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Pile driving apparatus and construction machine

Abstract

A pile driving apparatus is described that is capable of simultaneously pile driving a plurality of piles. The pile driving apparatus includes a main body that travels by a traveling device, a first pile driver that is connected to the main body and performs pile driving along a vertical direction, and a second pile driver that is connected to the main body and performs pile driving along the vertical direction.

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Background/Summary

TECHNICAL FIELD
(1) The present invention relates to a pile driving apparatus and a construction machine, and particularly relates to a pile driving apparatus capable of simultaneously pile driving a plurality of piles and a construction machine capable of reducing greenhouse gases.
BACKGROUND
(2) In related art, improvement of the efficiency of pile driving has been studied. JP Patent Publication No. JP 2015-113668 A discloses that four anchor piles having different pile driving directions are simultaneously pile driven obliquely at a prescribed angle in the ground.
SUMMARY
(3) However, simultaneously pile driving a plurality of piles in the vertical direction has not been disclosed. In a construction site, a large number of piles, that is, several thousands to several tens of thousands of piles are sometimes driven, and efficient pile driving has been desired.
(4) In addition, reduction of greenhouse gases is required worldwide, and construction machines that emit less greenhouse gases are also required for construction machines.
(5) Therefore, an object of the first embodiment and the second embodiment of the invention is to provide a pile driving apparatus capable of simultaneously pile driving a plurality of piles.
(6) In addition, an object of the present third embodiment of the invention is to provide a construction machine that emits less greenhouse gas.
(7) A pile driving apparatus according to the first embodiment includes a main body (also called a main body device) that travels by a traveling device, a first pile driver that is connected to the main body and performs pile driving along a vertical direction, and a second pile driver that is connected to the main body and performs pile driving along the vertical direction.
(8) A pile driving apparatus according to the second embodiment includes a main body that travels by a traveling device, a first pile driver that is connected to the main body and performs pile driving, a second pile driver that is connected to the main body and performs pile driving, and a conveyance unit that is connected to the main body and conveys a component to a pile that is pile driven.
(9) A construction machine according to the third embodiment includes a main body that travels by a traveling device, a power generation device provided on an upper face of the main body, and a vibration power generation element provided in a vicinity of the traveling device.
(10) According to the first embodiment and the second embodiment, because the first pile driver and the second pile driver are provided, it is possible to provide a pile driving apparatus capable of simultaneously pile driving a plurality of piles.
(11) According to the third embodiment of the present invention, it is possible to provide a construction machine that emits less greenhouse gas by using a power generation device and a vibration power generation element.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1**A is a top view of a schematic diagram when a pile driving system according to the first embodiment is at an initial position, and FIG. **1**B is a front view thereof.
(2) FIG. **2**A is a top view of a schematic view illustrating an example when the pile driving system of the first embodiment is at a work position, and FIG. **2**B is a front view thereof.
(3) FIG. **3** is a block diagram of the pile driving system according to the first embodiment.
(4) FIG. **4** is a cross-sectional view of the main body device when a work device is at an initial position.
(5) FIG. **5** is a cross-sectional view of the main body device when the work device is at a work position.

(6) FIG. **6**A is a view illustrating a state in which a chuck is open, and FIG. **6**B is a view illustrating a state in which the chuck is closed.
(7) FIG. **7** is a flowchart related to pile driving performed by a heavy machine control device according to the first embodiment.
(8) FIG. **8**A is a view illustrating movement of a counter mass during an operation of pile driving, FIG. **8**B is a view illustrating a state of gripping a pile during the operation of pile driving, FIG. **8**C is a view illustrating a state of raising the pile during the operation of pile driving, FIG. **8**D is a view illustrating a state in which a direction of the pile is changed during the operation of pile driving, FIG. **8**E is a view illustrating a state of pile driving the pile during the operation of pile driving, and FIG. **8**F is a view illustrating a state in which a component is attached to the pile after the pile driving.
(9) FIG. **9**A is a schematic view of a construction site illustrating a case where a work device is at an initial position, FIG. **9**B is a schematic view of the construction site illustrating a case where a counter mass and a jack are at a work position, and FIG. **9**C is a schematic view of the constructions site illustrating a state where the work device pile drives a pile.
(10) FIG. **10**A is a schematic view of a construction site illustrating a state in which a work device pile drives a pile, FIG. **10**B is a schematic view of the construction site illustrating a state in which a component is attached to the pile, and FIG. **10**C is a schematic view of the construction site illustrating a state in which the pile driving system moves to a next pile driving place.
(11) FIG. **11** is a diagram illustrating a state in which images of a pile driven pile are captured by two drones.
(12) FIG. **12** is a diagram illustrating a state in which a pile driven pile is imaged by one drone.
(13) FIG. **13**A is a diagram illustrating an example in which a pile driving depth mark DM is provided in a lower portion of a pile, and FIG. **13**B is a diagram illustrating an example in which the pile driving depth mark DM is provided in an upper portion of the pile.
(14) FIG. **14** is a schematic diagram illustrating a modification of the pile driving system according to the first embodiment.
(15) FIG. **15** is a schematic diagram of a pile driving system according to the second embodiment.
(16) FIG. **16** is a block diagram of a pile driving system according to the second embodiment.
(17) FIG. **17** is a flowchart regarding solar panel installation executed by a heavy machine control device of the second embodiment.
(18) FIG. **18**A is a view illustrating a state of pile driving during an operation of installing a solar panel, FIG. **18**B is a view illustrating a state of releasing gripping of a pile during the operation, and FIG. **18**C is a view illustrating a state of sucking the solar panel during the operation.
(19) FIG. **19**A is a view illustrating a state of lifting a solar panel during an operation of installing the solar panel, FIG. **19**B is a view illustrating a state of turning during the operation, FIG. **19**C is a view illustrating a state of rotating by 90 degrees during the operation, and FIG. **19**D is a view illustrating a state of installing the solar panel.

DETAILED DESCRIPTION

(20) Hereinafter, a pile driving system **1** according to the first embodiment of the present invention will be described in detail with reference to the accompanying drawings. Note that the present invention is not limited by the embodiments described below.

