaging device **45** captures images of the region in front of the work implement **3** and of the work implement **3**.

Specifically, the surroundings imaging device **40** includes a front imaging device **41**, a left imaging device **42**, a right imaging device **43**, and a rear imaging device **44**. A camera mounted with a fish-eye lens, for example, may be used as the front imaging device **41**, the left imaging device **42**, the right imaging device **43**, and the rear imaging device **44**. As illustrated in FIG. **2**, the front imaging device **41** is attached to the supporting member **33**. The front imaging device **41** is disposed in front of the lift cylinder **18**. The front imaging device **41** captures images in front of the vehicle body **2**. The left imaging device **42** is attached to a left side part of the vehicle body **2**. The left imaging device **42** captures images to the left of the vehicle body **2**. As illustrated in FIG. **3**, the right imaging device **43** is attached to a right side part of the vehicle body **2**. The right imaging device **43** captures images to the right of the vehicle body **2**. The rear imaging device **44** is attached to a rear part of the vehicle body **2**. The rear imaging device **44** captures images behind the vehicle body **2**.

The work implement imaging device **45** is a camera including a lens with a normal angle of view. The work implement imaging device **45** is disposed above the work implement **3**. Specifically, the work implement imaging device **45** is disposed higher than the upper end of the work implement **3**. The work implement imaging device **45** is disposed higher than the front imaging device **41**. The work implement imaging device **45** is disposed forward of the front imaging device **41**. The work implement imaging device **45** is supported by the supporting member **33**.

The front imaging device **41** and the work implement imaging device **45** are attached to the supporting member **33**. The supporting member **33** is attached to a front part of the vehicle body **2**. The supporting member **33** is attached to a center part of the vehicle body **2** in the vehicle width direction. The supporting member **33** is formed with a bent metal plate. The supporting member **33** has a pillar part **34** and a holding part **35**.

The pillar part **34** extends upward from the vehicle body **2**. The pillar part **34** has a shape that is tapered upward. The pillar part **34** is disposed in front of the engine compartment **5**. The pillar part **34** is disposed behind the work implement **3**. The front imaging device **41** is attached to the pillar part **34**. The front imaging device **41** is attached to the front surface of the pillar part **34**.

The holding part **35** extends toward the front from the pillar part **34**. The holding part **35** is positioned above the work implement **3**. The holding part **35** has a shape that is tapered toward the front. The holding part **35** supports the work implement imaging device **45**. The work implement imaging device **45** is attached to the tip end part of the holding part **35**. Specifically, the work implement imaging device **45** is attached to the lower surface of the tip end part of the holding part **35**.

FIGS. **6** and **7** are perspective views of the supporting member **33**. As illustrated in FIG. **6**, a penetrating part **341** is formed on the back surface of the pillar part **34**. The penetrating part **341** has a shape that is recessed toward the front. The penetrating part **341** extends in the up-down direction and penetrates the supporting member **33** in the up-down direction.

As illustrated in FIG. **2**, a front surface **342** of the pillar part **34** is inclined toward the front and upward from the vehicle body **2**. A recessed part **343** is formed on the lower part of the front surface **342** of the pillar part **34**. The recessed part **343** has a shape that is recessed upward. The penetrating part **341** communicates with the recessed part **343**.

FIGS. **8** and **9** are perspective views of the supporting member **33** and the lift cylinder **18**. FIG. **10** is a cross-sectional view of the supporting member **33**. As illustrated in FIGS. **9** and **10**, the lift cylinder **18** is disposed in the penetrating part **341**. As a result, the lift cylinder **18** overlaps the pillar part **34** as seen in a side view of the vehicle as illustrated in FIG. **2**. The lift cylinder **18** passes through the penetrating part **341** and protrudes upward from the supporting member **33**. The lift cylinder **18** passes through the penetrating part **341** and protrudes downward from the supporting member **33**.

