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(54) **SHOVEL AND SHOVEL CONTROL SYSTEM**

- (57) A shovel includes a lower traveling body, an upper swiveling body swivelably mounted to the lower traveling body, an attachment attached to the upper swiveling body, an operation device including an electric operation lever, a communication device configured to transmit or receive information to or from an external device, and a control device. The control device is configured to perform switching between first control that controls the lower traveling body, the upper swiveling body,
- the attachment, or any combination thereof in accordance with first operation information received by the operation device, and second control that receives, from the external device, a control signal for controlling the lower traveling body, the upper swiveling body, the attachment, or any combination thereof, and controls the lower traveling body, the upper swiveling body, the attachment, or any combination thereof in accordance with the received control signal.

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Description

BACKGROUND

1. Technical Field

[0001] The present disclosure relates to shovels and shovel control systems.

2. Description of Related Art

[0002] In recent years, what is called an information and communication technology (ICT) shovel has been proposed. The ICT shovel semi-automates or fully-automates operations thereof based on: position information obtained through a global navigation satellite system (GNSS); and three-dimensional design information. For example, International Publication No. WO2018/164152 proposes an ICT shovel that can realize construction assistance in accordance with items set on a setting screen.

[0003] However, for example, the ICT shovel as described in International Publication No. WO2018/164152 needs to include various sensors and high-performance controllers, and thus causes an increase in cost. Here, the high-performance controllers are for performing control based on calculation results obtained by calculating, for example, the position of a working portion of the ICT shovel based on detection results of the sensors. This is not limited to the ICT shovels that semi-automate or fully-automate the operations thereof, such as the ICT shovel described in International Publication No. WO2018/164152, and is applicable to ICT shovels that realize high-level control such as remote control.

[0004] In view of the above, the present disclosure proposes a technique of reducing the operation burden on operators by enabling high-level control with the assistance of an external device, even in a standard shovel that is not provided with, for example, a high-performance controller in the ICT shovel.

SUMMARY

[0005] A shovel according to one embodiment of the present disclosure includes a lower traveling body, an upper swiveling body swivelably mounted to the lower traveling body, an attachment attached to the upper swiveling body, a bucket provided at an end of the attachment, an operation device, a communication device configured to transmit or receive information to or from an external device, and a control device. The control device is configured to perform switching between: first control that controls the upper swiveling body, the attachment, the bucket, or any combination thereof in accordance with first operation information received by the operation device; and second control that receives, from the external device, a control signal for controlling the upper swiveling body, the attachment, the bucket, or any combination thereof, and controls the upper swiveling

body, the attachment, the bucket, or any combination thereof in accordance with the received control signal.

[0006] According to the above-described embodiment, in which the first control and the second control are switchable, it is possible to reduce the burden on operators by switching the controls in accordance with working statuses.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIG. 1 is a schematic view illustrating one example of a shovel control system according to a first embodiment;

FIG. 2 is a block diagram schematically illustrating one example of a configuration of a shovel according to the first embodiment;

FIG. 3 is a view illustrating a configurational example of a drive control system of the shovel according to the first embodiment;

FIG. 4 is a view schematically illustrating one example of a configuration of a hydraulic system of the shovel according to the first embodiment;

FIGS. 5A to 5D are each a view illustrating details of a configuration in relation to a machine control function of the shovel according to the first embodiment;

FIG. 6 is a functional block diagram illustrating one example of a functional configuration of the shovel control system according to the first embodiment;

FIG. 7 is a conceptual view illustrating a virtual working site space generated by a virtual working site space generation part according to the first embodiment;

FIG. 8 is a view illustrating a movement performed in accordance with a control signal received by the shovel according to the first embodiment;

FIG. 9 is a sequence diagram illustrating a flow of a process when semi-automated control of a shovel is performed in the shovel control system according to the first embodiment;

FIG. 10 is a sequence diagram illustrating a flow of a process when fully-automated control of a shovel is performed in a shovel control system according to a second embodiment;

FIG. 11 is a schematic view illustrating a configurational example of a shovel control system according to a third embodiment; and

FIG. 12 is a sequence diagram illustrating a flow of a process when semi-automated control of a shovel is performed by a remote operation in the shovel control system according to the third embodiment.

DETAILED DESCRIPTION

[0008] Hereinafter, embodiments of the present disclosure will be described with reference to the drawings.

The embodiments as described below do not limit the present disclosure but are illustrative. All of the features described in the embodiments and combinations thereof are not necessarily essential to the present disclosure. Note that, throughout the drawings, the same or corresponding components are denoted by the same or corresponding symbols, and description thereof may be omitted.

(First embodiment)

[0009] First, referring to FIG. 1, an overview of a shovel control system SYS will be described. FIG. 1 is a schematic view illustrating one example of the shovel control system SYS according to the first embodiment.

[0010] As illustrated in FIG. 1, the shovel control system SYS according to the first embodiment includes a shovel 100, a management device 300 (one example of the external device), and a fixed-point measurement device 400. The shovel 100, the management device 300, and the fixed-point measurement device 400 can transmit or receive information to or from each other through a communication network NW.

[0011] The number of shovels 100 included in the shovel control system SYS may be one or more. The shovel control system SYS can perform control and the like for each of the shovels 100.

[0012] Also, the number of management devices 300 included in the shovel control system SYS may be one or more. Thereby, the shovel control system SYS can realize various functions by the two or more management devices 300 in a distributed manner.

[0013] Also, the number of fixed-point measurement devices 400 included in the shovel control system SYS may be one or more. Thereby, using the two or more fixed-point measurement devices 400, the shovel control system SYS can measure the space of a working site where the shovel 100 works and recognize the status of the whole working site based on measurement results. The present embodiment will be described as an example using the fixed-point measurement device 400 as one example of a space recognition device for measuring the working site. However, a drone, an operator's space recognition device, or the like may be used.

<Overview of the shovel>

[0014] Referring to FIG. 2, an overview of the shovel 100 according to the present embodiment will be described. FIG. 2 is a lateral view of the shovel 100 as an excavator according to the first embodiment. An upper swiveling body 3 is swivelably mounted via a swiveling mechanism 2 to a lower traveling body 1 of the shovel 100. A boom 4 is attached to the upper swiveling body 3. An arm 5 is attached to an end of the boom 4. A bucket 6, which is an end attachment, is attached to an end of the arm 5. The end attachment may be, for example, a bucket for slope formation or a bucket for dredging.

[0015] The boom 4, the arm 5, and the bucket 6 form an excavating attachment, which is one example of the attachment. The boom 4, the arm 5, and the bucket 6 are hydraulically driven by a boom cylinder 7, an arm cylinder 8, and a bucket cylinder 9, respectively. A boom angle sensor S1 is attached to the boom 4, an arm angle sensor S2 is attached to the arm 5, and a bucket angle sensor S3 is attached to the bucket 6. The excavating attachment may be provided with a bucket tilt mechanism.

[0016] The boom angle sensor S1 is configured to detect a rotation angle of the boom 4. In the present embodiment, the boom angle sensor S1 is an acceleration sensor, and can detect a boom angle that is the rotation angle of the boom 4 with respect to the upper swiveling body 3. The boom angle is, for example, the minimum angle when the boom 4 is moved down to the lowest position, and the boom angle increases as the boom 4 is raised.

[0017] The arm angle sensor S2 is configured to detect a rotation angle of the arm 5. In the present embodiment, the arm angle sensor S2 is an acceleration sensor, and can detect an arm angle that is the rotation angle of the arm 5 with respect to the boom 4. The arm angle is, for example, the minimum angle when the arm 5 is closed at most, and the arm angle increases as the arm 5 is opened.

[0018] The bucket angle sensor S3 is configured to detect a rotation angle of the bucket 6. In the present embodiment, the bucket angle sensor S3 is an acceleration sensor, and can detect a bucket angle that is the rotation angle of the bucket 6 with respect to the arm 5. The bucket angle is, for example, the minimum angle when the bucket 6 is closed at most, and the bucket angle increases as the bucket 6 is opened.

[0019] The boom angle sensor S1, the arm angle sensor S2, and the bucket angle sensor S3 may each be, for example, a potentiometer using a variable resistor, a stroke sensor that detects a stroke amount of a corresponding hydraulic cylinder, or a rotary encoder that detects the rotation angle about a coupling pin. The boom angle sensor S1, the arm angle sensor S2, and the bucket angle sensor S3 form a posture sensor configured to detect a posture of the excavating attachment.

[0020] A cab 10, which is an operation room, is provided in the upper swiveling body 3 and a power source such as an engine 11 is mounted to the upper swiveling body 3. Also, a machine body tilt sensor S4 and a swivel angular velocity sensor S5 are attached to the upper swiveling body 3. Also, a communication device T1 and a positioning device S6 are attached to the upper swiveling body 3.

[0021] The machine body tilt sensor S4 is configured to detect the tilt of the upper swiveling body 3 with respect to a predetermined flat plane. In the present embodiment, the machine body tilt sensor S4 is an acceleration sensor that detects the tilting angle, with respect to the horizontal surface, about the front-back axis of the upper swiveling body 3 and the tilting angle about the left-right axis of the

upper swiveling body 3. The front-back axis and the left-right axis of the upper swiveling body 3 are orthogonal to each other at the center point of the shovel, which is a point on the swiveling axis of the shovel 100, for example.

[0022] The swivel angular velocity sensor S5 is configured to detect a swiveling angular velocity of the upper swiveling body 3. In the present embodiment, the swivel angular velocity sensor S5 is a gyro sensor. The swivel angular velocity sensor S5 may be a resolver, a rotary encoder, or the like. The swivel angular velocity sensor S5 may detect a swiveling velocity. The swiveling velocity may be calculated from the swivel angular velocity.

[0023] The communication device T1 is a device that controls communication between the shovel 100 and the exterior thereof. The communication device T1 controls, for example, wireless communication between an external GNSS (Global Navigation Satellite System) survey system and the shovel 100. The shovel 100 can obtain design data through wireless communication by using the communication device T1. However, the shovel 100 may obtain design data using a semiconductor memory or the like. Note that, the design data includes three-dimensional design data.

[0024] The positioning device S6 is configured to obtain information in relation to a position of the shovel 100. In the present embodiment, the positioning device S6 is configured to measure the position and an orientation of the shovel 100. Specifically, the positioning device S6 is a GNSS receiver including an electronic compass, and measures the latitude, the longitude, and the altitude of the shovel 100 and measures the orientation of the shovel 100. The position information obtained by the positioning device S6 is expressed in a reference coordinate system. The reference coordinate system is, for example, the world geodetic system. The world geodetic system is a three-dimensional orthogonal XYZ coordinate system in which the origin is set at the center of gravity of the globe, the X axis is taken in a direction toward the intersection between the Greenwich meridian and the equator, the Y axis is taken in a direction at 90 degrees of the east longitude, and the Z axis is taken in a direction toward the North Pole.

[0025] In the cab 10, an input device D1, a sound output device D2, a display device D3, a storage device D4, a gate lock lever D5, and a controller 30 are disposed.

[0026] The controller 30 is configured to function as a main control part that performs drive control of the shovel 100. In the present embodiment, the controller 30 is configured by a processor including a CPU, an internal memory, and the like. Various functions of the controller 30 are achieved by, for example, the CPU executing programs stored in the internal memory.

[0027] The input device D1 is a device that enables the operator of the shovel 100 to input various information to the controller 30. In the present embodiment, the input device D1 is a membrane switch that is attached around the display device D3. The input devices D1 may be in-

dividually disposed so as to correspond to each of the display devices D3. In this case, the input device D1 may be a touch panel.

[0028] The sound output device D2 outputs various sound information in accordance with a sound output command from the controller 30. In the present embodiment, the sound output device D2 is an on-board speaker that is directly connected to the controller 30. The sound output device D2 may be an alarm such as a buzzer.

[0029] The display device D3 outputs various image information in accordance with a command from the controller 30. In the present embodiment, the display device D3 is an on-board liquid crystal display that is directly connected to the controller 30.

[0030] The storage device D4 is a device that stores various information. In the present embodiment, as the storage device D4, a non-volatile storage medium, such as a semiconductor memory, is used. The storage device D4 stores design data and the like. The storage device D4 may store various information output by the controller 30 and the like.

[0031] The gate lock lever D5 is a mechanism that prevents the shovel 100 from being wrongly operated. In the present embodiment, the gate lock lever D5 is disposed between a door of the cab 10 and an operation room 10S. When the gate lock lever D5 is pulled upward, various operation devices can become operated. Meanwhile, when the gate lock lever D5 is pressed downward, various operation devices cannot become operated.

[0032] FIG. 3 is a view illustrating a configurational example of a drive control system of the shovel 100 of FIG. 2. In FIG. 3, a mechanical power transmission system is denoted by a double line, a hydraulic oil line is by a bold solid line, a pilot line is by a dashed line, and an electrical driving/control system is by a dotted line.

[0033] A drive system of the shovel 100 according to the present embodiment includes an engine 11, a regulator 13, a main pump 14, and a control valve 17. Also, the hydraulic drive system of the shovel 100 according to the present embodiment includes, as described above, the hydraulic actuators such as traveling hydraulic motors 1L and 1R, a swiveling hydraulic motor 2A, the boom cylinder 7, the arm cylinder 8, and the bucket cylinder 9 that hydraulically drive the lower traveling body 1, the upper swiveling body 3, the boom 4, the arm 5, and the bucket 6, respectively.

[0034] The engine 11 is a main power source in the hydraulic drive system and is provided, for example, at the back portion of the upper swiveling body 3. Specifically, the engine 11 constantly rotates at a preset target rotation speed under direct or indirect control by a controller 30 described below, thereby driving the main pump 14 and a pilot pump 15. The engine 11 is, for example, a diesel engine using diesel oil as a fuel.