First Embodiment

(21) FIGS. **1**A and **1**B are schematic diagrams when a pile driving system **1** representing the present embodiment is at an initial position. FIG. **1**A is a top view, and FIG. **1**B is a front view. FIGS. **2**A and **2**B are schematic views illustrating an example when the pile driving system **1** representing the first embodiment is at a work position. FIG. **2**A is a top view, and FIG. **2**B is a front view. As illustrated in these figures, because the present embodiment is a double arm pile driving system **1**, an unbalanced load easily acts in the +X direction in the drawing. In the present embodiment, a position where a work device **50** to be described later is less likely to generate an

unbalanced load (that is, a position where there are few portions extending in the +X direction) is referred to as an initial position, and a position where the work device **50** extends in the +X direction by a series of pile driving operations of the work device **50** is referred to as a work position. FIG. **3** is a block diagram of the pile driving system **1** of the present embodiment. Hereinafter, the configuration of the pile driving system **1** will be described using FIGS. **1**A to **3**.
(22) The pile driving system **1** of the present embodiment includes a base machine **10** (see FIG. **3**), a plurality of pile driving attachments **60**, and an unmanned aerial vehicle (UAV), hereinafter, referred to as a drone **100**, which is an unmanned airplane or unmanned flight vehicle. To simplify the block diagram, FIG. **3** illustrates only a block diagram of one drone **100** and components of one work device **50**. In addition, FIGS. **2**A and **2**B also illustrate only one drone **100** to illustrate the state of the take-off and landing portion.
(23) Further, as is clear from FIGS. **1**A through **2**B, the base machine **10** of the present embodiment is an automated driving type without a driver seat. In the base machine **10**, traveling at a construction site may be performed by automated driving, and the base machine **10** may be carried on a trailer on a public road. In addition, the operation of the base machine **10** may be an automatic operation or a remote operation at a remote place away from the pile driving place.
(24) Base Machine **10**
(25) The base machine **10** of the present embodiment includes a traveling device **20**, a turning device **30**, and a main body device **40**. In addition, the base machine **10** includes two drones **100** that can take-off and land from and on a take-off and landing portion provided on the upper face of the main body device **40**. Note that the number of drones **100** may be one or three or more.
(26) The traveling device **20** includes a pair of crawler belts **22**, which is wound around an idler wheel (not illustrated) and a drive wheel **21**, and drives the pair of crawler belts **22** by the drive wheels **21** to cause the base machine **10** to travel. An engine **23** (see FIG. **3**) of the internal combustion engine constituting the traveling device **20** can be disposed in the main body device **40**. Further, the traveling device **20** may be driven by a battery and a motor instead of the engine **23** of the internal combustion engine, or may be a hybrid type in which the engine **23** of the internal combustion engine and the motor are combined. Note that the traveling device **20** may be a tire type wheel system.
(27) The turning device **30** is disposed between the traveling device **20** and the main body device **40**. The turning device **30** includes a bearing (not illustrated) and a turning hydraulic motor **31**, and turns the main body device **40** and the work device **50**.
(28) The main body device **40** has a flat upper face, and the side face to which two work devices **50** are connected. Inside the main body device **40**, the engine **23** described above, a hydraulic device **41**, a posture detector **42** (see FIG. **3**), and an electric motor **44** (see FIG. **3**) that moves a counter mass **43** described later are provided.
(29) The hydraulic device **41** includes a hydraulic pump connected to the engine **23**, a hydraulic control valve, and the like, and drives a plurality of cylinders as actuators provided in the work device **50**.
(30) The posture detector **42** (see FIG. **3**) is a sensor that detects the posture of the main body device **40**, and examples thereof include an inclinometer and a level. In the present embodiment, the posture detector **42** is provided inside the main body device **40**, and detects the posture of the main body device **40** when the work device **50** and the two pile driving attachments **60** are driven.
(31) FIG. **4** is a cross-sectional view of the main body device **40** when the work device **50** is at the initial position, and FIG. **5** is a cross-sectional view of the main body device **40** when the work device **50** is at the work position. Hereinafter, the counter mass **43**, which is a mass body, will be described with reference to FIGS. **4** and **5**.
(32) The counter mass **43** is provided on the lower side of the main body device **40**, and a pair of sliders **45** separated from each other in the Y direction is attached thereto. The pair of sliders **45** extends in the X direction and is movably supported in the X direction by the pair of base members

46. The counter mass **43** corrects an unbalanced load acting on the pile driving system **1** when the work device **50** moves. In the present embodiment, the weight of the counter mass **43** is about 4 tons to 7 tons, but the weight is not limited thereto. Part of the counter mass **43** may be a container, and the counter mass **43** may be configured by the container with which a liquid (for example, mercury) having a high specific gravity at normal temperature is filled. Although the electric motor **44** is used to drive the counter mass as described above, another type of actuator may be used. By moving the counter mass **43** in the −X direction, the weight of the counter mass **43** can be reduced as compared with a case where the counter mass **43** does not move in the −X direction.
(33) The counter mass **43** is housed in the main body device **40** when the work device **50** is at the initial position, and moves in the −X direction in response to the movement of the work device **50** to the work position. In order to prevent an accident when the counter mass **43** having a weight of about 4 tons to 7 tons moves to the outside of the main body device **40**, it is desirable to provide a warning lamp in the main body device **40** to call attention visually, or provide a speaker in the main body device **40** to call attention audibly, or both. In addition, prior to the movement of the counter mass **43**, an imaging device **102** of the drone **100** may acquire an image of the surroundings where the counter mass **43** moves, and a UAV control device **108** or a heavy machine control device **29** may confirm safety. In addition, the imaging by the imaging device **102** of the drone **100** is preferably performed until the movement of the counter mass **43** is completed.
(34) From the viewpoint of accident prevention, it is preferable to move the work device **50** to the work position after the counter mass **43** moves in the −X direction, but the movement of the counter mass **43** and the movement of the work device **50** to the work position may be performed substantially simultaneously.
(35) The work device **50** includes a pair of jacks **47** between the two work devices **50**. In the present embodiment, the pair of jacks **47** is a hydraulic jack, and is positioned in the +Z direction with respect to the pair of crawler belts **22** so as not to contact the ground when the work device **50** is at the initial position. In addition, the pair of jacks **47** extends so as to be in contact with the ground to support the pile driving system **1** when the work device **50** is at the work position. Although the unbalanced load acting on the pile driving system **1** is corrected by the counter mass **43** described above, because the construction site may be inclined, the pair of jacks **47** is used as the overturning prevention of the pile driving system **1**. Note that the pair of jacks **47** may be not a pair but a single, or may be three or more, or may be omitted.
(36) As illustrated in FIG. **2**A, a take-off and landing portion for the drone **100** is formed on an upper face of the work device **50**, and a visually recognized mark **25** is formed on the take-off and landing portion. The visually recognized mark **25** is for recognizing a landing position by visually recognizing one visually recognized mark **25** by an imaging device **102** to be described later when the drone **100** lands on the take-off and landing portion. Note that the size of the plurality of visually recognized marks **25** is smaller than the size of the drone **100**, and in a case where one drone **100** lands on one visually recognized mark **25**, this one visually recognized mark **25** is in a state of being invisible from the other drone **100**. In addition, an interval between the plurality of visually recognized marks **25** is set so that the drones **100** do not interfere with each other when the plurality of drones **100** lands on the take-off and landing portion. Note that the shape of the visually recognized mark **25** is not limited to a circular shape, and may be a rectangular shape, an elliptical shape, a triangular shape, a double mark, or a single mark. Furthermore, the number of the visually recognized marks **25** may be one.
(37) In the present embodiment, the main body device **40** includes a first global navigation satellite system (GNSS) **26** that is a global positioning system illustrated in FIG. **3**, a first communication device **27**, a first memory **28**, and a heavy machine control device **29** that controls the entire base machine **10**. The first GNSS **26** measures the position of the base machine **10** using an artificial satellite.
(38) The first communication device **27** is a wireless communication unit that accesses a second