As illustrated in FIGS. **8** and **10**, the vehicle body **2** has a mounting member **36** and a universal joint **37**. The mounting member **36** is disposed in front of the engine compartment **5**. The mounting member **36** is coupled to a vehicle body frame that is not illustrated inside the vehicle body **2**. The mounting member **36** has the lift cylinder **18** attached thereto via the universal joint **37**. The pillar part **34** of the supporting member **33** is attached to the mounting member **36**. The pillar part **34** is disposed on the mounting member **36**. A bottom part of the pillar part **34** is attached to the mounting member **36**.

The universal joint **37** supports the lift cylinder **18** so as to allow rotational movement to the front and rear and to the left and right. The universal joint **37** is disposed in the recessed part **343**. The universal joint **37** has a joint body **51**, a left shaft bearing part **52**, a right shaft bearing part **53**, a front shaft bearing part **54**, and a rear shaft bearing part **55**.

FIG. **11** is a perspective view of the joint body **51**. As illustrated in FIG. **11**, the joint body **51** has an opening **511**. The opening **511** penetrates the joint body **51** in the up-down direction. The lift cylinder **18** passes through the opening **511**. The joint body **51** has a left rotating shaft part **512** and a right rotating shaft part **513**. The left rotating shaft part **512** and the right rotating shaft part **513** are disposed with a gap therebetween in the vehicle width direction. The opening **511** is disposed between the left rotating shaft part **512** and the right rotating shaft part **513**. The left rotating shaft part **512** and the right rotating shaft part **513** extend in the vehicle width direction. The left rotating shaft part **512** is supported in a manner that allows rotation on the left shaft bearing part **52**. The right rotating shaft part **513** is supported in a manner that allows rotation on the right shaft bearing part **53**. As a result, the lift cylinder **18** is supported by the universal joint **37** so as to allow rotational movement to the front and rear.

The joint body **51** has a front attachment part **514** and a rear attachment part **515**. The front attachment part **514** and the rear attachment part **515** are disposed so as to have a gap therebetween in the front-back direction. The opening **511** is disposed between the front attachment part **514** and the rear attachment part **515**. The front shaft bearing part **54** is attached to the front attachment part **514**. As illustrated in FIGS. **8** and **10**, the front shaft bearing part **54** supports, in a manner that allows rotation, a front rotating shaft part **181** provided on the lift cylinder **18**. The front rotating shaft part **181** protrudes toward the front from the lift cylinder **18**. The rear shaft bearing part **55** is attached to the rear attachment part **515**. As illustrated in FIGS. **9** and **10**, the rear shaft bearing part **55** supports, in a manner that allows rotation, a rear rotating shaft part **182** provided on the lift cylinder **18**. The rear rotating shaft part **182** protrudes toward the rear from the lift cylinder **18**. As a result, the lift cylinder **18** is supported by the universal joint **37** so as to allow rotational movement to the right and left.

Next, a processing for generating the display image will be explained in detail. First, image capturing is carried out by the imaging devices **41**-**45**. The vehicle controller **24** acquires image data of the surroundings of the vehicle body **2** from the surroundings imaging device **40**. That is, as illustrated in FIG. **5**, the vehicle controller **24** acquires a front image Im**1**, a left image Im**2**, a right image Im**3**, and a rear image Im**4**, respectively, from the front imaging device **41**, the left imaging device **42**, the right imaging device **43**, and the rear imaging device **44**.

The front image Im**1** is an image toward the front of the vehicle body **2**. The left image Im**2** is an image in the leftward direction of the vehicle body **2**. The right image Im**3** is an image in the rightward direction of the vehicle body **2**. The rear image Im**4** is an image toward the rear of the vehicle body **2**.

Moreover, the vehicle controller **24** acquires image data of the region in front of the work implement **3** from the work implement imaging device **45**. That is, the vehicle controller **24** acquires a work implement front image Im**5** from the work implement imaging device **45**. The work implement front image Im**5** is an image toward the front of the work implement **3** including the work implement **3**.

The vehicle controller **24** sends the front image Im**1**, the left image Im**2**, the right image Im**3**, the rear image Im**4**, and the work implement front image Im**5** to the remote controller **28** via the communication device **25**.

The remote controller **28** generates a surroundings composite image Is**1** from the images Im**1** to Im**4** captured by the surroundings imaging device **40**. The surroundings composite image Is**1** is an image depicting the surroundings of the work vehicle **1** from a bird's eye view, and is synthesized with a vehicle model M**1** (FIG. **14**). The vehicle model M**1** is a model indicating the shape of the work vehicle **1**.