[0035] The regulator 13 controls the discharge amount of the main pump 14. For example, the regulator 13 adjusts the angle of a swashplate (tilting angle) of the main pump 14 in accordance with a control command from the

controller 30. As described below, for example, the regulator 13 includes regulators 13L and 13R.

[0036] Similar to the engine 11, the main pump 14 is provided, for example, at the back portion of the upper swiveling body 3, and feeds hydraulic oil to the control valve 17 through the high-pressure hydraulic line. The main pump 14 is, as described above, driven by the engine 11. The main pump 14 is, for example, a variable displacement hydraulic pump. As described above, when the tilting angle of the swashplate is adjusted by the regulator 13 under control by the controller 30, the stroke length of the piston is adjusted and the discharge flow rate (discharge pressure) is controlled. For example, the main pump 14 includes main pumps 14L and 14R as described below.

[0037] The control valve 17 is a hydraulic control device that controls a hydraulic system in the shovel 100. In the present embodiment, the control valve 17 includes control valves 171 to 176. The control valve 175 includes a control valve 175L and a control valve 175R, and the control valve 176 includes a control valve 176L and a control valve 176R. The control valve 17 can selectively feed the hydraulic oil discharged by the main pump 14 to one or more hydraulic actuators through the control valves 171 to 176. The control valves 171 to 176 control, for example, the flow rate of the hydraulic oil flowing from the main pump 14 to the hydraulic actuators and the flow rate of the hydraulic oil flowing from the hydraulic actuators to a hydraulic oil tank. The hydraulic actuator includes the boom cylinder 7, the arm cylinder 8, the bucket cylinder 9, the traveling hydraulic motors 1L and 1R, and the swiveling hydraulic motor 2A. More specifically, the control valve 171 corresponds to the left traveling hydraulic motor 1L, the control valve 172 corresponds to the right traveling hydraulic motor 1R, and the control valve 173 corresponds to the swiveling hydraulic motor 2A. Also, the control valve 174 corresponds to the bucket cylinder 9, the control valve 175 corresponds to the boom cylinder 7, and the control valve 176 corresponds to the arm cylinder 8. Also, for example, the control valve 175 includes control valves 175L and 175R as described below, and for example, the control valve 176 includes control valves 176L and 176R as described below. Details of the control valves 171 to 176 will be described below.

[0038] The pilot pump 15 is one example of a pilot pressure generating device, and is configured to feed the hydraulic oil to a hydraulic pressure control device through the pilot line. In the present embodiment, the pilot pump 15 is a fixed displacement hydraulic pump. However, the pilot pressure generating device may be achieved by the main pump 14. That is, the main pump 14 may have a function of feeding the hydraulic oil to various hydraulic control devices through the pilot line, in addition to the function of feeding the hydraulic oil to the control valve 17 through the hydraulic oil line. In this case, the pilot pump 15 may be omitted.

[0039] The operation device 26 is a device used by an operator for operating the actuator. The actuator includes

the hydraulic actuator, an electric-powered actuator, or both.

[0040] The discharge pressure sensor 28 is configured to detect the discharge pressure of the main pump 14. In the present embodiment, the discharge pressure sensor 28 outputs a detected value to the controller 30. For example, the discharge pressure sensor 28 includes discharge pressure sensors 28L and 28R, as described below.

[0041] An operation sensor 29 is configured to detect an operation content of the operator using the operation device 26. In the present embodiment, the operation sensor 29 detects the direction and the amount of the operation of the operation device 26 corresponding to each of the actuators, and outputs a detected value to the controller 30. In the present embodiment, the controller 30 controls an opening area of a proportional valve 31 in accordance with the output of the operation sensor 29. The controller 30 feeds the hydraulic oil discharged by the pilot pump 15 to pilot ports of corresponding control valves in the control valve 17. The pressure (pilot pressure) of the hydraulic oil fed to each of the pilot ports is, in principle, a pressure in accordance with the direction and the amount of the operation of the operation device 26 corresponding to each of the hydraulic actuators. In this way, the operation device 26 is configured to feed the hydraulic oil discharged by the pilot pump 15 to the pilot ports of the corresponding control valves in the control valve 17.

[0042] The proportional valve 31, which functions as a machine control valve, is disposed in a conduit connecting the pilot pump 15 to the pilot port of the control valve in the control valve 17 and is configured to change the flow area of the conduit. In the present embodiment, the proportional valve 31 operates in response to a control command output by the controller 30. Thus, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the pilot port of the control valve in the control valve 17 through the proportional valve 31, independently of the operation of the operation device 26 by the operator. For example, the proportional valve 31 includes proportional valves 31AL, 31AR, 31BL, 31BR, 31CL, and 31CR, as described below.

[0043] With this configuration, even if no operation is being performed on a specific operation device 26, the controller 30 can operate the hydraulic actuator corresponding to the specific operation device 26.

[0044] For example, the controller 30 sets the target rotation speed based on, for example, a working mode that is previously set by a predetermined operation of the operator or the like, and performs drive control that constantly rotates the engine 11.

[0045] Also, for example, the controller 30, if necessary, outputs a control command to the regulator 13, and changes the discharge amount of the main pump 14.

[0046] Also, for example, the controller 30 performs, for example, control in relation to a machine guidance function that guides a manual operation of the shovel 100

by the operator through the operation device 26. Also, the controller 30 performs, for example, control in relation to a machine control function that automatically assists a manual operation of the shovel 100 by the operator through the operation device 26.

[0047] Note that, a part of the functions of the controller 30 may be realized by another controller (control device). In other words, the functions of the controller 30 may be realized in a distributed manner by a plurality of controllers. For example, the machine guidance function and the machine control function may be realized by dedicated controllers (control devices).

[Hydraulic system of the shovel]

[0048] Next, referring to FIG. 4, a hydraulic system of the shovel 100 according to the present embodiment will be described.

[0049] FIG. 4 is a view schematically illustrating one example of a configuration of the hydraulic system of the shovel 100 according to the present embodiment.

[0050] Note in FIG. 4 that, similar to FIG. 3 and the like, a mechanical power system is denoted by a double line, a hydraulic oil line is by a solid line, a pilot line is by a dashed line, and an electrical driving/control system is by a dotted line.

[0051] The hydraulic system realized by the hydraulic circuit circulates the hydraulic oil from the respective main pumps 14L and 14R driven by the engine 11 to the hydraulic oil tank through center bypass oil paths C1L and C1R and parallel oil paths C2L and C2R.

[0052] The center bypass oil path C1L starts with the main pump 14L, and sequentially passes through the control valves 171, 173, 175L, and 176L disposed in the control valve 17 and reaches the hydraulic oil tank.

[0053] The center bypass oil path C1R starts with the main pump 14R, and sequentially passes through the control valves 172, 174, 175R, and 176R disposed in the control valve 17 and reaches the hydraulic oil tank.

[0054] The control valve 171 is a spool valve that feeds the hydraulic oil discharged from the main pump 14L to the traveling hydraulic motor 1L, and discharges the hydraulic oil discharged by the traveling hydraulic motor 1L to the hydraulic oil tank.

[0055] The control valve 172 is a spool valve that feeds the hydraulic oil discharged from the main pump 14R to the traveling hydraulic motor 1R, and discharges the hydraulic oil discharged by the traveling hydraulic motor 1R to the hydraulic oil tank.

[0056] The control valve 173 is a spool valve that feeds the hydraulic oil discharged from the main pump 14L to the swiveling hydraulic motor 2A, and discharges the hydraulic oil discharged by the swiveling hydraulic motor 2A to the hydraulic oil tank.

[0057] The control valve 174 is a spool valve that feeds the hydraulic oil discharged from the main pump 14R to the bucket cylinder 9, and discharges the hydraulic oil in the bucket cylinder 9 to the hydraulic oil tank.

[0058] The control valves 175L and 175R are spool valves that feed the hydraulic oil discharged by the main pumps 14L and 14R to the boom cylinder 7, and discharge the hydraulic oil in the boom cylinder 7 to the hydraulic oil tank.

[0059] The control valves 176L and 176R feed the hydraulic oil discharged by the main pumps 14L and 14R to the arm cylinder 8, and discharge the hydraulic oil in the arm cylinder 8 to the hydraulic oil tank.

[0060] In accordance with the pilot pressure applied to the pilot port, each of the control valves 171, 172, 173, 174, 175L, 175R, 176L, and 176R adjusts the flow rate of the hydraulic oil to be fed to or discharged from the hydraulic actuator, and switches the flowing direction.

[0061] The parallel oil path C2L feeds the hydraulic oil of the main pump 14L to the control valves 171, 173, 175L, and 176L in parallel to the center bypass oil path C1L. Specifically, the parallel oil path C2L branches from the center bypass oil path C1L upstream of the control valve 171, and is configured to feed the hydraulic oil of the main pump 14L to the control valves 171, 173, 175L, and 176R, in parallel. Thereby, when the flow of the hydraulic oil passing through the center bypass oil path C1L is restricted or blocked by any one of the control valves 171, 173, and 175L, the parallel oil path C2L can feed the hydraulic oil to the more downstream control valve.

[0062] The parallel oil path C2R feeds the hydraulic oil of the main pump 14R to the control valves 172, 174, 175R, and 176R in parallel to the center bypass oil path C1R. Specifically, the parallel oil path C2R branches from the center bypass oil path C1R upstream of the control valve 172, and is configured to feed the hydraulic oil of the main pump 14R to the control valves 172, 174, 175R, and 176R, in parallel. When the flow of the hydraulic oil passing through the center bypass oil path C1R is restricted or blocked by any one of the control valves 172, 174, and 175R, the parallel oil path C2R can feed the hydraulic oil to the more downstream control valve.

[0063] The regulators 13L and 13R adjust the tilting angles of the swashplates of the main pumps 14L and 14R under control by the controller 30, thereby adjusting the discharge amounts of the main pumps 14L and 14R.

[0064] The discharge pressure sensor 28L detects the discharge pressure of the main pump 14L, and a detection signal corresponding to the detected discharge pressure is input to the controller 30. The same applies to the discharge pressure sensor 28R. Thereby, the controller 30 can control the regulators 13L and 13R in accordance with the discharge pressures of the main pumps 14L and 14R.

[0065] In the center bypass oil paths C1L and C1R, restrictors for negative control (hereinafter referred to as "negative-control restrictors") 18L and 18R are provided between the most downstream control valves 176L and 176R and the hydraulic oil tank. Thereby, the flow of the hydraulic oil discharged by the main pumps 14L and 14R is restricted by the negative-control restrictors 18L and 18R. The negative-control restrictors 18L and 18R gen-

erate control pressures (hereinafter referred to as "negative-control pressures) for controlling the regulators 13L and 13R.

[0066] Negative-control pressure sensors 19L and 19R detect the negative-control pressures, and detection signals corresponding to the detected negative-control pressures are input to the controller 30.

[0067] In accordance with the discharge pressures of the main pumps 14L and 14R detected by the discharge pressure sensors 28L and 28R, the controller 30 may control the regulators 13L and 13R and adjust the discharge amounts of the main pumps 14L and 14R. For example, in accordance with an increase in the discharge pressure of the main pump 14L, the controller 30 may control the regulator 13L and adjust the tilting angle of the swashplate of the main pump 14L, thereby reducing the discharge amount. The same applies to the regulator 13R. Thereby, the controller 30 can control the total horsepower of the main pumps 14L and 14R so that the suction horsepower of the main pumps 14L and 14R, which is represented by a product of the discharge pressure and the discharge amount, does not exceed the output horsepower of the engine 11.

[0068] Also, in accordance with the negative-control pressures detected by the negative-control pressure sensors 19L and 19R, the controller 30 may control the regulators 13L and 13R and adjust the discharge amounts of the main pumps 14L and 14R. For example, the controller 30 reduces the discharge amounts of the main pumps 14L and 14R at higher negative-control pressures, and increases the discharge amounts of the main pumps 14L and 14R at lower negative-control pressures.

[0069] Specifically, when the shovel 100 is in a standby state in which all of the hydraulic actuators are not operated (the state as illustrated in FIG. 4), the hydraulic oil discharged from the main pumps 14L and 14R passes through the center bypass oil paths C1L and C1R to reach the negative-control restrictors 18L and 18R. Then, the flow of the hydraulic oil discharged from the main pumps 14L and 14R increases the negative-control pressures generated upstream of the negative-control restrictors 18L and 18R. As a result, the controller 30 reduces the discharge amounts of the main pumps 14L and 14R to allowable minimum discharge amounts, and suppresses pressure loss (pumping loss) when the discharged hydraulic oil passes through the center bypass oil paths C1L and C1R.

[0070] Meanwhile, when any one of the hydraulic actuators is operated through the operation device 26, the hydraulic oil discharged from the main pumps 14L and 14R flows into the operated hydraulic actuator via the control valve corresponding to the operated hydraulic actuator. Then, the amount of the flow of the hydraulic oil discharged from the main pumps 14L and 14R that reaches the negative-control restrictors 18L and 18R is reduced or eliminated, resulting in reducing the negative-control pressures generated upstream of the negative-

control restrictors 18L and 18R. As a result, the controller 30 increases the discharge amounts of the main pumps 14L and 14R and circulates a sufficient amount of the hydraulic oil in the operated hydraulic actuator. This can reliably drive the operated hydraulic actuator.

[0071] The operation device 26 includes a left operation lever 26L, a right operation lever 26R, and a traveling lever 26D. The traveling lever 26D includes a left traveling lever 26DL and a right traveling lever 26DR.