communication device **106** described later and a wide area network such as the Internet. In the present embodiment, the first communication device **27** communicates the flight paths of the plurality of drones **100** to the second communication device **106** based on the position of the base machine **10** detected by the first GNSS **26**.
(39) The first memory **28** is a nonvolatile memory (for example, a flash memory), and stores various pieces of data and programs for driving the base machine **10** and various pieces of data and programs for automatically driving the base machine **10**. In addition, the first memory **28** stores data regarding flight paths of the plurality of drones **100**.
(40) The heavy machine control device **29** is a control device that includes a CPU and controls the entire base machine **10**. The control of the base machine **10** and the pile driving attachment **60** by the heavy machine control device **29** will be described later with reference to the flowchart of FIG. **7**.
(41) The work device **50** includes a first work device **51** and a second work device **52**. As illustrated in FIGS. **1**A and **1**B, the first work device **51** and the second work device **52** extend from one side of the main body device **40** along the X direction and are separated from each other in the Y direction. In the present embodiment, the first work device **51** and the second work device **52** are connected to the main body device **40** to be parallel to the X direction. The number of the work devices **50** is not limited to two work devices, but may be three or more. In this case, the third work device **50** may be connected to a place other than the one side of the main body device **40**. In the present embodiment, the base machine **10** and the two pile driving attachments **60** constitute the first pile driver and the second pile driver.
(42) In the present embodiment, because the first work device **51** and the second work device **52** have the same configuration, the configuration of the first work device **51** will be described. In addition, the configurations and reference numerals of the first work device **51** and the second work device **52** are the same, but in a case where identification is required, each configuration of the first work device **51** is denoted by a after the reference numeral, and each configuration of the second work device **52** is denoted by b after the reference numeral. The first work device **51** includes a boom **53**, a boom cylinder **54**, an arm **55**, an arm cylinder **56**, and a boom attachment base **57**.
(43) The boom **53** is a rotary L-shaped component connected to the main body device **40** via the boom attachment base **57**, and is rotated by the boom cylinder **54**. The boom **53** is at the initial position in FIGS. **1**A and **1**B when the boom cylinder **54** is maximally extended, and is at the work position in FIGS. **2**A and **2**B when the boom cylinder **54** is shortened.
(44) The arm **55** is connected to the distal end of the boom **53** and is rotated by the arm cylinder **56**. The arm **55** is at the initial position in FIGS. **1**A and **1**B when the arm cylinder **56** is maximally extended, and is at the work position in FIGS. **2**A and **2**B when the arm cylinder **56** is shortened.
(45) A shift cylinder **58** is a cylinder that adjusts the interval between the first work device **51** and the second work device **52** in the Y direction according to the interval between two pile drivings. As illustrated in FIGS. **4** and **5**, the shift cylinder **58** adjusts the distance in the Y direction between the first work device **51** and the second work device **52** using a pair of guides **48** separated in the Z direction as guides. In this case, the shift cylinder **58** may slide the second work device **52** in the Y direction (e.g., the traveling direction) while fixing the first work device **51**. Alternatively, the shift cylinder **58** may slide the first work device **51** and the second work device **52** in the Y direction.
(46) A cylinder **59** rotates the pile driving attachment **60**. The cylinder **59** is at the initial position in FIGS. **1**A and **1**B when the cylinder **59** is maximally extended, and the cylinder **59** is at the work position in FIGS. **2**A and **2**B when the cylinder **59** is shortened.
(47) In the present embodiment, the boom cylinder **54**, the arm cylinder **56**, the shift cylinder **58**, and the cylinder **59** are hydraulic cylinders, and each extends and contracts by hydraulic pressure. In addition, the boom cylinder **54**, the arm cylinder **56**, the shift cylinder **58**, the cylinder **59**, and a vibrator **63** to be described later are extended and contracted by the hydraulic device **41**.
(48) One end (−Z side) of the pile driving attachment **60** is connected to the arm **55** and the

cylinder **59**, and the other end (+Z side) is provided with an attachment/detachment mechanism for attaching a pile **5** (see FIGS. **6**A and **6**B) to be pile driven or removing the pile driven pile **5**. The pile driving attachment **60** includes an attachment arm **61**, a hanger **62**, a vibrator **63**, and a chuck **64**.

(49) The attachment arm **61** is a rotating L-shaped component, and one end (−Z side) thereof is connected to the arm **55** and the cylinder **59**.

(50) The hanger **62** is suspended from the other end of the attachment arm **61** and is rotatable about the Z axis.

(51) The vibrator **63** is suspended from the hanger **62** and generates vibration using hydraulic pressure as energy. The pile driving of the present embodiment is performed using the vibration of the vibrator **63**. The vibrator **63** may be a pendulum type or a piston type.

(52) The chuck **64** is attached to a lower end portion of the vibrator **63** and detachably grips the pile **5**. In addition, the chuck **64** transmits vibration from the vibrator **63** to the pile **5** when the pile **5** is gripped.

(53) FIGS. **6**A and **6**B are views illustrating an open/close state of the chuck **64**. FIG. **6**A is a view illustrating a state in which the chuck **64** is open, and FIG. **6**B is a view illustrating a state in which the chuck **64** is closed. The opening and closing of the chuck **64** are also extended and contracted by the hydraulic device **41**.

(54) Returning to FIG. **3**, a power transmission device **95** supplies power to a power reception device **103** to be described later for the drone **100**. A wireless power supply is used in the present embodiment. The wireless power supply supplies power to the power reception device **103** in a non-contact manner, and a magnetic field resonance system, an electromagnetic induction system, and the like are known. The power transmission device **95** of the present embodiment includes a power supply (or power supply unit), a control circuit, and a power transmission coil. The power transmission coil is preferably provided in the take-off and landing portion. In this case, when the power transmission coil is provided inside the visually recognized mark **25**, charging can be promptly started when the drone **100** lands.

(55) Note that a contact-type power supply method may be used instead of wireless power supply. In this case, a metal contact may be provided in each of the power transmission device **95** and the power reception device **103**, and power may be supplied by mechanically connecting the contact points. For example, a concave contact may be provided on the take-off and landing portion, and a convex contact may be provided on the drone **100**. The number of concave contacts and convex contacts may each be one, and may each be plural.

(56) In a case where the base machine **10** moves on a construction site with unevenness in a state where the drone **100** lands on the take-off and landing portion, it is desirable to mechanically engage or electromagnetically connect the drone **100** and the take-off and landing portion so that the drone **100** does not move away from the take-off and landing portion. In the present embodiment, a lock mechanism that applies a mechanical lock when the drone **100** lands on the take-off and landing portion is used.

(57) The drone **100** of the present embodiment includes a flight device **101**, an imaging unit or imaging device **102**, a power reception device **103**, a sensor group **104**, a battery **105**, a second communication device **106**, a second memory **107**, and a UAV control device **108**.

(58) The flight device **101** includes a motor (not illustrated) and a plurality of propellers, and generates thrust for floating the drone **100** in the air and moving in the air. Note that the number of drones landing on the take-off and landing portion is two in FIGS. **1**A and **1**B, but can be any number, and the number is not limited to two. In addition, the configurations of the respective drones **100** may be the same, or part thereof may be changed. Furthermore, the sizes of the respective drones **100** may be the same or different.