The remote controller **28** generates a work implement composite image Is**2** from the work implement front image Im**5** captured by the work implement imaging device **45**. The work implement composite image Is**2** is an image indicating an area to the front of the work implement **3**, and is synthesized with the vehicle model M**1** and the surroundings composite image Is**1**.

FIG. **12** is a perspective view illustrating actual conditions of the work vehicle **1**. FIG. **13** illustrates examples of images captured by the surroundings imaging device **40** mounted on the work vehicle **1** in the state depicted in FIG. **12**. Specifically, FIG. **13**A is the front image Im**1** captured by the front imaging device **41**. FIG. **13**B is the left image Im**2** captured by the left imaging device **42**. FIG. **13**C is the right image Im**3** captured by the right imaging device **43**. FIG. **13**D is the rear image Im**4** captured by the rear imaging device **44**.

As illustrated in FIG. **14**, the remote controller **28** generates the surroundings composite image Is**1** by projecting the images captured by the surroundings imaging device **40** onto a first projection plane A**1**. FIG. **14** illustrates an example of the surroundings composite image Is**1** generated by the remote controller **28**.

The first projection plane A1 has a hemispherical curved surface A11 that encloses the vehicle model M1, and a flat surface A12 corresponding to the ground surface. The vehicle model M1 is disposed on the flat surface A12. Although not illustrated in the drawings, the first projection plane A1 has a mesh structure and the remote controller **28** generates the surroundings composite image Is1 by projecting the images captured by the surroundings imaging device **40** onto the first projection plane A1 by texture mapping.

As illustrated in FIG. **14**, the front image Im1, the left image Im2, the right image Im3, and the rear image Im4 are projected onto the first projection plane A1 and synthesized as the surroundings composite image Is1 of the vehicle model M1. However, because an image of the rear part of the work implement **3** (see FIG. **13**(A)) is photographed in the front image Im1, the portion in front of the work implement **3** including the front surface of the work implement **3** becomes a blind spot. As a result, an image Imw (diagonal line hatched portion in FIG. **14**) in front of the work implement **3** is omitted or not displayed accurately in the surroundings composite image Is1 as illustrated in FIG. **14**.

FIG. **15** illustrates an example of the work implement front image Im5 captured by the work implement imaging device **45**. As illustrated in FIG. **15**, the work implement front image Im5 includes an image Ima depicting the front surface of the work implement **3**, and an image Imb depicting the ground surface located in front of the work implement **3**. When the actual work vehicle **1** is carrying a work object X, such as sand and dirt as illustrated in FIG. **16**, an image Imx depicting the work object X as illustrated in FIG. **15** is included in the work implement front image Im5.

The remote controller **28** generates the work implement composite image Is2 by projecting the work implement front image Im5 captured by the work implement imaging device **45** onto a second projection plane A2 as illustrated in FIG. **17**. The second projection plane A2 is disposed in the front surface of the work implement **3** of the vehicle model M1 and on the ground surface located in front of the work implement **3** of the vehicle model M1.

The display device **30** displays a display image Is. FIG. **18** illustrates an example of the display image Is. As illustrated in FIG. **18**, the display image Is displays the work vehicle **1** and the surroundings thereof in a three-dimensional manner as seen diagonally from in front and from above. The display image Is includes the vehicle model M1, the surroundings composite image Is1, and the work implement composite image Is2 generated as described above. Specifically, the condition of the surroundings of the work vehicle **1** captured by the surroundings imaging device **40** is displayed as the surroundings composite image Is1 of the surroundings of the vehicle model M1 in the display image Is. Further, the condition of the front of the work implement **3** captured by the work implement imaging device **45** is displayed on the front surface of the work implement **3** of the vehicle model M1 and on the ground surface therebelow as the work implement composite image Is2. The display image Is is updated in real time and displayed as a video.