[0072] The left operation lever 26L is used for the swivel operation and the operation of the arm 5. The left operation lever 26L, when operated in the forward and backward directions, utilizes the hydraulic oil discharged by the pilot pump 15 to introduce a control pressure in accordance with the amount of the lever operation into the pilot port of the control valve 176. Also, the left operation lever 26L, when operated in the leftward and rightward directions, utilizes the hydraulic oil discharged by the pilot pump 15 to introduce the control pressure in accordance with the amount of the lever operation into the pilot port of the control valve 173.

[0073] Specifically, the left operation lever 26L introduces the hydraulic oil to the right pilot port of the control valve 176L and introduces the hydraulic oil to the left pilot port of the control valve 176R when operated in an arm closing direction. Also, the left operation lever 26L, when operated in an arm opening direction, introduces the hydraulic oil to the left pilot port of the control valve 176L and introduces the hydraulic oil to the right pilot port of the control valve 176R. Also, the left operation lever 26L introduces the hydraulic oil to the left pilot port of the control valve 173 when operated in a leftward swiveling direction and introduces the hydraulic oil to the right pilot port of the control valve 173 when operated in a rightward swiveling direction.

[0074] The right operation lever 26R is used to operate the boom 4 and the bucket 6. The right operation lever 26R utilizes the hydraulic oil discharged by the pilot pump 15 when operated in the forward and backward directions to introduce a control pressure in accordance with the amount of the lever operation into the pilot port of the control valve 175. When operated in the leftward and rightward directions, the hydraulic oil discharged by the pilot pump 15 is used to introduce the control pressure in accordance with the amount of the lever operation into the pilot port of the control valve 174.

[0075] Specifically, the right operation lever 26R introduces the hydraulic oil to the left pilot port of the control valve 175R when operated in a boom lowering direction. The right operation lever 26R, when operated in a boom raising direction, introduces the hydraulic oil to the right pilot port of the control valve 175L and introduces the hydraulic oil to the left pilot port of the control valve 175R. The right operation lever 26R introduces the hydraulic oil to the right pilot port of the control valve 174 when operated in a bucket closing direction, and introduces the hydraulic oil to the left pilot port of the control valve 174 when operated in a bucket opening direction.

[0076] In the following, the left operation lever 26L operated in the leftward and rightward directions may be referred to as a "swivel operation lever" and the left operation lever 26L operated in the forward and backward directions may be referred to as an "arm operation lever". The right operation lever 26R operated in the leftward and rightward directions may be referred to as a "bucket operation lever" and the right operation lever 26R operated in the forward and backward directions may be referred to as a "boom operation lever".

[0077] The left traveling lever 26DL is used to operate a left crawler 1CL. The left traveling lever 26DL may be configured to interlock with a left traveling pedal. The left traveling lever 26DL, when operated in the forward and backward directions, utilizes the hydraulic oil discharged by the pilot pump 15 to introduce the control pressure in accordance with the amount of the lever operation into the pilot port of the control valve 171. The right traveling lever 26DR is used to operate a right crawler 1CR. The right traveling lever 26DR may be configured to interlock with a right traveling pedal. The right traveling lever 26DR, when operated in the forward and backward directions, utilizes the hydraulic oil discharged by the pilot pump 15 to introduce the control pressure in accordance with the amount of the lever operation into the pilot port of the control valve 172.

[0078] The operation sensor 29 is configured to detect an operation content of the operator using the operation device 26. In the present embodiment, the operation sensor 29 detects the direction and the amount of the operation of the operation device 26 corresponding to each of the actuators, and outputs a detected value to the controller 30.

[0079] The operation sensor 29 includes operation sensors 29LA, 29LB, 29RA, 29RB, 29DL, and 29DR. The operation sensor 29LA detects the content of the operation in the forward and backward directions by the operator relative to the left operation lever 26L and outputs a detected value to the controller 30. The content of the operation is, for example, the direction of the lever operation and the amount of the lever operation (angle of the lever operation).

[0080] Similarly, the operation sensor 29LB detects the content of the operation by the operator in the leftward and rightward directions relative to the left operation lever 26L and outputs a detected value to the controller 30. The operation sensor 29RA detects the content of the operation by the operator in the forward and backward directions relative to the right operation lever 26R and outputs a detected value to the controller 30. The operation sensor 29RB detects the content of the operation by the operator in the leftward and rightward directions relative to the right operation lever 26R and outputs a detected value to the controller 30. The operation sensor 29DL detects the content of the operation by the operator in the forward and backward directions relative to the left traveling lever 26DL and outputs a detected value to the controller 30. The operation sensor 29DR detects the

content of the operation by the operator in the forward and backward directions relative to the right traveling lever 26DR and outputs a detected value to the controller 30.

[0081] The controller 30 receives the output of the operation sensor 29 and outputs a control command to the regulator 13 as needed to change the discharge amount of the main pump 14. The controller 30 receives an output of a control pressure sensor 19 disposed upstream of a restrictor 18, and outputs a control command to the regulator 13 as needed to change the discharge amount of the main pump 14. The restrictor 18 includes a left restrictor 18L and a right restrictor 18R, and the control pressure sensor 19 includes the negative-control pressure sensors 19L and 19R.

[Details of configuration in relation to the machine control function of the shovel]

[0082] Next, referring to FIGS. 5A to 5D, details of the configuration in relation to the machine control function of the shovel 100 will be described.

[0083] FIGS. 5A to 5D are views of parts extracted from the hydraulic system. Specifically, FIG. 5A is a view of a part extracted from the hydraulic system in relation to the operation of the arm cylinder 8. FIG. 5B is a view of a part extracted from the hydraulic system in relation to the operation of the boom cylinder 7. FIG. 5C is a view of a part extracted from the hydraulic system in relation to the operation of the bucket cylinder 9. FIG. 5D is a view of a part extracted from the hydraulic system in relation to the operation of the swiveling hydraulic motor 2A.

[0084] As illustrated in FIGS. 5A to 5D, the hydraulic system includes the proportional valve 31. The proportional valve 31 includes proportional valves 31AL to 31DL and 31AR to 31DR.

[0085] The proportional valve 31 functions as a control valve for machine control. The proportional valve 31 is disposed in a conduit connecting the pilot pump 15 to the pilot port of the corresponding control valve in the control valve 17, and is configured to change the flow path area of the conduit. In the present embodiment, the proportional valve 31 operates in response to a control command output by the controller 30. Thus, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the pilot port of the corresponding control valve in the control valve 17 through the proportional valve 31, independently of the operation of the operation device 26 by the operator. The controller 30 can apply a pilot pressure generated by the proportional valve 31 to the pilot port of the corresponding control valve.

[0086] With this configuration, even if no operation is being performed on a specific operation device 26, the controller 30 can operate the hydraulic actuator corresponding to the specific operation device 26. Also, even if an operation is being performed on the specific operation device 26, the controller 30 can forcibly stop the operation of the hydraulic actuator corresponding to the

specific operation device 26.

[0087] For example, as illustrated in FIG. 5A, the left operation lever 26L is used to operate the arm 5. Specifically, the left operation lever 26L utilizes the hydraulic oil discharged by the pilot pump 15 to apply a pilot pressure to the pilot port of the control valve 176 in response to the operation in the forward and backward directions. More specifically, the left operation lever 26L, when operated in the arm closing direction (backward direction), applies a pilot pressure in accordance with the operation amount to the right pilot port of the control valve 176L and the left pilot port of the control valve 176R. Also, the left operation lever 26L, when operated in the arm opening direction (forward direction), applies a pilot pressure in accordance with the operation amount to the left pilot port of the control valve 176L and the right pilot port of the control valve 176R.

[0088] The operation device 26 is provided with a switch SW. In the present embodiment, the switch SW includes a switch SW1 and a switch SW2. The switch SW1 is a push-button switch provided at the end of the left operation lever 26L. The operator can operate the left operation lever 26L while pressing the switch SW1. The switch SW1 may be provided at the right operation lever 26R or at other locations within the cab 10. The switch SW2 is a push-button switch provided at the end of the left traveling lever 26DL. The operator can operate the left traveling lever 26DL while pressing the switch SW2. The switch SW2 may be provided at the right traveling lever 26DR or at other locations within the cab 10.

[0089] The operation sensor 29LA detects the content of the operation in the forward and backward directions by the operator relative to the left operation lever 26L and outputs a detected value to the controller 30.

[0090] The proportional valve 31AL operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the hydraulic oil introduced from the pilot pump 15 to the right pilot port of the control valve 176L and the left pilot port of the control valve 176R through the proportional valve 31AL. The proportional valve 31AR operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the hydraulic oil introduced from the pilot pump 15 to the left pilot port of the control valve 176L and the right pilot port of the control valve 176R through the proportional valve 31AR. The proportional valve 31AL can adjust the pilot pressure so that the control valve 176L and the control valve 176R can be stopped at a given valve position. Similarly, the proportional valve 31AR can adjust the pilot pressure so that the control valve 176L and the control valve 176R can be stopped at a given valve position.

[0091] With this configuration, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the right pilot port of the control valve 176L and the left pilot port of the control valve 176R through the propor-

tional valve 31AL in response to the arm closing operation by the operator. Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the right pilot port of the control valve 176L and the left pilot port of the control valve 176R through the proportional valve 31AL independently of the arm closing operation by the operator. That is, the controller 30 can close the arm 5 in response to the arm closing operation by the operator or independently of the arm closing operation by the operator.

[0092] Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the left pilot port of the control valve 176L and the right pilot port of the control valve 176R through the proportional valve 31AR in response to the arm opening operation by the operator. Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the left pilot port of the control valve 176L and the right pilot port of the control valve 176R through the proportional valve 31AR independently of the arm opening operation by the operator. That is, the controller 30 can open the arm 5 in response to the arm opening operation by the operator or independently of the arm opening operation by the operator.

[0093] With this configuration, even if the arm closing operation is being performed by the operator, the controller 30, as needed, can reduce the pilot pressure applied to the pilot port on the closing side of the control valve 176 (the left pilot port of the control valve 176L and the right pilot port of the control valve 176R) and forcibly stop the closing movement of the arm 5. The same applies to the case of forcibly stopping the opening movement of the arm 5 when the arm opening operation is performed by the operator.

[0094] Even if the arm closing operation is being performed by the operator, the controller 30, as needed, may forcibly stop the closing movement of the arm 5 by controlling the proportional valve 31AR to increase the pilot pressure applied to the pilot port on the opening side of the control valve 176, which is located opposite to the pilot port on the closing side of the control valve 176, (the right pilot port of the control valve 176L and the left pilot port of the control valve 176R), thereby forcibly returning the control valve 176 to a neutral position. The same applies to the case of forcibly stopping the opening movement of the arm 5 when the arm opening operation is performed by the operator.

[0095] Although description with reference to FIGS. 5B to 5D is omitted in the following, the same applies to: the case of forcibly stopping the movement of the boom 4 when a boom raising operation or a boom lowering operation is being performed by the operator; the case of forcibly stopping the movement of the bucket 6 when a bucket closing operation or a bucket opening operation is being performed by the operator; and the case of forcibly stopping the swiveling movement of the upper swiveling body 3 when a swiveling operation is being performed by the operator.

[0096] Also, the same applies to the case of forcibly

stopping a traveling movement of the lower traveling body 1 when a traveling operation is being performed by the operator.

[0097] Also, as illustrated in FIG. 5B, the right operation lever 26R is used to operate the boom 4. Specifically, the right operation lever 26R utilizes the hydraulic oil discharged by the pilot pump 15 to apply a pilot pressure to the pilot port of the control valve 175 in response to the operation in the forward and backward directions. More specifically, the right operation lever 26R, when operated in the boom raising direction (backward direction), applies a pilot pressure in accordance with the operation amount to the right pilot port of the control valve 175L and the left pilot port of the control valve 175R. The right operation lever 26R, when operated in the boom lowering direction (forward direction), applies a pilot pressure in accordance with the operation amount to the right pilot port of the control valve 175R.

[0098] The operation sensor 29RA detects the content of the operation in the forward and backward directions by the operator relative to the right operation lever 26R and outputs a detected value to the controller 30.

[0099] The proportional valve 31BL operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the hydraulic oil introduced from the pilot pump 15 to the right pilot port of the control valve 175L and the left pilot port of the control valve 175R through the proportional valve 31BL. The proportional valve 31BR operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the hydraulic oil introduced from the pilot pump 15 to the right pilot port of the control valve 175R through the proportional valve 31BR. The proportional valve 31BL can adjust the pilot pressure so that the control valve 175L and the control valve 175R can be stopped at a given valve position. Also, the proportional valve 31BR can adjust the pilot pressure so that the control valve 175R can be stopped at a given valve position.

[0100] With this configuration, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the right pilot port of the control valve 175L and the left pilot port of the control valve 175R through the proportional valve 31BL in response to the boom raising operation by the operator. Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the right pilot port of the control valve 175L and the left pilot port of the control valve 175R through the proportional valve 31BL independently of the boom raising operation by the operator. That is, the controller 30 can raise the boom 4 in response to the boom raising operation by the operator or independently of the boom raising operation by the operator.

[0101] Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the right pilot port of the control valve 175R through the proportional valve 31BR in response to the boom lowering operation by the

operator. Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the right pilot port of the control valve 175R through the proportional valve 31BR independently of the boom lowering operation by the operator. That is, the controller 30 can lower the boom 4 in response to the boom lowering operation by the operator or independently of the boom lowering operation by the operator.