(59) The imaging device **102** is a digital camera that includes a lens, an imaging element, an image processing engine, and the like and captures a moving image and a still image. In the present

embodiment, the imaging device **102** conducts a survey and performs imaging for supporting pile driving. In addition, the imaging device **102** visually recognizes one visually recognized mark **25** when the drone **100** lands on the take-off and landing portion to recognize the landing position. Note that when a power transmission coil or a contact of the power transmission device **95** is provided in the visually recognized mark **25**, it is possible to quickly charge the battery **105** via the power reception device **103** after the drone **100** lands on the take-off and landing portion. Note that the imaging device **102** is preferably provided with a biaxial or triaxial gimbal to perform aerial imaging without blurring. Note that prevention of blurring of the imaging device may be performed by software.
(60) In the enlarged view surrounded by the alternate long and short dash line in FIG. **1**B, the lens of the imaging device **102** is attached to the side face (front face) of the drone **100**, but the lens of the imaging device **102** may be attached to the lower face of the drone **100**, or a plurality of lenses may be provided in the drone **100**. Further, a movement mechanism for moving the lens attached to the side face toward the lower face may be provided. Furthermore, a mechanism for rotating the imaging device **102** about the Z axis may be provided to position the lens of the imaging device **102** at any position about the Z axis. In addition, when the drone **100** lands on the take-off and landing portion, in a case where the lens of the imaging device **102** is directed in the X direction or the Y direction, it is possible to capture images close to images visually recognized by the operator from the driver seat of the conventional base machine from a plurality of directions. In addition, because the take-off and landing portion is provided at the top of the main body device **40** as apparent from FIG. **1**B, for example, the drone **100** can perform imaging by the imaging device **102** without being blocked by the main body device **40**. Note that an omnidirectional camera (360-degree camera) may be used as the imaging device **102**, or a three-dimensional scanner may be used instead of the imaging device **102**.
(61) The power reception device **103** includes a power reception coil, a charging circuit, and the like provided in the leg portion **109** of the drone **100**, and charges the battery **105** with power from the power transmission device **95**.
(62) The battery **105** is a secondary battery connected to the power reception device **103**, and an example thereof may include a lithium ion secondary battery, a lithium polymer secondary battery, or the like, but is not limited thereto. The battery **105** can supply power to the flight device **101**, the imaging device **102**, the second communication device **106**, the second memory **107**, and the UAV control device **108**.
(63) Examples of the sensor group **104** include a GNSS, an infrared sensor that avoids collision between the drone **100** and another device (for example, the work device **50**), an atmospheric pressure sensor that measures altitude, a magnetic sensor that detects orientation, a gyro sensor that detects the posture of the drone **100**, an acceleration sensor that detects acceleration acting on the drone **100**, or the like.
(64) The second communication device **106** includes a wireless communication unit and communicates with the first communication device **27**. In the present embodiment, the second communication device **106** transmits image data captured by the imaging device **102** and a detection result detected by the sensor group **104** to the first communication device **27** and transmits a flight command from the first communication device **27** to the UAV control device **108**.
(65) The second memory **107** is a nonvolatile memory (for example, a flash memory), and stores various pieces of data and programs for flying the drone **100** and stores image data captured by the imaging device **102**, a detection result detected by the sensor group **104**, and the like.
(66) The UAV control device **108** includes a CPU, a posture control circuit, a flight control circuit, and the like, and controls the entire drone **100**. Furthermore, the UAV control device **108** determines the timing of charging from the remaining amount of the battery **105**, and controls the imaging position, the angle of view, the frame rate, and the like of the imaging device **102**.
(67) Examples of the pile **5** (see FIGS. **8**A through **8**F) may include an H-shaped steel, an L-shaped

steel, an angle-shaped steel, a grooved steel, a round steel, or the like. In the present embodiment, an H-shaped steel is used. The H-shaped steel pile **5** is composed of an upper flange, a lower flange, and a web sandwiched between the upper flange and the lower flange. It is assumed that the H-shaped steel pile **5** is placed on a construction site so that an end face of the upper flange and an end face of the lower flange are in contact with the ground. The operation of the pile driving system **1** configured as described above will be described below.
(68) Description of Flowchart
(69) FIG. **7** is a flowchart of pile driving performed by the heavy machine control device **29** according to the present embodiment. FIGS. **8**A-**8**F are diagrams illustrating an operation of pile driving. Specifically, FIG. **8**A is a diagram illustrating movement of the counter mass **43**, FIG. **8**B is a diagram illustrating a state of gripping the pile **5**, FIG. **8**C is a diagram illustrating a state of raising the pile **5**, FIG. **8**D is a diagram illustrating a state of changing the orientation of the pile **5**, FIG. **8**E is a diagram illustrating a state of pile driving the pile **5**, and FIG. **8**F is a diagram illustrating a state in which a component is attached to the pile **5** after the pile driving.
(70) FIGS. **9**A through **9**C are schematic views of the construction site according to the present embodiment. FIG. **9**A is a view illustrating a case where the work device **50** is at an initial position, FIG. **9**B is a view illustrating a case where the counter mass **43** and the jack **47** (e.g., a stabilizing member) are at a work position, and FIG. **9**C is a view illustrating a state where the work device **50** drives the pile **5**.
(71) In addition, FIGS. **10**A through **10**C are schematic diagrams of the construction site according to the present embodiment. FIG. **10**A is a diagram illustrating a state in which the work device **50** drives the pile **5**, FIG. **10**B is a diagram illustrating a state in which a component is attached to the pile **5**, and FIG. **10**C is a diagram illustrating a state in which the pile driving system **1** moves to the next pile driving place. Note that, to avoid complication of the drawings, only components necessary for description are denoted by reference numerals in FIGS. **8**A to **10**C, and illustration of the drone **100** is omitted in FIGS. **9**A to **10**C.
(72) Hereinafter, the flowchart of FIG. **7** will be described with reference to FIGS. **8**A to **10**C.
(73) In the flowchart of FIG. **7**, part thereof may be performed by an operator.
(74) Before starting pile driving, the heavy machine control device **29** acquires point group data from images as a survey by the imaging devices **102** of the two drones **100** (step S**1**). Note that, at the time of conducting a survey, the lens of the imaging device **102** faces the lower face (−Z direction). By conducting a survey by two drones **100**, the survey time can be shortened as compared with a case that conducts a survey by one drone **100**.
(75) Note that a survey may be conducted by three or more drones **100**. Note that because it takes considerable time before performing step S**2** after conducting a survey in step S**1**, step S**1** may be excluded from this flowchart. Step S**1** may instead be the preparation work of this flowchart.
(76) Based on the survey in step S**1** and the data of the positions at which the piles **5** are to be pile driven, a plurality of piles **5** is placed laterally on the construction site. At this time, the plurality of piles **5** is laterally placed on the construction site while avoiding a traveling path P on which the pile driving system **1** travels. The horizontal placement of the plurality of piles **5** may be performed by a conveyance robot (not illustrated) or may be performed by an operator. Note that a plurality of points in FIGS. **9**A through **10**C virtually indicate positions where pile driving is to be performed.
(77) In the present embodiment, a solar panel **67** (see FIG. **10**C) is inclined with respect to the four piles **5**. Therefore, as indicated by arrows in FIG. **9**A, of the four points to be pile driven, long piles **5***a* are pile driven at two points on the +X side and short piles **5***b* are pile driven at two points on the −X side. An angle adjustment member **65** described later is used to adjust the inclination of the solar panel **67**.
(78) With the pile driving attachment **60** attached to each of the first work device **51** and the second work device **52**, each of the first work device **51** and the second work device **52** is extended to the +X side to perform pile driving of two long piles **5***a* as illustrated in FIG. **9**C. Then, each of the