The conditions of the surroundings of the work vehicle **1** can be easily recognized by the display image Is in the work vehicle **1** according to the first exemplary embodiment as explained above. In particular, the region in front of the work implement **3** that becomes a blind spot when only using the surroundings imaging device **40** can be captured by the work implement imaging device **45** attached to the holding part **35** of the supporting member **33**. As a result, the condition of the region in front of the work implement **3** can be easily recognized.

The lift cylinder **18** is attached to the center part of the vehicle body **2** in the vehicle width direction. As a result, the load from torsion transmitted from the work implement **3** to the vehicle body **2** can be reduced in comparison to when a pair of lift cylinders are disposed away from each other to the left and right.

The operator of the work vehicle **1** is able to recognize the conditions in front of the work implement **3** due to the display image Is. As a result, there is no problem with a decrease in forward visibility even if the lift cylinder **18** is attached to the center part of the vehicle body **2** in the vehicle width direction.

Furthermore, the lift cylinder **18** is disposed in the penetrating part **341** of the supporting member **33**. As a result, interference of the lift cylinder **18** with regard to the supporting member **33** is avoided and the supporting member **33** and the lift cylinder **18** can be disposed in a compact manner.

The pillar part **34** is attached to the mounting member **36**. Further, the supporting member **33** can be firmly supported. Moreover, the supporting member **33** and the lift cylinder **18** can be disposed in a compact manner. In particular, the lift cylinder **18** is disposed in the penetrating part **341** of the pillar part **34** and the pillar part **34** and the lift cylinder **18** overlap as seen in a side view of the vehicle. As a result, the supporting member **33** and the lift cylinder **18** can be disposed in a compact manner.

The lift cylinder **18** is attached to the mounting member **36** via the universal joint **37**. As a result, the load transmitted from the lift cylinder **18** to the vehicle body **2** due to the rotational movement of the lift cylinder **18** to the front and rear and to the left and right can be further reduced.

The front surface **342** of the pillar part **34** is inclined toward the front and upward from the vehicle body **2**. As a result, the mobility range of the work implement **3** disposed in front of the pillar part **34** can be increased. Consequently, the amount of dirt that can be carried by the work implement **3** during excavation can be increased.

The holding part **35** has a shape that is tapered toward the front. As a result, the load of the supporting member **33** on an attachment part of the vehicle body **2** can be reduced. In other words, the holding part **35** has a shape that becomes thicker toward the rear. As a result, the work implement imaging device **45** can be firmly supported and vibration of the work implement imaging device **45** can be reduced.

Second Exemplary Embodiment

The work vehicle that demonstrates the above effects is not limited to the vehicle according to the first exemplary embodiment. A work vehicle in which the shape of the supporting member **33** in particular is different from that of the first exemplary embodiment will be explained in the second exemplary embodiment. FIG. **19** is a perspective view of a work vehicle **1**A according to the second exemplary embodiment. FIG. **20** is a side view of the work vehicle **1**A according to the second exemplary embodiment. FIG. **21** is a plan view of the work vehicle **1**A according to the second exemplary embodiment. Configurations that are the same as in the first exemplary embodiment will be provided with the same reference numerals and detailed explanations thereof will be omitted in the second exemplary embodiment.

The work vehicle **1**A is a bulldozer according to the present exemplary embodiment. The work vehicle **1**A is a vehicle that is not provided with an operator's cab. The work vehicle **1**A can be operated remotely in the same way as in

the first exemplary embodiment. The work vehicle **1**A includes a vehicle body **2**A and the work implement **3**. The vehicle body **2**A has an engine compartment **5**A instead of the engine compartment **5** of the first exemplary embodiment. The engine compartment **5**A differs from the engine compartment **5** of the first embodiment due to the shape of a cladding member **60** that covers the engine compartment **5**A. A seen from above, the length in the vehicle width direction of the cladding member **60** decreases further toward the front.

As can be seen in FIG. **21**, the cladding member **60** includes a center front part **61**, a left side part **62**, and a right side part **63**. The center front part **61** is a wall part at the front end of the engine compartment **5**A. The center front part **61** corresponds to the center part of the vehicle body **2** in the vehicle width direction to which the lift cylinder **18** is attached. The left side part **62** is located to the rear and on the left side of the center front part **61**. The left side part **62** is, for example, a left side wall that extends to the rear and to the left from the center front part **61** as seen from above. The right side part **63** is located to the rear and on the right side of the center front part **61**. The right side part **63** is, for example, a right side wall that extends to the rear and to the right from the center front part **61** as seen from above. The engine compartment **5**A is the same as the engine compartment **5** of the first exemplary embodiment in other points.