[0102] As illustrated in FIG. 5C, the right operation lever 26R is also used to operate the bucket 6. Specifically, the right operation lever 26R utilizes the hydraulic oil discharged by the pilot pump 15 to apply a pilot pressure to the pilot port of the control valve 174 in response to the operation in the leftward and rightward directions. More specifically, the right operation lever 26R, when operated in the bucket closing direction (leftward direction), applies a pilot pressure in accordance with the operation amount to the left pilot port of the control valve 174. The right operation lever 26R, when operated in the bucket opening direction (rightward direction), applies a pilot pressure in accordance with the operation amount to the right pilot port of the control valve 174.

[0103] The operation sensor 29RB detects the content of the operation in the leftward and rightward directions by the operator relative to the right operation lever 26R and outputs a detected value to the controller 30.

[0104] The proportional valve 31CL operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the hydraulic oil introduced from the pilot pump 15 to the left pilot port of the control valve 174 through the proportional valve 31CL. The proportional valve 31CR operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the hydraulic oil introduced from the pilot pump 15 to the right pilot port of the control valve 174 through the proportional valve 31CR. The proportional valve 31CL can adjust the pilot pressure so that the control valve 174 can be stopped at a given valve position. Similarly, the proportional valve 31CR can adjust the pilot pressure so that the control valve 174 can be stopped at a given valve position.

[0105] With this configuration, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the left pilot port of the control valve 174 through the proportional valve 31CL in response to the bucket closing operation by the operator. Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the left pilot port of the control valve 174 through the proportional valve 31CL independently of the bucket closing operation by the operator. That is, the controller 30 can close the bucket 6 in response to the bucket closing operation by the operator or independently of the bucket closing operation by the operator.

[0106] Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the right pilot port of the control valve 174 through the proportional valve 31CR in response to the bucket opening operation by the

the operator. Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the right pilot port of the control valve 174 through the proportional valve 31CR independently of the bucket opening operation by the operator. That is, the controller 30 can open the bucket 6 in response to the bucket opening operation by the operator or independently of the bucket opening operation by the operator.

[0107] As illustrated in FIG. 5D, the left operation lever 26L is also used to operate the swiveling mechanism 2. Specifically, the left operation lever 26L utilizes the hydraulic oil discharged by the pilot pump 15 to apply a pilot pressure to the pilot port of the control valve 173 in response to the operation in the leftward and rightward directions. More specifically, the left operation lever 26L, when operated in the leftward swiveling direction (leftward direction), applies a pilot pressure in accordance with the operation amount to the left pilot port of the control valve 173. The left operation lever 26L, when operated in the rightward swiveling direction (rightward direction), applies a pilot pressure in accordance with the operation amount to the right pilot port of the control valve 173.

[0108] The operation sensor 29LB detects the content of the operation in the leftward and rightward directions by the operator relative to the left operation lever 26L and outputs a detected value to the controller 30.

[0109] The proportional valve 31DL operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the hydraulic oil introduced from the pilot pump 15 to the left pilot port of the control valve 173 through the proportional valve 31DL. The proportional valve 31DR operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the hydraulic oil introduced from the pilot pump 15 to the right pilot port of the control valve 173 through the proportional valve 31DR. The proportional valve 31DL can adjust the pilot pressure so that the control valve 173 can be stopped at a given valve position. Similarly, the proportional valve 31DR can adjust the pilot pressure so that the control valve 173 can be stopped at a given valve position.

[0110] With this configuration, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the left pilot port of the control valve 173 through the proportional valve 31DL in response to the leftward swiveling operation by the operator. Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the left pilot port of the control valve 173 through the proportional valve 31DL independently of the leftward swiveling operation by the operator. That is, the controller 30 can swivel the swiveling mechanism 2 leftward in response to the leftward swiveling operation by the operator or independently of the leftward swiveling operation by the operator.

[0111] Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the right pilot port of

the control valve 173 through the proportional valve 31DR in response to the rightward swiveling operation by the operator. Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the right pilot port of the control valve 173 through the proportional valve 31DR independently of the rightward swiveling operation by the operator. That is, the controller 30 can swivel the swiveling mechanism 2 rightward in response to the rightward swiveling operation by the operator or independently of the rightward swiveling operation by the operator.

[0112] The left traveling lever 26DL is also used to operate the left crawler 1CL. Specifically, the left traveling lever 26DL utilizes the hydraulic oil discharged by the pilot pump 15 to apply a pilot pressure in accordance with the operation in the forward and backward directions to the pilot port of the control valve 171. The operation sensor 29DL electrically detects the content of the operation in the forward and backward directions by the operator relative to the left traveling lever 26DL, and outputs an electric current command indicating a detected value to the controller 30. Thereby, the controller 30 operates in response to the electric current command.

[0113] Similar to the above-described configuration, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the left pilot port of the control valve 171 through an unillustrated proportional valve. That is, the left crawler 1CL can be caused to travel forward. Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the right pilot port of the control valve 171 through an unillustrated proportional valve. That is, the left crawler 1CL can be caused to travel backward.

[0114] The right traveling lever 26DR is also used to operate the right crawler 1CR. Specifically, the right traveling lever 26DR utilizes the hydraulic oil discharged by the pilot pump 15 to apply a pilot pressure in accordance with the operation in the forward and backward directions to the pilot port of the control valve 172. The operation sensor 29DR electrically detects the content of the operation in the forward and backward directions by the operator relative to the right traveling lever 26DR, and outputs an electric current command indicating a detected value to the controller 30. Thereby, the controller 30 operates in response to the electric current command.

[0115] Similar to the above-described configuration, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the right pilot port of the control valve 172 through the proportional valve 31. That is, the right crawler 1CR can be caused to travel forward. Also, the controller 30 can feed the hydraulic oil discharged by the pilot pump 15 to the left pilot port of the control valve 172 through the proportional valve 31. That is, the right crawler 1CR can be caused to travel backward.

[0116] Also, the shovel 100 may include a structure configured to automatically operate the bucket tilt mechanism. In this case, a part of the hydraulic system in relation to a bucket tilt cylinder forming the bucket tilt mechanism may be configured in the same manner as in, for

example, the part of the hydraulic system in relation to the operation of the boom cylinder 7.

[0117] Although the operation device 26 that is an electric operation lever has been described, the operation device 26 may be a hydraulic operation lever rather than the electric operation lever. In this case, the amount of the lever operation of the hydraulic operation lever may be detected by a pressure sensor in the form of pressure and input to the controller 30. Also, an electromagnetic valve may be disposed between the operation device 26 that is the hydraulic operation lever, and the pilot port of each of the control valves. The electromagnetic valve is configured to operate in response to an electric signal from the controller 30. With this configuration, in response to manually operating the operation device 26 that is the hydraulic operation lever, the operation device 26 increases or decreases a pilot pressure in accordance with the amount of the lever operation, thereby moving each of the control valves. Also, each of the control valves may be configured with an electromagnetic spool valve. In this case, the electromagnetic spool valve operates in response to an electric signal from the controller 30 corresponding to the amount of the lever operation of the electric operation lever.

[0118] FIG. 6 is a functional block diagram illustrating one example of a functional configuration of the shovel control system SYS according to the present embodiment. Configurations of the management device 300 and the fixed-point measurement device 400 will be described. Note that, the configuration of the shovel 100 is as described above, and description thereof will be omitted.

<Configuration of the management device>

[0119] The management device (one example of the external device) 300 includes a communication device 301, a storage device 302, and a controller 303.

[0120] The communication device 301 is an interface that communicates through the communication network NW with the shovel 100 and the exterior thereof, such as the fixed-point measurement device 400. The communication device 301 may be a mobile communication module responding to a mobile communication standard, such as LTE, 4G, or 5G.

[0121] The controller 303 performs control in relation to the management device 300. The functions of the controller 303 may be realized by, for example, given hardware or a combination of given hardware and given software. For example, the controller 303 may be mainly composed of a computer including: a processor device, such as a CPU; a memory device (main storage device), such as a RAM; an auxiliary storage device, such as a ROM; an interface device with the exterior thereof; and the like. For example, the controller 303 realizes various functions by loading, in the memory device, a program installed in the auxiliary storage device, and executing the program on the CPU. Data of the program is, for ex-

ample, obtained by the controller 303 from a predetermined storage medium through a predetermined external interface, and installed in the auxiliary storage device.

[0122] The storage device 302 is a readable/writable non-volatile storage medium. The storage device 302 includes a construction information storage part 321 and a working site information storage part 322.

[0123] The construction information storage part 321 stores construction information for the shovel 100 to operate in the working site. The construction information is three-dimensional data representing shapes, after construction, of soil and sand and the like existing in the working site. In the construction information, three-dimensional shapes and positions of objects after construction are expressed in the above-described reference coordinate system.

[0124] The working site information storage part 322 stores working site information representing a three-dimensional shape of a virtual working site space generated based on measurement information obtained by the fixed-point measurement device 400. The working site information retains three-dimensional shapes and positions of current objects in the working site in the above-described reference coordinate system.

<Configuration of the fixed-point measurement device>

[0125] The fixed-point measurement device 400 includes a communication device 401, a position information storage part 402, a space recognition device 403, and a controller 404.

[0126] The communication device 401 is an interface that communicates through the communication network NW with the shovel 100 and the exterior thereof, such as the management device 300. The communication device 401 may be a mobile communication module responding to a mobile communication standard, such as LTE, 4G, or 5G.

[0127] The position information storage part 402 stores position information of the fixed-point measurement device 400. The position information is, for example, expressed in a reference coordinate system like in position information obtained by the GNSS. The reference coordinate system is, for example, the above-described world geodetic system.

[0128] As the space recognition device 403, a LIDAR sensor is used for detecting the objects existing in the working site where the shovel 100 is working. The LIDAR sensor measures, for example, distances between the LIDAR sensor and one million or more points within a surveillance range. Note that, the present embodiment is not limited to a method using the LIDAR sensor, and may use a space recognition device that can measure distances between the space recognition device and objects. The space recognition device may be, for example, a stereo camera or a distance measurement device, such as a distance image camera or a millimeter wave radar. When a millimeter wave radar or the like is used as the

space recognition device 403, the space recognition device 403 may emit many signals (e.g., laser beams) toward objects, and receive reflected signals, thereby deriving distances and directions of the objects from the reflected signals.

[0129] The controller 404 performs control in relation to the fixed-point measurement device 400. The functions of the controller 404 may be realized by, for example, given hardware or a combination of given hardware and given software. For example, the controller 404 may be mainly composed of a computer including: a processor device, such as a CPU; a memory device (main storage device), such as a RAM; an auxiliary storage device, such as a ROM; and the like. For example, the controller 404 realizes various functions by loading, in the memory device, a program installed in the auxiliary storage device, and executing the program on the CPU.

[Description of services provided to the shovel]

[0130] The shovel 100 according to the present embodiment does not include the space recognition device or the like. A shovel controller 50 of the shovel 100 does not include any program for performing high-level control (e.g., semi-automated control) that operates the shovel 100 in accordance with the construction information when a predetermined lever is tilted in the operation device 26.

[0131] This is because, for example, there is hesitation to introduce the above-described shovel that can realize semi-automated control due to its cost.

[0132] However, the semi-automated control or the like may be desired even for the shovel 100 in accordance with a working step.

[0133] In the present embodiment, the management device 300 performs assistance of the semi-automated control or the like that operates the shovel 100 in accordance with the construction information.

[0134] Specifically, the fixed-point measurement device 400 measures the working site of the shovel 100, and transmits the measurement results to the management device 300. Thereby, the management device 300 can recognize statuses surrounding the shovel 100 in the form of a three-dimensional shape. In other words, even if the shovel 100 does not include the space recognition device, the management device 300 can recognize statuses surrounding the shovel 100. Note that, the present embodiment does not limit the measurement device of the statuses surrounding the shovel 100 to the fixed-point measurement device 400, and may use a drone or the like.

[0135] Also, the shovel 100 transmits position information measured by the positioning device S6 to the management device 300. Thereby, the management device 300 can recognize the position of the shovel 100 in the working site.

[0136] Moreover, the management device 300 retains the construction information representing the three-di-

mensional shapes of soil and sand and the like after construction. Thereby, when the management device 300 has received an operation signal from the shovel 100, the management device 300 generates, in response to the operation signal, a control signal for performing working in accordance with the construction information, and transmits the control signal to the shovel 100.

[0137] As described above, the shovel 100 according to the present embodiment includes the electric operation lever in the form of the operation device 26. Therefore, when the shovel controller 50 of the shovel 100 has received the control signal from the management device 300, the shovel controller 50 can perform, based on the control signal, semi-automated control of the upper swiveling body 3, the boom 4, the arm 5, the bucket 6, or any combination thereof.

[0138] That is, the shovel controller 50 of the shovel 100 according to the present embodiment realizes switching between: manual control (an example of the first control) that moves the upper swiveling body 3, the boom 4, the arm 5, the bucket 6, or any combination thereof in accordance with the operation information (an example of the first operation information) received by the operation device 26; and network control (an example of the second control) that performs semi-automated control or the like in accordance with the control signal received from the management device 300. The manual control and the network control will be described below.

[0139] Next, functional blocks of the controller 404 of the fixed-point measurement device 400, the shovel controller 50 of the shovel 100, or the controller 303 of the management device 300 will be described.

«Functional blocks of the fixed-point measurement device»

[0140] The functional blocks in the controller 404 of the fixed-point measurement device 400 will be described. The functional blocks in the controller 404 are conceptual and are not necessarily physically configured as illustrated. All or a part of the functional blocks can be configured in a functionally or physically distributed or integrated manner in a given unit. All or a part of the processing functions performed in the functional blocks are or is realized by programs executed in the CPU. Alternatively, the functional blocks may be realized as hardware based on a wired logic.