first work device **51** and the second work device **52** is shortened to the −X side to perform pile driving of two short piles **5***b* as illustrated in FIG. **10**A. The number of the piles **5** supporting the solar panel **67** may be two, three, or one.
(79) In the present embodiment, when the pile driving of the four piles **5** is completed, the heavy machine control device **29** moves the pile driving system **1** in the Y direction by the traveling device **20**. The pile driving system **1** drives the first work device **51** and the second work device **52** in the movement in the X direction, and drives the traveling device **20** in the movement in the Y direction. To quickly move in the X direction and the Y direction, at the initial position and the work position, the traveling device **20** is positioned so that the pair of crawler belts **22** is directed along the Y direction, and the first work device **51** and the second work device **52** are positioned along the X direction.
(80) The heavy machine control device **29** moves the counter mass **43** in the −X direction along the pair of base members **46** by the electric motor **44** (step S**2**). As illustrated in FIG. **8**A, the heavy machine control device **29** images the periphery of the counter mass **43** by the imaging device **102** of the other drone **100**. In addition, the heavy machine control device **29** desirably makes notification of movement of the counter mass **43** using a warning light, a speaker, or the like before the movement of the counter mass **43**. In addition, the heavy machine control device **29** moves the pair of jacks **47** at the initial position to the work position, and implements the overturning prevention measure for the pile driving system **1** by the pair of jacks **47**. FIG. **9**B illustrates a state in which step S**2** is completed.
(81) The heavy machine control device **29** causes the first work device **51** and the second work device **52** to approach the respective two piles **5** to be pile driven, and causes the two pile driving attachments **60** to grip the web portions of the two piles **5** from a state in which each chuck **64** is opened to a state in which each is closed (step S**3**). FIG. **8**B is a diagram illustrating a state of work in step S**3**, and the other drone **100** that has finished imaging the periphery of the counter mass **43** is charged at the take-off and landing portion. Note that, in addition to one drone **100**, the other drone **100** may capture an image of the periphery of the first work device **51** and the second work device **52** or the periphery of the two pile driving attachments **60**.
(82) The heavy machine control device **29** controls each of the first work device **51** and the second work device **52** to raise each of the two piles **5** (step S**4**). FIG. **8**C illustrates a state of the pile **5** raised in step S**4**.
(83) As illustrated in FIG. **8**D, the heavy machine control device **29** adjusts the orientation of the pile **5** so that the web of the H-shaped steel pile **5** is along the X direction (so that the upper flange and the lower flange are orthogonal to the paper) (step S**5**). The orientation of the pile **5** may be adjusted by a rotation motor (not illustrated) provided in the pile driving attachment **60**, or the orientation may be adjusted by an operator. After step S**5**, to pile drive the two piles **5** almost simultaneously, the heavy machine control device **29** drives the shift cylinder **58** to adjust in advance the interval in the Y direction between the first work device **51** and the second work device **52** based on the interval between the two piles.
(84) As illustrated in FIGS. **8**E and **9**C, the heavy machine control device **29** performs pile driving while applying vibration to the respective H-shaped steel piles **5** by the two vibrators **63** (step S**6**). In addition, the heavy machine control device **29** determines whether it is necessary to correct the pile driving during the pile driving in step S**6** (step S**7**).
(85) FIG. **11** is a diagram illustrating a state in which an image of the pile driven pile **5** is captured by two drones **100**. As illustrated in FIG. **11**, the heavy machine control device **29** causes two drones **100** to fly. The heavy machine control device **29** causes the imaging device **102** of one of the drones **100** to perform imaging from the X direction to acquire an image IMG**1** illustrated in the upper square frame of FIG. **11**. In addition, the heavy machine control device **29** causes the imaging device **102** of the other drone **100** to perform imaging from the Y direction orthogonal to the X direction and the Z direction to acquire an image IMG**2** illustrated in the lower square frame

of FIG. **11**. In the image IMG**1** and the image IMG**2**, a thick line extending in the Z direction in a square frame represents a reference image (e.g., from a recording unit that records the reference image). The heavy machine control device **29** compares the reference image with the acquired image to determine whether the correction of the pile driving is necessary.
(86) Here, the heavy machine control device **29** determines that it is necessary to correct the pile driving, and proceeds to step S**8**. The heavy machine control device **29** continues the pile driving operation while adjusting the position of the pile **5** by appropriately controlling the boom cylinder **54**, the arm cylinder **56**, the shift cylinder **58**, and the cylinder **59**, acquires images by the imaging devices **102** of the two drones **100**, compares the acquired images with the reference image, and adjusts the posture of the pile **5** (step S**8**).
(87) In FIG. **11**, because the posture of one pile **5** is imaged by two drones **100**, four drones **100** are required in a case where two piles **5** are almost simultaneously pile driven.
(88) FIG. **12** is a diagram illustrating a state in which an image of the pile driven pile **5** is captured by one drone. In FIG. **12**, a circular mark is formed on a flange (for example, an upper flange) of the pile **5**. The image captured by the imaging device **102** of one drone includes an image of the lower flange indicating a tilt in the Y direction and an image of the circular mark indicating a tilt in the X direction. In a case where there is no tilt in the X direction, the image captured by the imaging device **102** of the drone is circular, but in a case where there is a tilt in the X direction, the image captured by the imaging device **102** of the drone is elliptical. Although the reference image extending in the Z direction is displayed in the image IMG**3**, a circular reference image may be displayed in addition to the reference image.
(89) The heavy machine control device **29** determines whether each pile **5** is pile driven to a predetermined depth (step S**9**). FIGS. **13**A and **13**B are diagrams illustrating a pile driving depth mark DM formed on the upper flange of the pile **5**. FIG. **13**A is a diagram illustrating an example in which the pile driving depth mark DM is provided in the lower portion of the pile **5**, and FIG. **13**B is a diagram illustrating an example in which the pile driving depth mark DM is provided in the upper portion of the pile **5**. Note that an example of the depth mark DM is a horizontal line.
(90) As illustrated in FIG. **13**A, when the ground surface substantially matches the horizontal line forming the pile driving depth mark DM from the image captured by the imaging device **102** of the drone **100** from obliquely above the pile **5**, the heavy machine control device **29** determines that the pile **5** has been pile driven to a predetermined depth and proceeds to step S**10**. On the other hand, when the horizontal line forming the pile driving depth mark DM is located above the ground surface, the heavy machine control device **29** determines that pile driving has not been performed to a predetermined depth and repeats step S**6** and subsequent steps.
(91) In addition, the heavy machine control device **29** sets the altitude of the drone **100** based on the survey result in step S**1** and the height information about the pile driving depth mark DM formed on the upper portion of the pile **5**. This is because the position of the pile driving depth mark DM is detected based on the altitude of the drone **100**. The UAV control device **108** controls the altitude of the drone **100** based on the output of the atmospheric pressure sensor so that the altitude is the set altitude. When the drone **100** reaches the altitude, the UAV control device **108** causes the imaging device **102** to image the pile driving depth mark DM. As illustrated in FIG. **13**B, when the pile driving depth mark DM is located at a predetermined height from the ground surface from the image captured by the imaging device **102**, the heavy machine control device **29** determines that the pile **5** has been pile driven to a predetermined depth and proceeds to step S**10**. On the other hand, when the pile driving depth mark DM is higher than the predetermined height from the ground surface, the heavy machine control device **29** determines that the pile driving has not been performed to the predetermined depth, and repeats step S**6** and the subsequent steps.
(92) When determining in step S**9** that each of the piles **5** has been pile driven to a predetermined depth, the heavy machine control device **29** releases the gripping of the web of the pile **5** from the closed state to the open state of the chuck **64** (step S**10**).