The vehicle body **2**A has a rear compartment **6**A, a right compartment **7**, and the left compartment **8**. The engine compartment **5**A, the rear compartment **6**A, the right compartment **7**, and the left compartment **8** are disposed so as to surround the maintenance area MA. The engine compartment **5**A is disposed in front of the maintenance area MA. The rear compartment **6**A is disposed behind the maintenance area MA.

The rear compartment **6**A is the fuel tank or is configured to house the fuel tank in the present exemplary embodiment. The rear compartment **6**A protrudes further to the rear in comparison to the rear compartment **6** as in the first exemplary embodiment.

A lid member **10**A is disposed above the maintenance area MA. The lid member **10**A is disposed so as to be able to open and close the maintenance area MA. The lid member **10**A is depicted while open in FIG. **1** and the lid member **10**A is depicted while closed in FIGS. **2** and **3**. The lid member **10**A differs from the lid member **10** of the first exemplary embodiment in that the lid member **10**A opens upward and toward the front.

In the second exemplary embodiment, the work vehicle **1**A further includes a headlight **46** and a rotating lamp **47**. The headlight **46**, the rotating lamp **47**, the front imaging device **41**, and the work implement imaging device **45** are attached to a supporting member **33**A. The supporting member **33**A is attached to a front part of the vehicle body **2**A. Specifically, the supporting member **33**A is attached to the left side part **62** and the right side part **63**. The supporting member **33**A is formed from a plate-like member. The supporting member **33**A has a left pillar part **34**L, a right pillar part **34**R, a first beam part **38**, and a second beam part **39**. The left pillar part **34**L and the right pillar part **34**R are collectively referred to as a pillar part **34**A in the second exemplary embodiment.

The left pillar part **34**L and the right pillar part **34**R exhibit left-right symmetry. The left pillar part **34**L extends upward and toward the front from the left side part **62**. The right pillar part **34**R extends upward and toward the front from the right side part **63**. Specifically, the pillar part **34**A extends upward from the vehicle body **2**A. A front surface **342**A of the left pillar part **34**L is inclined toward the front and upward from the vehicle body **2**A as can be seen in FIG. **20**. The front surface of the right pillar part **34**R is inclined in the same way as the left pillar part **34**L toward the front and upward from the vehicle body **2**A. Specifically, the front surface of the pillar part **34**A is inclined toward the front and upward from the vehicle body **2**.

The lift cylinder **18** overlaps the left pillar part **34**L as seen in a side view of the vehicle. Although not illustrated in the drawings, the lift cylinder **18** overlaps the right pillar part **34**R as seen in a side view of the vehicle. That is, the lift cylinder **18** overlaps the pillar part **34**A as seen in a side view of the vehicle. The lift cylinder **18** overlaps the supporting member **33**A as seen in a side view of the vehicle.

As can be seen in FIG. **21**, the left pillar part **34**L extends toward the right (in the direction toward the center in the vehicle width direction of the vehicle body **2**A) while extending toward the front. The right pillar part **34**R extends toward the left (in the direction toward the center in the vehicle width direction of the vehicle body **2**A) while extending toward the front. That is, the pillar part **34**A extends so as to face toward the center in the vehicle width direction of the vehicle body **2**A while extending toward the front. The left pillar part **34**L and the right pillar part **34**R are bent towards the center in the vehicle width direction of the first beam part **38** at the connecting parts with the first beam part **38**. That is, the pillar part **34**A is bent towards the center in the vehicle width direction of the first beam part **38** at the connecting parts with the first beam part **38**. The left pillar part **34**L and the right pillar part **34**R both have a shape that is tapered upward. That is, the pillar part **34**A has a shape that is tapered upward.