[0141] A transmission control part 411 transmits, to the management device 300, the measurement information obtained by the space recognition device 403 and the position information stored in the position information storage part 402 that are associated with each other. The transmission of the measurement information by the transmission control part 411 is performed every time a predetermined time passes. For example, the transmission control part 411 may transmit the measurement information every time the measurement information is obtained by the space recognition device 403 (e.g., every

time a frame is updated).

«Functional blocks of the shovel»

[0142] The functional blocks in a shovel controller (one example of a first control device) 50 of the shovel 100 will be described. The functional blocks in the shovel controller 50 are conceptual and are not necessarily physically configured as illustrated. All or a part of the functional blocks can be configured in a functionally or physically distributed or integrated manner in a given unit. All or a part of the processing functions performed in the functional blocks are or is realized by programs executed in the CPU. Alternatively, the functional blocks may be realized as hardware based on a wired logic. By realizing the programs, the shovel controller 50 includes a switch control part 501, a transmission control part 502, a reception control part 503, and a signal output part 504.

[0143] The switch control part 501 performs switching between the manual control and the network control in accordance with an input operation of the input device D1.

[0144] The manual control (an example of the first control) refers to control that moves the upper swiveling body 3, the boom 4, the arm 5, or the bucket 6 in accordance with an operation received by the operation device 26. For example, when the left operation lever 26L is operated in the forward and backward directions, obtained control is set to moving the arm 5 in the closing direction or moving the arm 5 in the opening direction. That is, the content assigned to the opening direction of the operation lever is control for movement in accordance with a tilt amount. In this way, the manual control does not include control of the shovel 100 based on the construction information representing the three-dimensional shape of the construction target.

[0145] The network control (an example of the second control) refers to control that moves the upper swiveling body 3, the boom 4, the arm 5, the bucket 6, or any combination thereof based on the control signal received from the management device 300. For example, the control signal transmitted from the management device 300 in the network control may be a signal for control of the shovel 100 (e.g., semi-automated control or fully-automated control) in order to form the three-dimensional shape of the construction target based on the construction information.

[0146] For example, in the network control, after loading of soil and sand in the bucket 6, operation information indicating an operation in a direction in which the boom 4 is opened is transmitted to the management device 300. Thereby, in a state where the opening surface of the bucket 6 is horizontally maintained so that the bucket 6 maintains the loaded state of the soil and sand, a control signal for moving the boom 4, the arm 5, and the bucket 6 so as to raise the boom 4 is received, and the boom 4, the arm 5, and the bucket 6 are moved based on the control signal.

[0147] As another example of the network control, when forming a three-dimensional shape defined for the construction target in accordance with the construction information, e.g., when forming a slope on the soil and sand, operation information indicating an operation in a direction in which the arm 5 is opened is transmitted to the management device 300. Thereby, a control signal for moving the boom 4, the arm 5, and the bucket 6 so that the back surface of the bucket 6 moves over the slope is received, and semi-automated control that moves the boom 4, the arm 5, and the bucket 6 based on the control signal is performed.

[0148] Note that, the network control is not limited to the above-described control as long as the network control is control in which the management device 300 performs assistance of movements (e.g., semi-automated control) in response to an operation received by the operation device 26.

[0149] The transmission control part 502 performs control for transmitting various information via the communication device T1 to the management device 300. For example, when the shovel 100 has been switched to the network control by the switch control part 501, the transmission control part 502 transmits, to the management device 300, operation information indicating the operation received by the operation device 26 (one example of second operation information), detection information indicating the detection results from various sensors provided in the shovel 100, and position information (including an orientation) of the shovel 100 obtained by the positioning device S6. The detection information includes, for example, information for identifying the positions of the boom 4, the arm 5, and the bucket 6 (attachments), such as a rotation angle of the boom 4 detected by the boom angle sensor (one example of a detection device) S1, a rotation angle of the arm 5 detected by the arm angle sensor (one example of the detection device) S2, and a rotation angle of the bucket 6 detected by the bucket angle sensor (one example of the detection device) S3.

[0150] The reception control part 503 performs control for receiving various information via the communication device T1 from the management device 300. For example, when the transmission control part 502 has received the operation information, the reception control part 503 receives, from the management device 300, a control signal for performing semi-automated control or the like of the shovel 100 in accordance with the operation information. Also, when the detection information has been transmitted to the management device 300, the control signal is a control signal for controlling the positions of the boom 4, the arm 5, and the bucket 6 defined from the detection information, in other words, a control signal for performing control based on the current moving status of the shovel 100.

[0151] The signal output part 504 outputs, to the hydraulic system or the like, the control signal for controlling the hydraulic system or the like. For example, when the shovel 100 has been switched to the manual control by

the switch control part 501, the signal output part 504 outputs, to the hydraulic system, the control signal for moving the component corresponding to the operation direction in response to the operation received by the operation device 26.

[0152] For example, when the shovel 100 has been switched to the network control by the switch control part 501, the signal output part 504 outputs, to the hydraulic system, the control signal received from the management device 300. Thereby, it is possible to realize semi-automated control or the like with the assistance of the management device 300.

«Functional blocks of the management device»

[0153] The functional blocks in the controller (one example of a second control device) 303 of the management device 300 will be described. The functional blocks in the controller 303 are conceptual and are not necessarily physically configured as illustrated. All or a part of the functional blocks can be configured in a functionally or physically distributed or integrated manner in a given unit. All or a part of the processing functions performed in the functional blocks are or is realized by programs executed in the CPU. Alternatively, the functional blocks may be realized as hardware based on a wired logic. By realizing the programs, the controller 303 includes a reception control part 331, a virtual working site space generation part 332, a moving track generation part 333, a signal generation part 334, and a transmission control part 335.

[0154] The management device 300 is a device provided for assisting the working of the shovel 100. The management device 300 may be realized by such a device as a server. Note that, the management device 300 is not limited to being provided from a server or the like, and may be realized through a cloud service.

[0155] When the shovel 100 has been switched to the network control, the management device 300 generates a control command for performing work, and performs control for transmitting the generated control command to the shovel 100.

[0156] The management device 300 may provide the control assistance of the shovel 100 as, for example, a paid service. For example, the management device 300 may measure the time from after the shovel 100 has been switched to the network control until the network control ends. A manager of the management device 300 may charge a manager of the shovel 100 for money equivalent to the measured time. How money is charged may be in any way, and may be a daily or monthly fixed charge.

[0157] The reception control part 331 may perform control for receiving various information via a communication device T2 from the fixed-point measurement device 400 and the shovel 100.

[0158] For example, the reception control part 331 receives the measurement information and the position information from the fixed-point measurement device 400.

[0159] As another example, the reception control part 331 receives, from the shovel 100, the position information, the detection information, and the operation information. The detection information includes detection results of various sensors. The detection results of various sensors include, for example, the rotation angle of the boom 4 detected by the boom angle sensor S1, the rotation angle of the arm 5 detected by the arm angle sensor S2, and the rotation angle of the bucket 6 detected by the bucket angle sensor S3. Because the management device 300 previously retains the sizes of the boom 4, the arm 5, and the bucket 6, the management device 300 can recognize the current statuses of the attachments of the shovel 100 including the position of the bucket 6. Therefore, the management device 300 can recognize the current position of the shovel 100, and the current moving statuses of the shovel 100 and the attachments thereof. The detection information may further include detection results of the machine body tilt sensor S4 and the swivel angular velocity sensor S5. When those detection results are included, the management device 300 can generate a control signal in consideration of the detection results.

[0160] The virtual working site space generation part 332 generates the virtual working site space representing a three-dimensional shape of the working site based on the measurement information and the position information received by the reception control part 331 from the fixed-point measurement device 400. The measurement information is a measurement result indicating a distance between the fixed-point measurement device 400 serving as a reference and an object in the working site. That is, from the measurement information and the position information, it is possible to recognize distances from the positions indicated by the position information to the objects. Therefore, the virtual working site space generation part 332 can generate a three-dimensional map representing the positions and the shapes of the objects existing in the working site from the position information and the measurement information, which are obtained from each of the two or more fixed-point measurement devices 400 disposed in the working site. The generated three-dimensional map is stored in the working site information storage part 322.

[0161] When the network control has been selected in the shovel 100, the moving track generation part 333 generates a moving track along which one or more of the bucket 6, the upper swiveling body 3, and the lower traveling body 1 of the shovel 100 move.

[0162] For example, when operation information indicating raising of the boom 4 has been received in a state where the bucket 6 is loaded with soil and sand and the like, the moving track generation part 333 generates a moving track of the bucket 6 for performing the raising of the boom 4 in a state where the opening surface of the bucket 6 is maintained approximately horizontally.

[0163] As another example, a moving track of the bucket 6 may be generated for forming the shape of soil and

sand represented in the three-dimensional map into a shape indicated by the construction information.

[0164] Based on the current status of the shovel 100 indicated by the detection information, the signal generation part 334 generates a control signal for the bucket 6, the upper swiveling body 3, or the lower traveling body 1 of the shovel 100 to move along the generated moving track. The generated control signal is a signal for moving the boom 4, the arm 5, the bucket 6, the upper swiveling body 3, the lower traveling body 1, or any combination thereof.

[0165] The transmission control part 335 transmits the control signal, generated by the signal generation part 334, to the shovel 100. Thereby, the shovel 100 can perform semi-automated control or the like in accordance with the moving track generated by the management device 300.

<Description of specific work>

[0166] Next, a process for the management device 300 to generate the control signal will be described. FIG. 7 is a conceptual view illustrating the virtual working site space generated by the virtual working site space generation part 332.

[0167] A three-dimensional map of a virtual working site space 1701 as illustrated in FIG. 7 is generated based on the measurement information and the position information from the fixed-point measurement device 400. The construction information indicates constructing a slope 1702.

[0168] The virtual working site space generation part 332 can identify a position coordinate $P(x_L, y_L, z_L)$ indicating a position 1713 of the bucket 6 in a machine body coordinate system 1712 of the shovel 100 based on: the sizes of the components of the shovel 100; and the rotation angle of the boom 4, the rotation angle of the arm 5, and the rotation angle of the bucket 6 included in the detection information.

[0169] The management device 300 receives, from the shovel 100, the position information (including the orientation) of the shovel 100 obtained by the positioning device S6. The position information (including the orientation) indicates the position and the orientation of the shovel 100 in a reference coordinate system 1711, in other words, a relative positional relationship between the reference coordinate system 1711 and the machine body coordinate system 1712. Based on the relative positional relationship between the reference coordinate system 1711 and the machine body coordinate system 1712, the virtual working site space generation part 332 can identify a position coordinate $P(x_G, y_G, z_G)$ indicating the position 1713 of the bucket 6 in the reference coordinate system 1711.

[0170] The moving track generation part 333 can generate a moving track for moving the bucket 6 so as to construct the slope 1702, with the current position of the bucket 6 being a start point.

[0171] Next, the control signal transmitted to the shovel 100 will be described. FIG. 8 is a view illustrating a movement performed in accordance with the control signal received by the shovel 100 according to the present embodiment. The example as illustrated in FIG. 8 is an example in which a moving track 1802 of the bucket 6 of the shovel 100 is generated for construction of a slope 1801.

[0172] In order to move the bucket 6 along the moving track 1802, the management device 300 generates, and then transmits, a control signal that is for rotating the bucket 6 in a rotation direction 1811, for rotating the arm 5 in a rotation direction 1812, and for rotating the boom 4 in a rotation direction 1813.

[0173] When the reception control part 503 of the shovel 100 has received the control signal, the signal output part 504 outputs the received control signal to the hydraulic system or the like. In this way, in the present embodiment, it is possible to provide the shovel 100 with, for example, semi-automated control.

<Flow of process in the shovel control system SYS>

[0174] Next, a flow of a process when semi-automated control of the shovel 100 is performed in the shovel control system SYS according to the present embodiment will be described. FIG. 9 is a sequence diagram illustrating the flow of the process when the semi-automated control of the shovel 100 is performed in the shovel control system SYS according to the present embodiment.

[0175] First, the fixed-point measurement device 400 measures objects and the like existing therearound using the space recognition device 403 (S1801). The transmission control part 411 of the fixed-point measurement device 400 transmits measurement information, which is a measurement result, to the management device 300 (S1802).

[0176] Then, the virtual working site space generation part 332 of the management device 300 generates, based on the received measurement information, the three-dimensional map of the virtual working site space 1701 (S1803). Note that, in steps S1801 to S1803, the three-dimensional map stored in the working site information storage part 322 may be updated every time the fixed-point measurement device 400 performs the measurement.

[0177] Then, in accordance with the operation received by the switch control part 501 from the input device D1, the shovel 100 is switched to the network control (S1804).

[0178] Then, the transmission control part 502 of the shovel 100 notifies the management device 300 of being switched to the network control (S1805).

[0179] In response to the notification of being switched to the network control, the moving track generation part 333 of the management device 300 reads out the construction information of the shovel 100 from the construction information storage part 321 (S1806).

[0180] The shovel controller 50 of the shovel 100 obtains the detection information indicating the detection results of various sensors, and the position information from the positioning device S6 (S1807). The detection information and the position information are regularly obtained. Then, the transmission control part 502 transmits the detection information and the position information to the management device 300 (S1808).

[0181] Then, the moving track generation part 333 of the management device 300 generates a moving track from the current position of the shovel 100 in order to perform construction in accordance with the construction information (S1809).

[0182] Again, the shovel controller 50 of the shovel 100 obtains the detection information indicating the detection results of various sensors, and the position information from the positioning device S6 (S1810). Moreover, the shovel controller 50 receives an operation of the operation device 26 (S1811).

[0183] Then, the transmission control part 502 transmits the position information, the detection information, and the operation information (S1812).