(93) The heavy machine control device **29** attaches the angle adjustment member **65** and a lateral beam member **66** to each of the two piles **5** that have been pile driven (step S**11**). The angle adjustment member **65** is a mechanical component that adjusts the degree of inclination of the solar panel **67**. The lateral beam member **66** is a mechanical component to which the solar panel **67** is attached. The angle adjustment member **65** and the lateral beam member **66** may be attached by an assembly robot (not illustrated) or by an operator.
(94) Before the movement, the heavy machine control device **29** moves the pair of jacks **47** from the work position to the initial position (step S**12**). In this case, because the two pile driving attachments **60** do not grip the pile **5**, the possibility of overturning is extremely low, but the heavy machine control device **29** may move part of the first work device **51** and the second work device **52** in the −X direction.
(95) The heavy machine control device **29** determines whether the planned pile driving is finished (step S**13**). When the planned pile driving is not finished (step S**13**/NO), the heavy machine control device **29** moves to the next pile driving place and repeats the processing of step S**3** and subsequent steps until the planned pile driving is finished. On the other hand, when the planned pile driving is finished (step S**13**/YES), the heavy machine control device **29** ends this flowchart. When ending this flowchart, the heavy machine control device **29** returns the pile driving system **1** to the initial position and houses the counter mass **43** in the main body device **40**. Then, the heavy machine control device **29** moves the pile driving system **1** to a predetermined place.
(96) Note that, during the execution of this flowchart, the heavy machine control device **29** may monitor the output of the posture detector **42**. The heavy machine control device **29** may interrupt the pile driving operation and return the pile driving system **1** to the initial position in a case where the main body device **40** inclines to a predetermined level or more due to the influence of wind, looseness of the ground surface, or the like. In this case, the heavy machine control device **29** may keep the counter mass **43** positioned outside the main body device **40**, or may house the counter mass **43** in the main body device **40** according to the output of the posture detector **42**.
Modification
(97) FIG. **14** is a schematic diagram illustrating a modification of the pile driving system **1** of the first embodiment. In the first embodiment, the first work device **51** and the second work device **52** are connected to the main body device **40** so as to be parallel to the X direction. In the present modification, the first work device **51** and the second work device **52** are connected to the main body device **40** at an angle from the X direction. Therefore, a swing unit **68** and a swing cylinder **69** are provided instead of the pair of guides **48**, the boom attachment base **57**, the shift cylinder **58**, and the like.
(98) The swing unit **68** is pivotally supported so that a portion connected to the main body device **40** and a portion connected to the boom **53** are rotatable about the Z axis. The swing cylinder **69** is a hydraulic cylinder having one end connected to the main body device **40** and the other end connected to the swing unit **68**, and performs the expansion/contraction operation by the hydraulic device **41**.
(99) In addition, the pile driving system **1** of the modification has a power generation device **8** on the upper face of the main body device **40**. As the power generation device **8**, power generation derived from natural energy is preferably used, and in the present modification, solar power generation using a solar panel is used. The power generated by the power generation device **8** is charged in a battery (not illustrated) and used to drive the engine **23**, the hydraulic device **41**, the electric motor **44**, the power transmission device **95**, and the like. By using power derived from natural energy in the pile driving system **1**, it is possible to reduce the emission amount of carbon dioxide, which is a greenhouse gas generated by the pile driving system **1**.
(100) An inclination mechanism that inclines the power generation device **8** toward the sun may be provided between the upper face of the main body device **40** and the power generation device **8**. By inclining the power generation device **8** according to the turning of the turning device **30** by this

inclination mechanism, efficient solar power generation can be performed. Note that the power generation device **8** can also be applied to the pile driving system **1** of the first embodiment and the second embodiment described later, and the upper face of the main body device **40** can have a function as a power generation unit in addition to a function as a take-off and landing portion of the drone **100** and a function as a charging unit of the drone **100**.
(101) In addition, in the pile driving system **1** of the modification, a vibration power generation element **9** is provided in each of the two vibrators **63**. The vibration power generation element **9** includes a piezoelectric body, and generates power by a piezoelectric effect due to deformation of the piezoelectric body by application of a force thereto. By charging the battery (not illustrated) with electric power generated by the power generation of the vibration power generation element **9**, it is possible to reduce the emission amount of carbon dioxide generated by the pile driving system **1**. The vibration power generation element **9** can also be applied to the pile driving system **1** of the first embodiment and the second embodiment described later. Note that the power generated by the power generation device **8** and the vibration power generation element **9** may be charged in the battery **105** of the drone **100**.
(102) Although the counter mass **43** and the jack **47** are not illustrated in FIG. **14** in order to simplify the drawing, at least one of the counter mass **43** and the jack **47** can be added to the present modification. That is, the counter mass **43**, the jack **47**, or both, may be added.
Second Embodiment
(103) Hereinafter, the second embodiment will be described with reference to FIGS. **15** to **19**D. The same components as those of the first embodiment are denoted by the same reference numerals, and the description thereof will be omitted or simplified. FIG. **15** is a schematic diagram of a pile driving system **1** of the second embodiment, and FIG. **16** is a block diagram of the pile driving system **1** of the second embodiment.
(104) In the pile driving system **1** of the second embodiment, the power generation device **8** is provided on the side face of the main body device **40**. When the side face of the main body device **40** is tapered and the power generation device **8** is inclined toward the sun, efficient solar power generation can be performed.
(105) In addition, the pile driving system **1** of the second embodiment has the vibration power generation element **9** in the arm member connected to the pair of crawler belts **22** in addition to the two vibrators **63**. The vibration power generation element **9** may be provided in the engine **23** and the main body of the drone **100**.
(106) In addition to the configuration of the first embodiment, the pile driving system **1** of the second embodiment includes, as the third work device **50**, a third work device **35** that conveys the solar panel **67** to the pile driven pile **5**.
(107) As in the first work device **51** and the second work device **52**, the third work device **35** includes the boom **53**, the boom cylinder **54**, the arm **55**, and the arm cylinder **56**, and further includes the swing unit **68** and the swing cylinder **69** described in the modification. The third work device **35** is connected to the center position of the main body device **40** via the swing unit **68** in the Y direction orthogonal to the X direction and the Z direction.
(108) The third work device **35** has a mounting attachment **70** for attaching the solar panel **67** to the lateral beam member **66**. The mounting attachment **70** includes an attachment arm **71**, a Y-axis rotation unit **72**, a Z-axis rotation unit **73**, a main body **74**, and a suction unit **75**.
(109) One end of the attachment arm **71** on the +X side is connected to the cylinder **59** that rotates the arm **55** and the mounting attachment **70**. The other end of the attachment arm **71** on the −X side is connected to the Y-axis rotation unit **72**.
(110) The Y-axis rotation unit **72** includes a motor, and rotates the mounting attachment **70** about the Y-axis orthogonal to the X-axis and the Z-axis. One end of the Y-axis rotation unit **72** on the +Z side is connected to the attachment arm **71**, and the other end on the −Z side is connected to the Z-axis rotation unit **73**.