The left pillar part **34**L and the right pillar part **34**R are disposed on the front side of the engine compartment **5**A. That is, the pillar part **34**A is disposed on the front side of the engine compartment **5**A. The left pillar part **34**L and the right pillar part **34**R are disposed behind the work implement **3**. That is, the pillar part **34**A is disposed behind the work implement **3**.

The first beam part **38** is connected to the left pillar part **34**L and the right pillar part **34**R and extends from the left pillar part **34**L and the right pillar part **34**R inwardly in the vehicle width direction. That is, the first beam part **38** extends in the vehicle width direction from the pillar part **34**A. As can be seen in FIG. **19**, the supporting member **33**A forms a penetrating part **341**A due to the left pillar part **34**L, the right pillar part **34**R, and the first beam part **38**. The lift cylinder **18** is disposed through the penetrating part **341**A.

The first beam part **38** is positioned above the work implement **3**. The first beam part **38** supports the front imaging device **41**, the work implement imaging device **45**, and the headlight **46**. FIG. **22** is an enlarged perspective view in the vicinity of the upper end of the supporting member **33**A according to the second exemplary embodiment. The illustration of the engine compartment **5**A behind the supporting member **33**A is omitted in FIG. **22**. As can be seen in FIG. **22**, the front imaging device **41** and the work implement imaging device **45** are disposed in a line vertically in the center in the vehicle width direction of the first beam part **38**. Specifically, the work implement imaging device **45** is disposed directly above the first beam part **38** and the front imaging device **41** is disposed directly above the work implement imaging device **45**.

The front imaging device **41** may be a camera having a fish-eye lens mounted thereon; however, a camera provided with a lens having a normal angle of view may also be used. The optical axis of the front imaging device **41** is oriented

toward the front and slightly downward. The work implement imaging device **45** is a camera including a lens with a normal angle of view. The optical axis of the work implement imaging device **45** is oriented further downward than the optical axis of the front imaging device **41**. The work implement imaging device **45** and the front imaging device **41** are disposed in front of the lift cylinder **18**.

The headlight **46** is disposed to the side of the front imaging device **41** and the work implement imaging device **45**. In the example in FIG. **22**, three headlights **46** are disposed on both the left and right of the front imaging device **41** and the work implement imaging device **45**; however the number of the headlight **46** is not limited in this way.

The second beam part **39** is connected to the upper ends of the left pillar part **34**L and the right pillar part **34**R. That is, the second beam part **39** is connected to the upper end of the pillar part **34**A. The second beam part **39** extends within the vehicle width direction from the upper ends of the left pillar part **34**L and the right pillar part **34**R above the first beam part **38**. That is, the second beam part **39** extends in the vehicle width direction from the upper end of the pillar part **34**A above the first beam part **38**. The second beam part **39** supports the rotating lamp **47**. The rotating lamp **47** is disposed on the second beam part **39**. Therefore, the upper end of the rotating lamp **47** is positioned higher than the upper end of the lift cylinder **18** as can be seen with the chain double-dashed line in FIG. **20**. As a result, the rotating lamp **47** is not shielded by the lift cylinder **18**. Therefore, the visibility of the rotating lamp **47** is improved.

The lift cylinder **18** is supported in the second exemplary embodiment by the mounting member **36** and the universal joint **37** in the same way as in the first exemplary embodiment. Therefore, the lift cylinder **18** is attached to the center part of the vehicle body **2** in the vehicle width direction. The lift cylinder **18** is attached to the vehicle body **2** while being inclined in the front-back direction of the vehicle body **2**.

The control system and the processing and the configurations of the display image of the work vehicle **1**A in the second exemplary embodiment are the same as those of the first exemplary embodiment.

The work vehicle **1**A according to the second exemplary embodiment as explained above demonstrates the same effects as the work vehicle **1** according to the first exemplary embodiment. That is, the conditions of the surroundings of the work vehicle **1** can also be easily recognized with the display image Is in the work vehicle **1**A. In particular, the region in front of the work implement **3** that becomes a blind spot when only using the surroundings imaging device **40** can be captured by the work implement imaging device **45** attached to the first beam part **38** of the supporting member **33**A.