[0184] Then, in the management device 300, when the reception control part 331 has received the position information, the detection information, and the operation information, the signal generation part 334 generates a control signal for moving the lower traveling body 1, the bucket 6, or the like along the moving track from the current position thereof (S1813).

[0185] The transmission control part 335 transmits the control signal, generated by the signal generation part 334, to the shovel 100 (S1814).

[0186] The signal output part 504 outputs the received control signal to the hydraulic system (S1815). In the present embodiment, steps S1810 to S1815 are repeated for moving the shovel 100 along the moving track.

[0187] In the above-described embodiment, in which the management device 300 transmits the control signal to the shovel 100, such high-level control as semi-automated control can be realized even in the shovel 100. Therefore, it is possible to reduce the operation burden on operators.

(Modified Example 1 of the first embodiment)

[0188] In the above-described embodiment, the management device 300 receives the position information and the detection information from the shovel 100, thereby recognizing the current position of the shovel 100 and the current moving status (e.g., the position of the bucket 6) of the shovel 100. However, the above-described embodiment does not limit a way to recognize the current position and the current moving status of the shovel 100 to the way based on the position information and the detection information from the shovel 100. In the present modified example described below, the position and the moving status of the shovel 100 are identified based on the measurement information from the fixed-point meas-

urement device 400.

[0189] The fixed-point measurement device 400 according to the present modified example transmits the measurement information. Because the measurement information includes information indicating a distance from the fixed-point measurement device 400 to an object, the measurement information also includes the position of the shovel 100 from the fixed-point measurement device 400 serving as a reference, and the shape of the shovel 100. Therefore, the virtual working site space generation part 332 recognizes the position and the shape of the shovel 100 based on the received measurement information. From the shape of the shovel 100, it is possible to recognize the positions of the attachments. In other words, the management device 300 of the present modified example can identify, from the measurement information, the position of the shovel 100 and the moving status (e.g., the position of the bucket 6) of the shovel 100.

[0190] Also, the fixed-point measurement device 400 may be provided with a photographing device. The fixed-point measurement device 400 may transmit image information photographed by the photographing device to the management device 300. The virtual working site space generation part 332 of the management device 300 may identify the position and the moving status of the shovel 100 based on a combination of the measurement information and the image information.

(Modified Example 2 of the first embodiment)

[0191] In the above-described embodiment, the management device 300 performs control based on the measurement information of the fixed-point measurement device 400. However, the above-described embodiment is not limited to the case where the fixed-point measurement device 400 performs the measurement. For example, a detachable space recognition device for the shovel 100 may be provided.

[0192] Before performing the network control, the space recognition device is attached to the shovel 100. Then, the communication device T1 of the shovel 100 may transmit, to the management device 300, the measurement information that is a measurement result of the space recognition device.

[0193] Moreover, the detachable component for the shovel 100 is not limited to the space recognition device, and any one or more of the positioning device S6, the boom angle sensor S1, the arm angle sensor S2, and the bucket angle sensor S3 may be detachable.

[0194] That is, according to the present modified example, in which the positioning device S6, the boom angle sensor S1, the arm angle sensor S2, and the bucket angle sensor S3 are attached to the shovel 100 together with the space recognition device, it is possible to realize similar control to the control in the above-described embodiment.

[0195] The space recognition device, the positioning device S6, the boom angle sensor S1, the arm angle

sensor S2, and the bucket angle sensor S3 may be borrowed from, for example, a predetermined vendor. Then, these components borrowed from the predetermined vendor may be attached to the shovel 100.

[0196] In the present modified example, providing the shovel 100 with sensing-related components as standard equipment involves an increase in cost, while there is a desire to perform semi-automated control or the like using those sensing-related components. In view thereof, the present modified example proposes a way to equip the shovel 100 with sensing-related components, if necessary. Therefore, even if the fixed-point measurement device 400 is not disposed in the working site unlike in the above-described embodiment, control assistance of the shovel 100 can be realized by the management device 300. Therefore, it is possible to reduce the operation burden on operators.

(Second embodiment)

[0197] In the above-described embodiment, what is called semi-automated control is performed, in which when the management device 300 has received the operation information received from the shovel 100, the management device 300 generates, and then transmits, the control signal. However, performing the semi-automated control as in the above-described embodiment is by no means a limitation, and the management device 300 may perform fully-automated control of the shovel 100. In the second embodiment, the shovel 100 performing the fully-automated control will be described. Note that, the configurations of the management device 300 and the shovel 100 are similar to those in the above-described embodiment, and thus description thereof will be omitted.

<Flow of process in the shovel control system SYS>

[0198] Next, a flow of a process when fully-automated control of the shovel 100 is performed in the shovel control system SYS according to the present embodiment will be described. FIG. 10 is a sequence diagram illustrating the flow of the process when the fully-automated control of the shovel 100 is performed in the shovel control system SYS according to the present embodiment.

[0199] First, in accordance with similar steps to the above-described S1801 to S1803, the management device 300 performs generation of a three-dimensional map of the working site (S2001 to S2003). Note that, in steps S2001 to S2003, the three-dimensional map may be updated every time the fixed-point measurement device 400 performs the measurement.

[0200] Then, in accordance with the operation received by the switch control part 501 from the input device D1, the shovel 100 is switched to the network control (S2004). In the present embodiment, the fully-automated control is performed when the shovel 100 is switched to the network control. Note that, such a way to perform

switching is by no means a limitation. For example, upon switching the shovel 100 to the network control, a user may select either the semi-automated control as described in the first embodiment or the fully-automated control as described in the present embodiment.

[0201] Note that, the present embodiment is not limited to the method of switching to the network control by the operation of the input device D1. For example, switching to the network control may be performed in accordance with operation information received by the switch control part 501 from a communication terminal of the manager of the working site. In this way, in the present embodiment, the switching to the network control can be performed even without an operator who rides in the shovel 100.

[0202] Subsequently, in accordance with similar steps to S1805 to S1809, the management device 300 generates a moving track for the shovel to work (S2005 to S2009).

[0203] The shovel controller 50 of the shovel 100 obtains the detection information indicating the detection results of various sensors, and the position information from the positioning device S6 (S2010). Then, the transmission control part 502 transmits the detection information and the position information to the management device 300 (S2011).

[0204] In the management device 300, when the reception control part 331 has received the position information and the detection information, the signal generation part 334 generates a control signal for moving the lower traveling body 1, the bucket 6, or the like along the moving track from the current position thereof (S2012).

[0205] The transmission control part 335 transmits the control signal, generated by the signal generation part 334, to the shovel 100 (S2013).

[0206] The signal output part 504 outputs the received control signal to the hydraulic system (S2014). In the present embodiment, steps S2010 to S2014 are repeated for moving the shovel 100 along the moving track.

[0207] That is, in the present embodiment, the control signal for moving the shovel 100 is generated, and then transmitted, based on the position information and the detection information received from the shovel 100. Thereby, even without an operator who rides in the shovel 100, it is possible to perform construction through the fully-automated control using the shovel 100.

(Third embodiment)

[0208] In the above-described embodiments, the semi-automated control or the fully-automated control is performed in the shovel 100. However, the control that can be realized in the shovel 100 is not limited to the semi-automated control or the fully-automated control. In a third embodiment, remote control performed in the shovel 100 will be described.

[0209] FIG. 11 is a schematic view illustrating a configurational example of a shovel control system SYS1

according to the present embodiment. In the example as illustrated in FIG. 11, the shovel 100, the management device 300, the fixed-point measurement device 400, and a remote operation room RC are connected to each other via the communication network NW. Note that, the configurations of the shovel 100 and the management device 300 are similar to those in the above-described embodiments.

[0210] The fixed-point measurement device 400 may be provided with a photographing device. The fixed-point measurement device 400 may transmit, to the management device 300, the measurement information including image information obtained by the photographing device.

[0211] In the shovel 100, the switch control part 501 enables switching to the network control or the manual control. The network control according to the present embodiment illustrates remote control. Note that, upon performing switching to the network control, any one of the semi-automated control of the shovel 100, the fully-automated control of the shovel 100, and the remote control of the shovel 100 may be selectable.

[0212] Upon the switching to the network control being performed, remote control by the remote operation room RC is started. Note that, the switching to the network control is not limited to being through the operation received by the input device D1 of the shovel 100, and may be based on operation information from a communication terminal of the manager of the working site.

[0213] Upon the network control being switched by the switch control part 501, the detection information from various sensors provided in the shovel 100 is transmitted to the management device 300 using the communication device T1 provided in the shovel 100.

[0214] The virtual working site space generation part 332 of the management device 300 generates a three-dimensional map of the working site. Based on the three-dimensional map and the received image information, the virtual working site space generation part 332 of the management device 300 generates a display screen representing the surroundings of the shovel 100 from the position of the shovel 100. The display screen may be a virtual display screen representing the surroundings of the shovel 100 as viewed from the cab 10 of the shovel 100, an overhead display screen representing the surroundings of the shovel 100, a virtual three-dimensional map of the working site, or any combination thereof. Then, the transmission control part 335 transmits the generated display screen to the remote operation room RC.

[0215] The remote operation room RC in the shovel control system SYS1 according to the present embodiment is provided with a display device DR, an operation device D1R, a pressure sensor D2R, an operation seat DS, a remote controller 80, and the communication device T2. An operator OP rides at the operation seat DS.

[0216] The remote controller (one example of a remote control device) 80 performs overall control of the remote operation room RC.

[0217] The communication device T2 transmits and receives information between the management device 300 and the shovel 100.

[0218] The display device DR displays a display screen received from the management device 300 via the communication device T2. Thereby, even if the operator OP at the operation seat DS is in the remote operation room RC, the operator OP can confirm the status surrounding the shovel 100.

[0219] The operator OP at the operation seat DS in the remote operation room RC operates an operation device (one example of a remote operation device) D1R. Then, the pressure sensor D2R detects the operation content received by the operation device D1R.

[0220] In the present embodiment, the manual control or the semi-automated control of the shovel 100 may be performed from the remote operation room RC.

[0221] When the manual control is performed, the remote controller 80 generates a control signal corresponding to the detected operation content. For example, one operation lever of the operation device D1R is used for the swiveling operation and the operation of the arm 5. When the operation lever is operated in the forward and backward directions, the remote controller 80 generates a control signal for moving the arm cylinder 8 by the action of a control pressure corresponding to the amount of the lever operation. In this way, the remote controller 80 generates a control signal for performing the manual control of the shovel 100 in accordance with the operation amount of the operation lever. Then, the communication device T2 transmits the generated control signal to the shovel 100. When the remote controller 80 transmits the control signal, it is possible to realize the manual control of the shovel 100 through the remote operation.

[0222] Note that, the remote operation of the shovel 100 from the remote operation room RC according to the present embodiment is not limited to the above-described manual control, and may be semi-automated control with the assistance of the management device 300. Next, the case of performing the semi-automated control will be described.

<Flow of process in the shovel control system SYS1>

[0223] Next, a flow of a process when semi-automated control of the shovel 100 is performed in the shovel control system SYS1 according to the present embodiment will be described. FIG. 12 is a sequence diagram illustrating the flow of the process when the semi-automated control of the shovel 100 is performed by a remote operation in the shovel control system SYS1 according to the present embodiment.

[0224] First, the fixed-point measurement device 400 measures objects and the like existing therearound using the space recognition device 403 (S2201). In the present embodiment, a photographing device may be used to photograph the surroundings. The transmission control part 411 of the fixed-point measurement device 400

transmits measurement information, which is a measurement result, to the management device 300 (S2202). The measurement information also includes the photographed image information.

[0225] Then, the virtual working site space generation part 332 of the management device 300 generates, based on the received measurement information, the three-dimensional map of the virtual working site space 1701 (S2203). The virtual working site space generation part 332 may attach image information to the generated three-dimensional shape. In steps S2201 to S2203, the three-dimensional map stored in the working site information storage part 322 may be updated every time the fixed-point measurement device 400 performs the measurement.

[0226] Then, in the shovel 100, the switch control part 501 performs switching to the network control (remote control) in accordance with an input operation received from the input device D1 or operation information received from a communication terminal (S2204). In the sequence diagram as illustrated in FIG. 12, settings for performing the semi-automated control are made.

[0227] Then, the transmission control part 502 of the shovel 100 notifies the management device 300 of being switched to the network control (S2205).

[0228] Then, based on the three-dimensional map of the working site and the image information, the virtual working site space generation part 332 of the management device 300 generates a display screen that can be referred to from the position of the shovel 100 (S2206).

[0229] The transmission control part 335 of the management device 300 transmits the generated display screen to the remote operation room RC (S2207).

[0230] The remote controller 80 of the remote operation room RC displays the received display screen on the display device DR (S2208).

[0231] Meanwhile, the moving track generation part 333 of the management device 300 reads out the construction information of the shovel 100 from the construction information storage part 321 (S2209).

[0232] The shovel controller 50 of the shovel 100 obtains the detection information indicating the detection results of various sensors, and the position information from the positioning device S6 (S2210). The detection information and the position information are regularly obtained. Then, the transmission control part 502 transmits the detection information and the position information to the management device 300 (S2211).

[0233] Then, the moving track generation part 333 of the management device 300 generates a moving track from the current position of the shovel 100 in order to perform construction in accordance with the construction information (S2212).

[0234] Meanwhile, the shovel controller 50 of the shovel 100 obtains the detection information indicating the detection results of various sensors, and the position information from the positioning device S6 (S2213). Then, the transmission control part 502 transmits the position

information and the detection information (S2214).

[0235] Meanwhile, the remote controller 80 receives an operation from the operation device D1R via the pressure sensor D2R (S2215).