(111) The Z-axis rotation unit **73** includes a motor and rotates the mounting attachment **70** about the Z-axis. One end of the Z-axis rotation unit **73** on the +Z side is connected to the Y-axis rotation unit **72**, and the other end on the −Z side is connected to the main body **74**.
(112) The main body **74** has a rectangular shape with long sides and short sides, and holds the solar panel **67** using the suction unit **75**. One end of the main body **74** on the +Z side is connected to the Z-axis rotation unit **73**.
(113) The suction unit **75** is formed on the main body **74**, and sucks the solar panel **67** by a plurality of sucking surfaces. The suction unit **75** performs suction by means of vacuum suction using vacuum, electromagnetic suction using an electromagnet, or the like can be used. The suction unit **75** may be a hybrid suction unit including a vacuum suction unit that performs vacuum suction and an electromagnetic suction unit that performs electromagnetic suction.
(114) The third work device **35** may function as a counter mass that corrects an unbalanced load acting on the pile driving system **1** when the first work device **51** and the second work device **52** are working. When the third work device **35** is driven as a counter mass, the jack **47** can be omitted, or the counter mass **43** can be reduced in weight or omitted. In addition, the counter mass **43** can be changed from a movable type to a fixed type. Therefore, in the block diagram of FIG. **16**, the electric motor **44**, the jack **47**, and the like that move the counter mass **43** are omitted. Note that when the third work device **35** is moved as a counter mass, it is desirable to provide a warning lamp to call attention visually, to provide a speaker to call attention aurally, or to provide both.
(115) The operation of the pile driving system **1** of the second embodiment configured as described above will be described below.
(116) Description of Flowchart
(117) FIG. **17** is a flowchart regarding conveyance and installation of the solar panel **67** executed by the heavy machine control device **29** of the second embodiment. The flowchart of FIG. **17** includes some steps of pile driving in order to describe the operation of causing the third work device **35** to function as a counter mass, but is not limited these steps. In the flowchart of FIG. **17**, part thereof may be performed by an operator.
(118) FIGS. **18**A through **18**C are views illustrating an operation of installing the solar panel **67**. FIG. **18**A is a view illustrating a state of pile driving, FIG. **18**B is a view illustrating a state of releasing the grip of the pile, and FIG. **18**C is a view illustrating a state of sucking the solar panel **67**.
(119) FIGS. **19**A through **19**D are also views illustrating an operation of installing the solar panel **67**. FIG. **19**A is a view illustrating a state of lifting the solar panel **67**, FIG. **19**B is a view illustrating a state of turning, FIG. **19**C is a view illustrating a state of rotating by 90 degrees, and FIG. **19**D is a view illustrating a state of installing the solar panel **67**. In FIGS. **18**A to **19**D, only components necessary for description are denoted by reference numerals to avoid complication of the drawings.
(120) Hereinafter, the flowchart of FIG. **17** will be described with reference to FIGS. **18**A to **19**D.
(121) As illustrated in FIG. **18**A, the heavy machine control device **29** pile drives the two short piles **5***b* using the first work device **51**, the second work device **52**, and the two pile driving attachments **60** (step S**101**). Note that the heavy machine control device **29** also performs steps S**7** to S**9** in the flowchart of FIG. **7** at the time of pile driving in step S**101**, the process is as described in the first embodiment, and thus description thereof is omitted.
(122) The heavy machine control device **29** performs unbalanced load correction using the third work device **35** and the mounting attachment **70** at the time of pile driving in step S**101** (step S**102**). The heavy machine control device **29** performs unbalanced load correction by moving the third work device **35** in the −X direction.
(123) When the pile driving in step S**101** is finished, the heavy machine control device **29** releases the gripping of the webs of the two short piles **5***b* from the closed state to the open state of the chuck **64**. The heavy machine control device **29** may continuously perform the unbalanced load

correction by moving the third work device **35** and the mounting attachment **70** according to the operation accompanying the release of the gripping of the short pile **5***b*. In this case, the heavy machine control device **29** may move the third work device **35** according to the output of the posture detector **42**.
(124) The heavy machine control device **29** sucks the solar panel **67** using the third work device **35** and the mounting attachment **70** (step S**103**). As illustrated in FIG. **18**C, the heavy machine control device **29** causes the drone **100** to fly above the mounting attachment **70**, and images the solar panel **67** and the main body **74** with the imaging device **102**. The heavy machine control device **29** moves the third work device **35** so that the positions of the solar panel **67** and the main body **74** in the X direction and the Y direction match with each other. For the image captured by the imaging device **102**, when the positions of the solar panel **67** and the main body **74** in the X direction and the Y direction match with each other, most of the solar panel **67** is hidden by the main body **74**. Therefore, the heavy machine control device **29** can determine that the positions of the solar panel **67** and the main body **74** in the X direction and the Y direction match with each other by pattern matching using the reference image. The operator may make a determination on the alignment between the solar panel **67** and the main body **74** in the X direction and the Y direction.
(125) Following the alignment of the solar panel **67** and the main body **74** in the X direction and the Y direction, the heavy machine control device **29** causes the third work device **35** to move the mounting attachment **70** in the −Z direction. Then, the heavy machine control device **29** sucks the solar panel **67** by the suction unit **75**.
(126) As shown in FIG. **19**A, the heavy machine control device **29** lifts the solar panel **67** using the third work device **35** and the mounting attachment **70** (step S**104**).
(127) Next, as illustrated in FIG. **19**B, the heavy machine control device **29** turns the turning device **30** by 180 degrees (step S**105**). Note that after the end of step S**105**, one of the two drones **100** may land on the take-off and landing portion to perform charging.
(128) As illustrated in FIG. **19**C, the heavy machine control device **29** rotates the solar panel **67** by 90 degrees about the Z axis by the Z-axis rotation unit **73** (step S**106**). As illustrated in FIG. **10**C, the solar panel **67** has a rectangular shape having long sides and short sides. When the long side direction of the solar panel **67** matches the X direction at the time of turning in step S**105**, the solar panel **67** protrudes more in the X direction than the third work device **35**, and it cannot be said that it is necessarily safe. Therefore, in the present embodiment, the short side direction of the solar panel **67** matches the X direction until the turning is finished, and the solar panel **67** is rotated by 90 degrees about the Z axis by the Z-axis rotation unit **73** after the turning is finished.
(129) When the suction unit **75** sucks the solar panel **67** from above, the solar panel **67** may drop when an abnormality occurs in the suction unit **75**. For this reason, the turning device **30** may perform turning in a state where the Y-axis rotation unit **72** is rotated by 180 degrees, and the suction unit **75** sucks the solar panel **67** from below.
(130) As illustrated in FIG. **19**D, the heavy machine control device **29** causes the third work device **35** to install the solar panel **67** on the lateral beam member **66** (step S**107**). The positioning of the solar panel **67** with respect to the lateral beam member **66** may be performed based on the imaging result by the imaging device **102** of the drone **100**, and can be performed by pattern matching using the reference image. The positioning of the solar panel **67** with respect to the lateral beam member **66** and the fastening of the solar panel **67** with respect to the lateral beam member **66** may be performed by an operator. After installing the solar panel **67** on the lateral beam member **66**, the heavy machine control device **29** releases the suction of the solar panel **67** by the suction unit **75**. In the present embodiment, because the solar panel **67** is a magnetic body, the suction unit **75** is a hybrid suction unit including a vacuum suction unit **75***a* and an electromagnetic suction unit **75***b* as illustrated in FIGS. **19**C and **19**D.
(131) The heavy machine control device **29** determines whether the installation of the solar panel **67** is finished (step S**108**). When the next solar panel **67** is to be installed (step S**108**/NO), the