Moreover, the lift cylinder **18** is attached to the center part of the vehicle body **2**A in the vehicle width direction. As a result, the load from torsion transmitted from the work implement **3** to the vehicle body **2**A can be reduced in comparison to when a pair of lift cylinders are disposed away from each other to the left and right.

The operator of the work vehicle **1**A is able to recognize the conditions in front of the work implement **3** with the display image Is. As a result, there is no problem with a decrease in forward visibility even if the lift cylinder **18** is attached to the center part of the vehicle body **2**A in the vehicle width direction.

Furthermore, the lift cylinder **18** is disposed in the penetrating part **341**A of the supporting member **33**A. As a result, interference of the lift cylinder **18** on the supporting member **33**A is avoided.

The front surface of the pillar part **34**A is inclined toward the front and upward from the vehicle body **2**A. As a result, the mobility range of the work implement **3** disposed in front of the pillar part **34**A can be increased. Consequently, the amount of dirt that can be carried by the work implement **3** during excavation can be increased.

The pillar part **34**A has a shape that is tapered upwards. As a result, the load of the supporting member **33**A on the attachment parts of the vehicle body **2**A can be reduced. In other words, the pillar part **34**A has a shape that becomes thicker toward the rear. As a result, the front imaging device **41** and the work implement imaging device **45** can be firmly supported and vibration of the front imaging device **41** and the work implement imaging device **45** can be reduced.

Although exemplary embodiments of the present invention have been described, the present invention is not limited to the above exemplary embodiments and various modifications may be made within the scope of the invention.

The work vehicle is not limited to a bulldozer, and may be another type of work vehicle **1**, such as a wheel loader and the like. The work vehicle is not limited to a vehicle that is operated remotely. For example, an operator's cab may be provided on the vehicle body **2** in the same way as a manned work vehicle and a device that is the same as the remote operating device **26** may be provided inside the operator's cab. Consequently, the operator is able to easily operate the work vehicle while viewing the display image.

The method for generating the display image is not limited to the above exemplary embodiments and may be changed. For example, the shapes of the first projection plane **A1** and the second projection plane **A2** may be changed.

The number of the imaging devices of the surroundings imaging device **40** is not limited to four and may be three or less or five or more. The dispositions of the imaging devices of the surroundings imaging device **40** are not limited to the dispositions indicated in the above exemplary embodiments and may be disposed differently. The imaging devices of the surroundings imaging device **40** are not limited to cameras provided with fish-eye lenses and may be another type of imaging device. The front imaging device **41** may be attached to another part and is not limited to the supporting member **33**. For example, the front imaging device **41** may be attached to the vehicle body **2**.

The number of the work implement imaging device **45** is not limited to one and may be two or more. The disposition of the work implement imaging device **45** is not limited to the disposition indicated in the above exemplary embodiments and may be disposed differently.

The structures of the supporting members **33** and **33**A are not limited to the structures of the above exemplary embodiments and may be changed. For example, the pillar part **34** may be attached to a part other than the mounting member **36**. The left pillar part **34**L and the right pillar part **34**R may be attached to positions further inside instead of the side walls of the engine compartment **5**A. The lift cylinder **18** may be attached to the mounting member **36** without the universal joint **37**. The shapes of the pillar part **34**, the left pillar part **34**L, and the right pillar part **34**R may be changed. Alternatively, the shapes of the holding part **35**, the first beam part **38**, and the second beam part **39** may be changed.

As illustrated in FIG. **23**, the work implement **3** (see FIG. **2**) may be removed from the work vehicle **1**. Moreover, the

ripper device **31** (see FIG. **2**) may also be removed from the work vehicle **1**. Similarly, as illustrated in FIG. **24**, the work implement **3** (see FIG. **20**) may be removed from the work vehicle **1**A. Moreover, the ripper device **31** (see FIG. **20**) may also be removed from the work vehicle **1**A.

According to the present invention, a work vehicle can be provided in which it is possible to easily recognize the conditions of a region in front of the work vehicle and in which it is possible to improve the balance of the load applied to the vehicle body from the work implement.