5 [0236] Then, using the communication device T2, the remote controller 80 transmits the operation information indicating the received operation (one example of remote operation information) (S2216).

10 [0237] Then, in the management device 300, when the reception control part 331 has received the position information and the detection information and then the operation information, the signal generation part 334 generates a control signal for moving the lower traveling body 1, the bucket 6, or the like along the moving track from the current position thereof in accordance with the operation (S2217).

[0238] The transmission control part 335 transmits the control signal, generated by the signal generation part 334, to the shovel 100 (S2218).

20 [0239] The signal output part 504 outputs the received control signal to the hydraulic system (S2219). In the present embodiment, steps S2213 to S2219 are repeated for moving the shovel 100 along the moving track.

25 [0240] In the present embodiment as described above, the remote operation room RC and the management device 300 are separately provided. However, the present embodiment is not limited to the case where the remote operation room RC and the management device 300 are separately provided, and the management device 300 may be provided in the remote operation room RC.

30 [0241] In the present embodiment, by performing an operation in the remote operation room RC, it is possible to control the shovel 100 even from a remote place. Therefore, even if the working site is a remote place, an operator of the shovel 100 can be readily provided.

<Effects>

40 [0242] The shovel 100 according to the embodiments and the modified examples as described above, each having the above-described configuration, can perform switching between the manual control and the network control. That is, the shovel 100 can perform working through the manual control when there is no need for high-level control using sensing-related components, and can perform working through the network control with the assistance of the management device 300 when there is a need for high-level control. Thereby, it is possible to reduce the operation burden on the operator.

45 [0243] In the above-described embodiments, the working site is visualized by the fixed-point measurement device 400, and thus the management device 300 can recognize the status of the working site. Therefore, even if the shovel 100 does not include any high-level sensing-related component, the shovel 100 can perform work based on the status of the working site by moving in accordance with the control signal from the management device 300. For example, the shovel 100 moves in ac-

cordance with the control signal from the management device 300, thereby enabling the bucket 6 to move so as to form a three-dimensional shape of the working site in accordance with the construction information retained by the management device 300.

[0244] In the embodiments and the modified examples as described above, even if the shovel does not include any sensing-related component such as a space recognition device and does not include any controller that can realize machine control (MC), it is possible to realize high-level control such as semi-automated control, fully-automated control, or remote control as described above, and thus realize reduction in cost.

[0245] Although embodiments of the present disclosure have been described above in detail, the present disclosure is not limited to such specific embodiments, and various alterations and modifications are possible within the scope of the claims as recited.

Reference Signs List

[0246]

100 shovel
 1 lower traveling body
 2 swiveling mechanism
 3 upper swiveling body
 4 boom
 5 arm
 6 bucket
 7 boom cylinder
 8 arm cylinder
 9 bucket cylinder
 S1 boom angle sensor
 S2 arm angle sensor
 S3 bucket angle sensor
 S4 machine body tilt sensor
 S5 swivel angular velocity sensor
 S6 positioning device
 T1 communication device
 50 shovel controller
 501 switch control part
 502 transmission control part
 503 reception control part
 504 signal output part
 400 fixed-point measurement device
 401 communication device
 402 position information storage part
 403 space recognition device
 404 controller
 411 transmission control part
 300 management device
 301 communication device
 302 storage device
 321 construction information storage part
 322 working site information storage part
 303 controller
 331 reception control part

332 virtual working site space generation part
 333 moving track generation part
 334 signal generation part
 335 transmission control part
 RC remote operation room
 DR display device
 D1R operation device
 D2R pressure sensor
 80 remote controller
 T2 communication device

Claims

1. A shovel, comprising:
 - a lower traveling body;
 - an upper swiveling body swivelably mounted to the lower traveling body;
 - an attachment attached to the upper swiveling body;
 - an operation device including an electric operation lever;
 - a communication device configured to transmit or receive information to or from an external device; and
 - a control device configured to perform switching between
 - first control that controls the lower traveling body, the upper swiveling body, the attachment, or any combination thereof in accordance with first operation information received by the operation device, and
 - second control that receives, from the external device, a control signal for controlling the lower traveling body, the upper swiveling body, the attachment, or any combination thereof, and controls the lower traveling body, the upper swiveling body, the attachment, or any combination thereof in accordance with the received control signal.
2. The shovel according to claim 1, wherein upon performing the second control, the communication device transmits, to the external device, second operation information received by the operation device, and receives, from the external device, the control signal based on the second operation information.
3. The shovel according to claim 1, further comprising a detection device configured to detect a position of the attachment, wherein upon performing the second control, the communication device transmits, to the external device, a detection result of the position detected by the detection

device, and receives, from the external device, the control signal for controlling the attachment based on the detection result.

4. The shovel according to any one of claims 1 to 3, wherein

the first control does not include control of the shovel based on construction information representing a three-dimensional shape of a construction target, and
the second control includes the control of the shovel for forming the three-dimensional shape of the construction target based on the construction information.

5. A shovel control system, comprising:

a shovel;
an external device; and
a space recognition device, wherein
the space recognition device includes a first communication device configured to transmit, to the external device, measurement information obtained by measuring surroundings of the shovel,
the shovel includes

a lower traveling body,
an upper swiveling body swivelably mounted to the lower traveling body,
an attachment attached to the upper swiveling body,
an operation device,
a second communication device configured to transmit or receive information to or from the external device, and
a first control device configured to perform switching between

first control that controls the lower traveling body, the upper swiveling body, the attachment, or any combination thereof in accordance with first operation information received by the operation device, and
second control that receives, from the external device, a control signal for controlling the lower traveling body, the upper swiveling body, the attachment, or any combination thereof, and controls the lower traveling body, the upper swiveling body, the attachment, or any combination thereof in accordance with the received control signal, and

the external device includes

a third communication device configured to receive the measurement information from the space recognition device, and
a second control device configured to generate the control signal based on the measurement information, and
the third communication device transmits the control signal to the second communication device.

6. The shovel control system according to claim 5, wherein

the shovel further includes a detection device configured to detect a position of the attachment, wherein
upon performing the second control, the second communication device transmits, to the external device, a detection result of the position detected by the detection device, and receives, from the external device, the control signal for controlling the attachment based on the detection result, and
the second control device of the external device generates the control signal based on the detection result and the measurement information.

7. The shovel control system according to claim 6, wherein

the external device further includes a storage device configured to store construction information representing a three-dimensional shape of a construction target, and
the second control device further generates the control signal based on the detection result, the measurement information, and the construction information.

8. The shovel control system according to any one of claims 5 to 7, further comprising a remote control device, wherein

the remote control device includes a fourth communication device and a remote operation device,
the fourth communication device transmits, to the external device, remote operation information received by the remote operation device, and
the second control device further generates the control signal based on the remote operation information.