heavy machine control device **29** turns the turning device **30** by 180 degrees and repeats step S**103** and the subsequent steps. When the scheduled installation of the solar panel **67** has been completed (step S**108**/YES), the heavy machine control device **29** ends this flowchart. When ending this flowchart, the heavy machine control device **29** returns the first work device **51** and the second work device **52** to the initial positions, and moves the pile driving system **1** to a predetermined place. As described above in detail, in the second embodiment, because the solar panel **67** can be installed following the pile driving, efficient construction can be performed, and the construction period can be shortened.
(132) The embodiments described above are merely examples for describing the present invention, and various modifications can be made without departing from the gist of the present invention. For example, when an infrared camera is used as the imaging device **102**, pile driving work can be performed even at night, and the construction period can be shortened. The warning lamp and the speaker described above may be provided in a place other than the main body device **40**. In addition, the first embodiment, the modification, and the second embodiment may be appropriately combined.
(133) In addition, even in a case where the remaining amount of the battery **105** of the flying drone **100** decreases, the drone **100** that is not flying is charged. Thus, it is possible to promptly replace the drone **100** to be flown, and thus, it is not necessary to substantially consider the limitation of the flight time of the drone **100**. In addition, according to the present embodiment, because the drone **100** assists the pile driving system **1**, automated construction work can be efficiently realized.
(134) The power generation device **8** can be provided not only in the pile driving system **1** but also in a construction heavy machine such as a backhoe. In this case, it is preferable to adopt the automated driving type having no driver seat as in the present embodiment. In addition, the vibration power generation element **9** can be provided not only in the pile driving system **1** but also in a machine component holding a traveling device of a construction heavy machine such as a backhoe or an engine.
(135) The following is a list of reference signs used in the drawing figures and in this specification. **1** pile driving system **10** base machine **20** traveling device **29** heavy machine control device **30** turning device **35** third work device **40** main body device **41** hydraulic device **50** work device **51** first work device **52** second work device **60** pile driving attachment **70** mounting attachment **100** drone **102** imaging device **103** power reception device **104** sensor group **105** battery **108** UAV control device

Claims

1. A pile driving apparatus, comprising: a main body that travels by a traveling device; a first pile driver that is connected to the main body and performs pile driving along a vertical direction; and a second pile driver that is connected to the main body and performs pile driving along the vertical direction, wherein: the first pile driver and the second pile driver are each disposed on a first side of the main body, and an adjuster disposed on the first side and configured to adjust a position of at least one of the first pile driver or the second pile driver.
2. The pile driving apparatus according to claim 1, further comprising: a take-off and landing portion provided in the main body; and an unmanned flight vehicle that takes off and lands from and on the take-off and landing portion.
3. The pile driving apparatus according to claim 2, further comprising: a communication device that communicates with a communication device provided in the unmanned flight vehicle.
4. The pile driving apparatus according to claim 2, wherein part of a power supply unit that supplies power to the unmanned flight vehicle is provided in the take-off and landing portion.
5. The pile driving apparatus according to claim 2, further comprising; a first control device that

controls the first pile driver and the second pile driver based on a survey result by the unmanned flight vehicle.
6. The pile driving apparatus according to claim 2, wherein the unmanned flight vehicle includes an imaging unit that performs imaging, and wherein the pile driving apparatus includes a second control device that controls at least one of the first pile driver and the second pile driver based on imaging by the imaging unit of a pile.
7. The pile driving apparatus according to claim 2, wherein the take-off and landing portion has a visually recognized mark.
8. The pile driving apparatus according to claim 1, wherein the first pile driver and the second pile driver are connected to the main body at a predetermined angle.
9. The pile driving apparatus according to claim 1, wherein the first pile driver and the second pile driver are connected to the main body so that a traveling direction of the traveling device matches a pile driving direction in which the first pile driver and the second pile driver pile drive a plurality of piles.
10. The pile driving apparatus according to claim 1, further comprising: a first moving device that moves a mass body prior to driving of the first pile driver and the second pile driver, wherein the mass body is disposed on a second side opposite to the first side and moves away from the first pile driver and the second pile driver.
11. The pile driving apparatus according to claim 1, further comprising: a second moving device that moves a stabilizing member toward a ground prior to driving of the first pile driver and the second pile driver.
12. The pile driving apparatus according to claim 1, wherein the main body includes a solar power generation device.
13. The pile driving apparatus according to claim 1, wherein: the adjuster adjusts the position of the first pile driver in accordance with a position of a first pile on the first side when driving the first pile on the first side, and the adjuster adjusts the position of the second pile driver in accordance with a position of a second pile on the first side when driving the second pile on the first side.
14. A pile driving apparatus, comprising: a main body that travels by a traveling device; a first pile driver that is connected to a first portion of the main body and performs pile driving; and a conveyance unit that is connected to a second portion of the main body, different from the first portion, and conveys a component to be attached to a pile that is pile driven, wherein the conveyance unit includes a latching unit that latches the component by at least one of a vacuum suction or an electromagnetic suction.
15. The pile driving apparatus according to claim 14, wherein positioning of the conveyance unit with respect to the component is performed by an imaging device provided in an unmanned flight vehicle.
16. The pile driving apparatus according to claim 14, further comprising: a second pile driver that is connected to the main body and performs pile driving.
17. The pile driving apparatus according to claim 14, further comprising: a turning device that turns the main body so as to turn the conveyance unit when conveying the components by the conveyance unit.
18. The pile driving apparatus according to claim 14, wherein the conveyance unit includes a first rotator that rotates the component sucked from above by the latching unit to suck the component from below.
19. The pile driving apparatus according to claim 14, wherein the component is rectangular in shape with long and short sides, the conveyance unit includes a rotator that rotates so that the short side is aligned with in a first direction.