The invention claimed is:

1. A work vehicle comprising:
a vehicle body;
a work implement disposed in front of the vehicle body;
a lift cylinder attached to a center part in a vehicle width direction of the vehicle body such that the lift cylinder is inclined in a front-back direction of the vehicle body, the lift cylinder being configured to move the work implement up and down;
a supporting member attached to the center part of the vehicle body in the vehicle width direction, the supporting member extending upward from the vehicle body; and
an imaging device supported by the supporting member, the imaging device being configured to capture an image of a region in front of the vehicle body,
a penetrating part being formed in the supporting member, and
the lift cylinder being disposed through the penetrating part.

2. The work vehicle according to claim **1**, wherein
the imaging device has a front imaging device disposed in front of the lift cylinder.

3. The work vehicle according to claim **1**, wherein
the supporting member includes
a pillar part extending upward from the vehicle body, and
a holding part extending forward from the pillar part, and
the imaging device has a work implement imaging device supported by the holding part.

4. The work vehicle according to claim **1**, wherein
the vehicle body has a mounting member to which the lift cylinder is attached, and
the supporting member is attached to the mounting member.

5. The work vehicle according to claim **4**, wherein
the vehicle body has a universal joint supporting the lift cylinder to be rotatable in a front and a rear direction and to be rotatable in a left and a right direction, and
the lift cylinder is attached to the mounting member via the universal joint.

6. The work vehicle according to claim **3**, wherein
a front surface of the pillar part is inclined forward and upward from the vehicle body.

7. The work vehicle according to claim **3**, wherein
the holding part has a shape that is tapered forward.

8. The work vehicle according to claim **1**, wherein
the lift cylinder overlaps the supporting member as seen in a side view of the vehicle.

9. The work vehicle according to claim **1**, further comprising
a communication device that communicates with an external remote operating device, the communication device being configured to transmit an image data captured by the imaging device to the remote operating device, and receive an operation signal for operating the work vehicle from the remote operating device; and
a controller configured to control the work vehicle on the basis of the operation signal received from the remote operating device.

10. A work vehicle comprising:
a vehicle body;
a work implement disposed in front of the vehicle body;
a lift cylinder attached to a center part in a vehicle width direction of the vehicle body such that the lift cylinder in a front-back direction of the vehicle body, the lift cylinder being configured to move the work implement up and down;
a supporting member attached to the vehicle body and extending upward from the vehicle body; and
an imaging device supported by the supporting member, the imaging device being configured to capture an image of a region in front of the vehicle body,
the supporting including
a pillar part extending upward from the vehicle body, and
a first beam part extending in the vehicle width direction from the pillar part, and
a penetrating part being formed by the pillar part and the first beam part, and
the lift cylinder being disposed through the penetrating part.

11. The work vehicle according to claim **10**, wherein
the imaging device has a front imaging device disposed in front of the lift cylinder.

12. The work vehicle according to claim **10**, wherein
the imaging device has a work implement imaging device supported by the first beam part.

13. The work vehicle according to claim **10**, wherein
a front surface of the pillar part is inclined forward and upward from the vehicle body.

14. The work vehicle according to claim **10**, further comprising
a headlight supported by the first beam part.

15. A work vehicle according to claim **10**, further comprising
a rotating lamp,
the supporting member having a second beam part extending in the vehicle width direction from the pillar part above the first beam part, and
the rotating lamp being supported by the second beam part.

16. The work vehicle according to claim **10**, wherein
an upper end of the rotating lamp is positioned higher than an upper end of the lift cylinder.

17. The work vehicle according to claim **10**, wherein
the lift cylinder overlaps the supporting member as seen in a side view of the vehicle.

18. The work vehicle according to claim **10**, wherein
the vehicle body includes
a universal joint supporting the lift cylinder to be rotatable in a front and a rear direction and to be rotatable in a left and a right direction; and
a mounting member to which the lift cylinder is attached via the universal joint.

19. The work vehicle according to claim **10**, further comprising
a communication device that communicates with an external remote operating device, the communication device being configured to transmit an image data captured by the imaging device to the remote operating device, and

receive an operation signal for operating the work vehicle from the remote operating device; and

a controller configured to control the work vehicle on the basis of the operation signal received from the remote operating device.

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