FIG.1

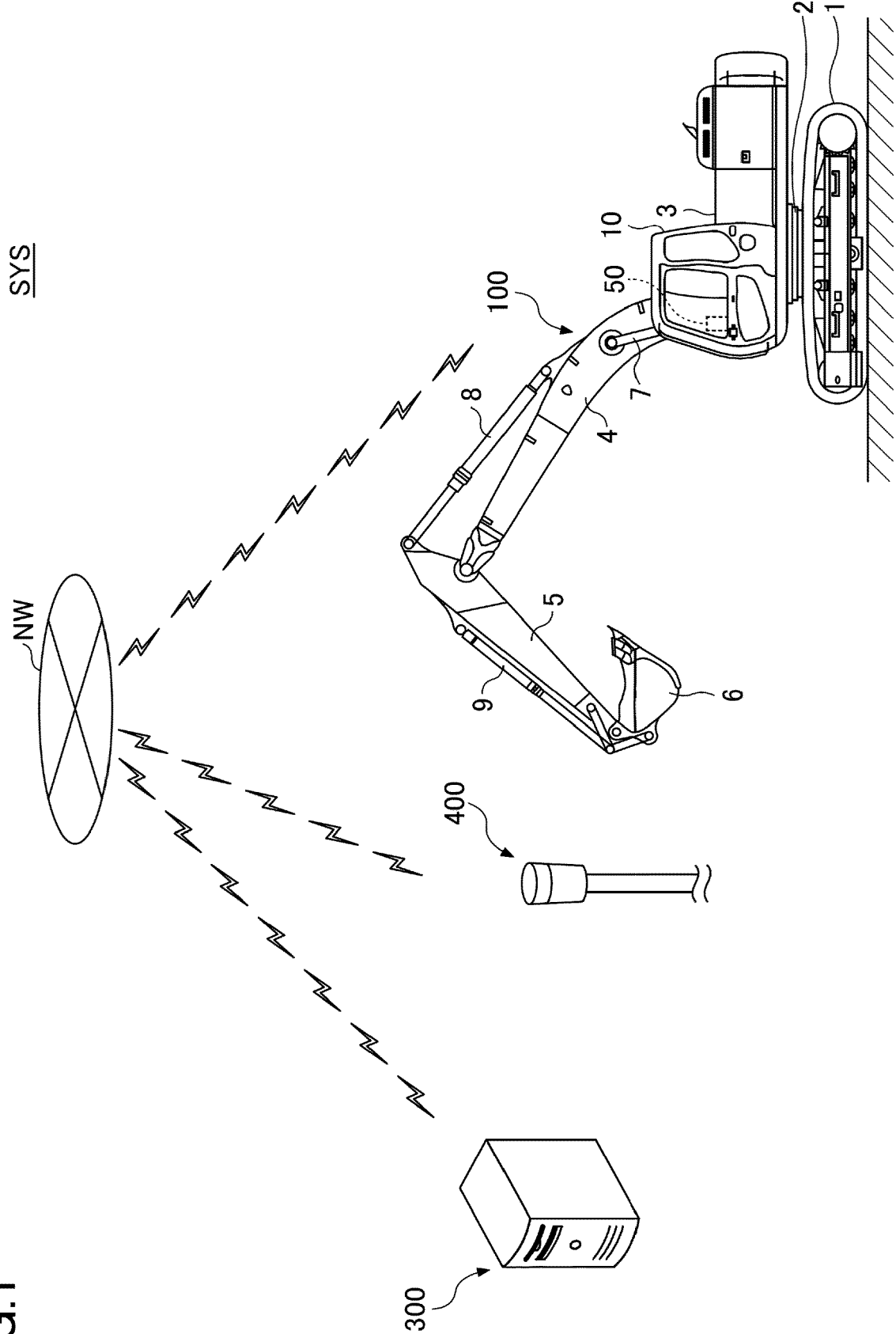


FIG.2

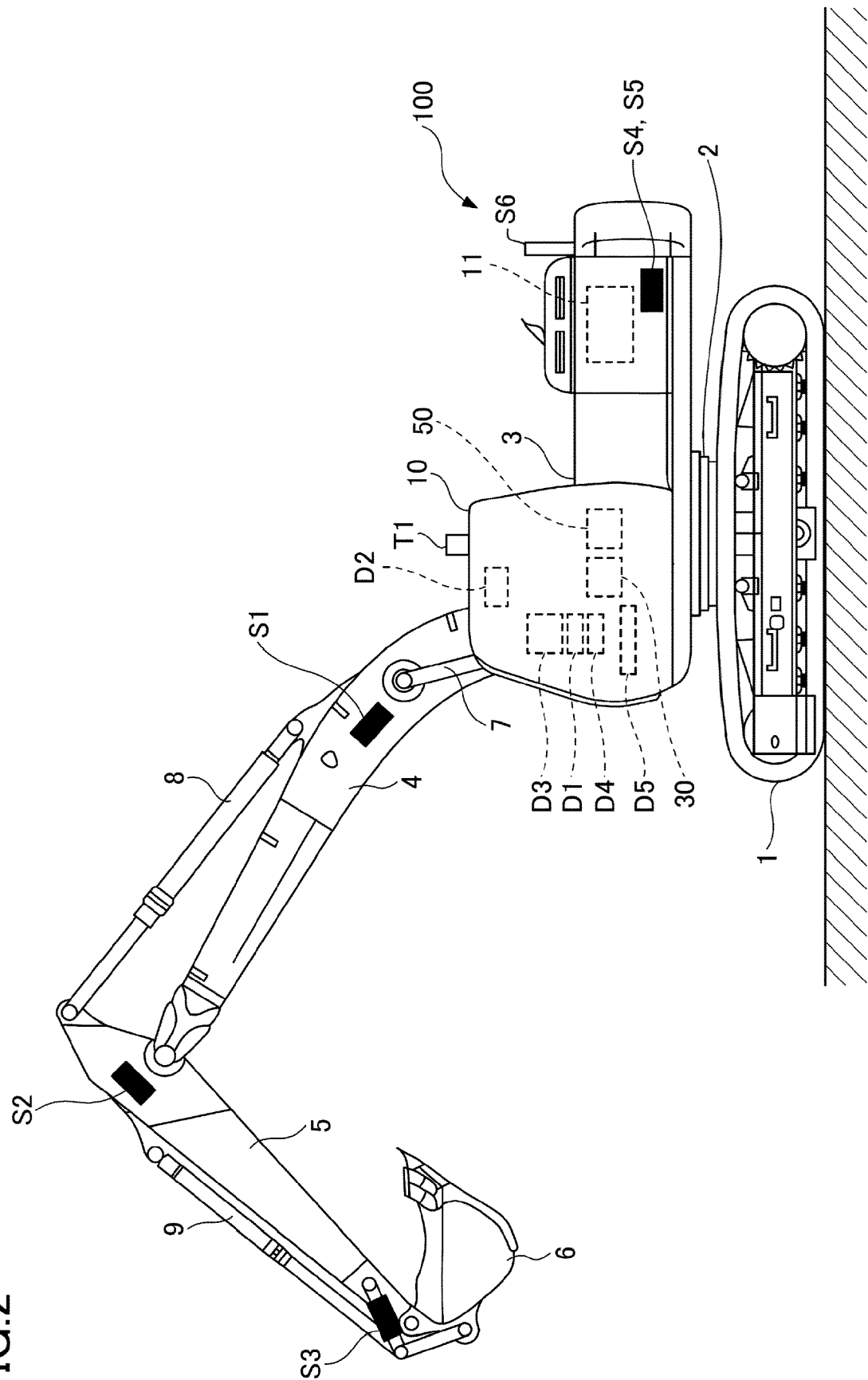


FIG.3

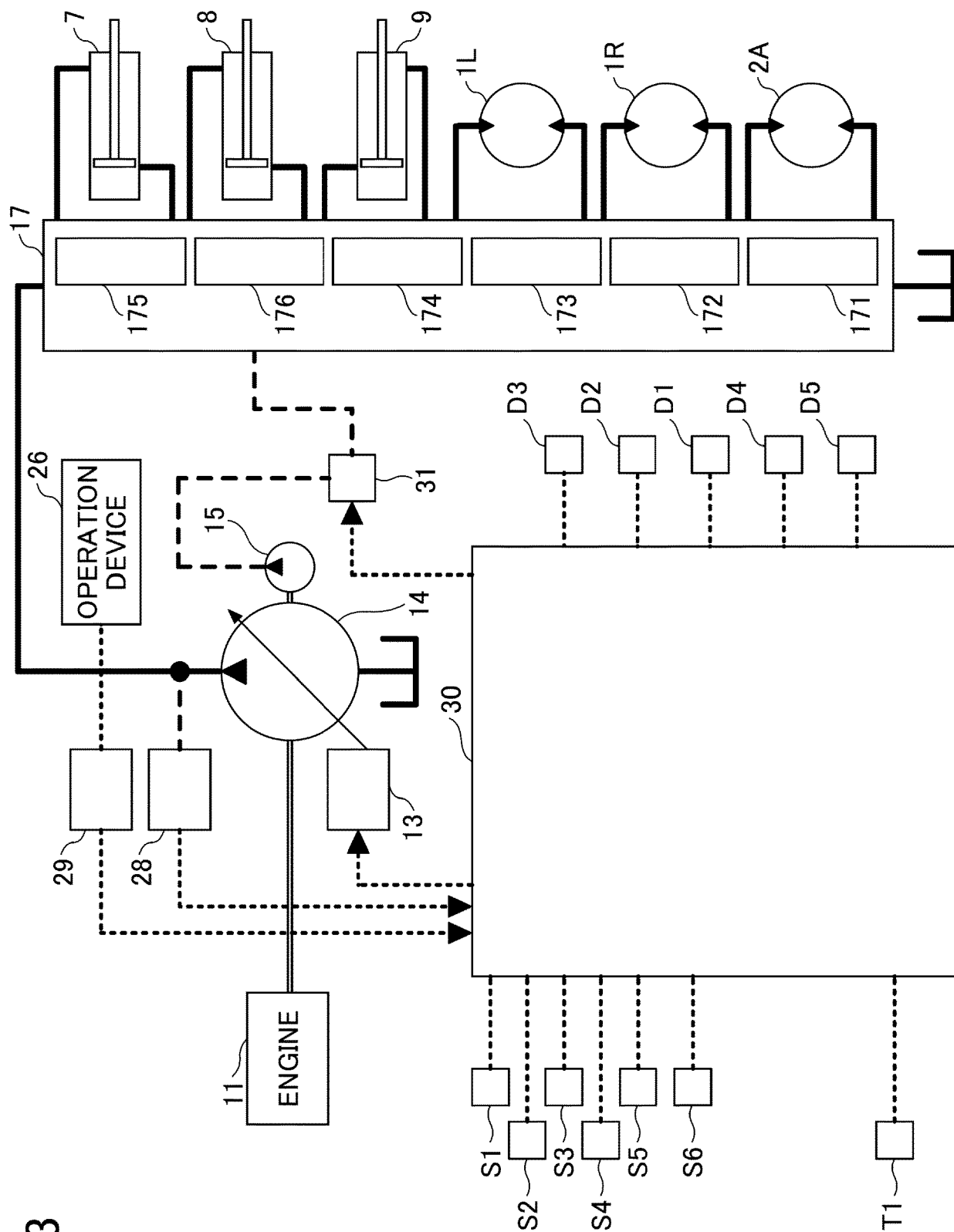


FIG. 4

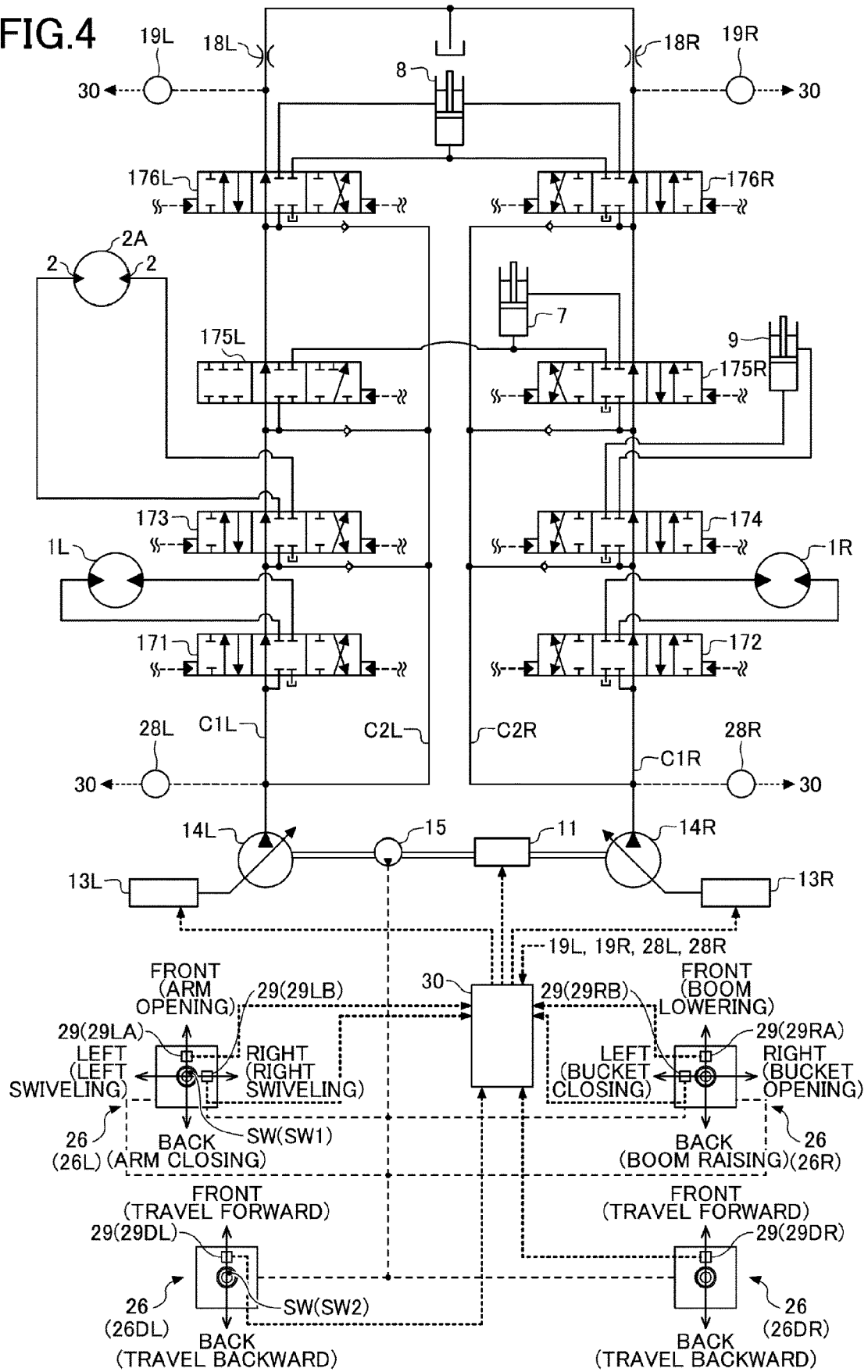


FIG. 5A

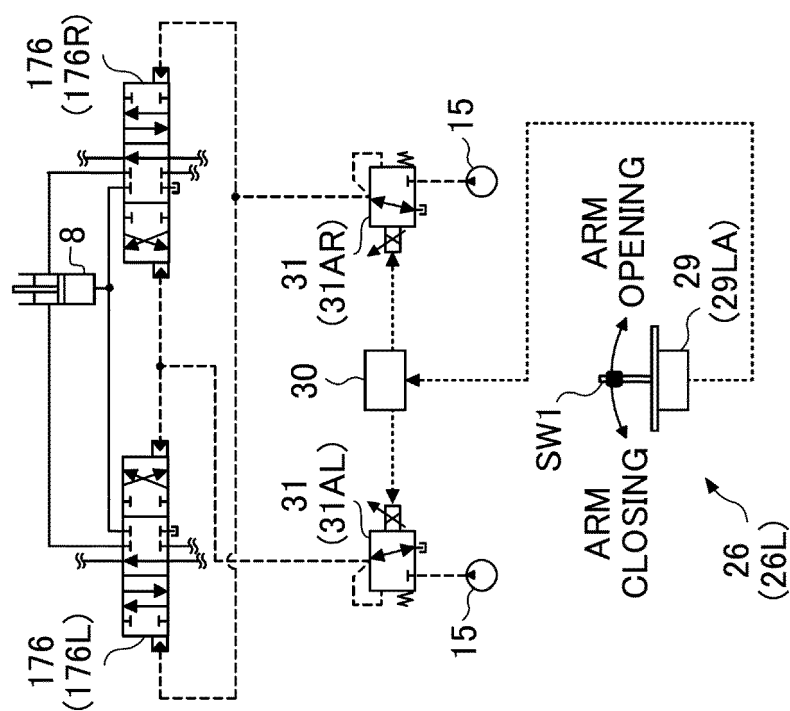


FIG. 5B

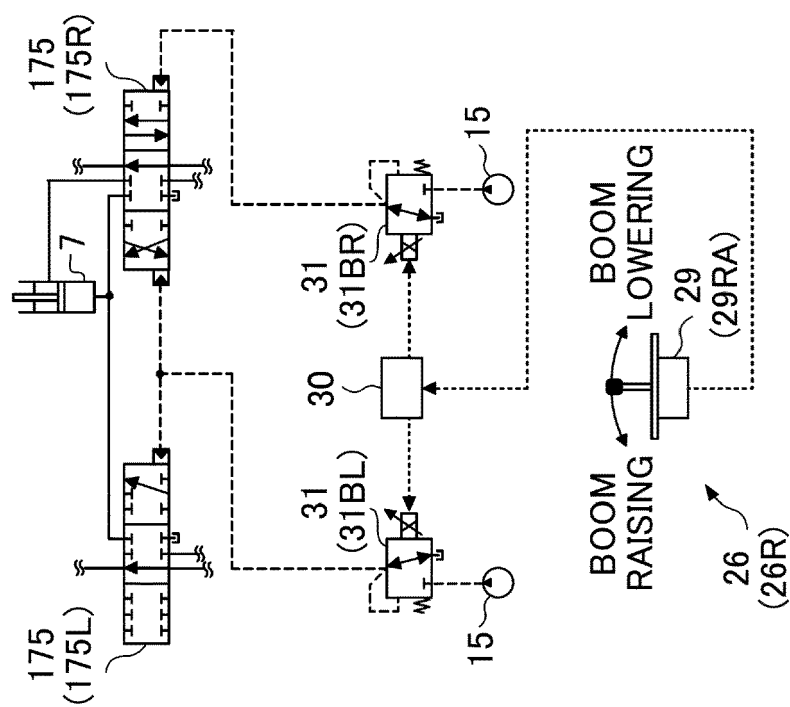


FIG. 5C

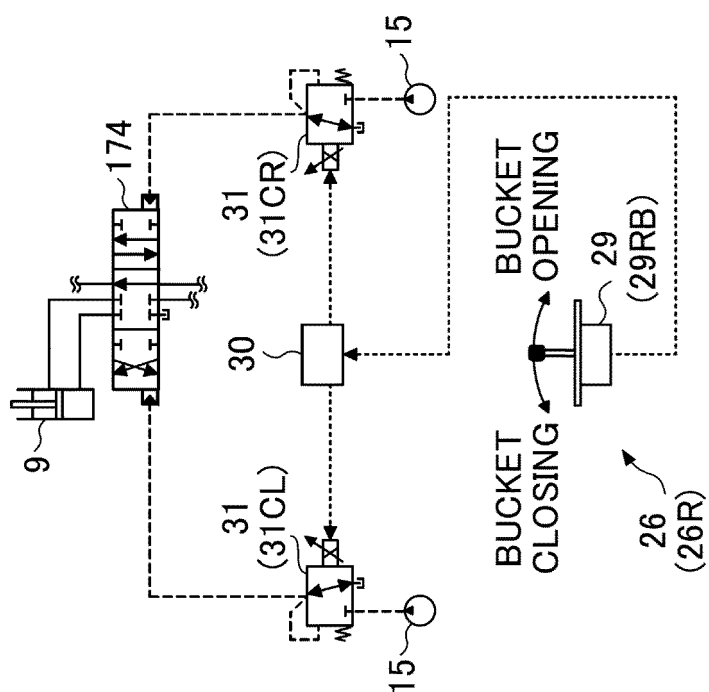
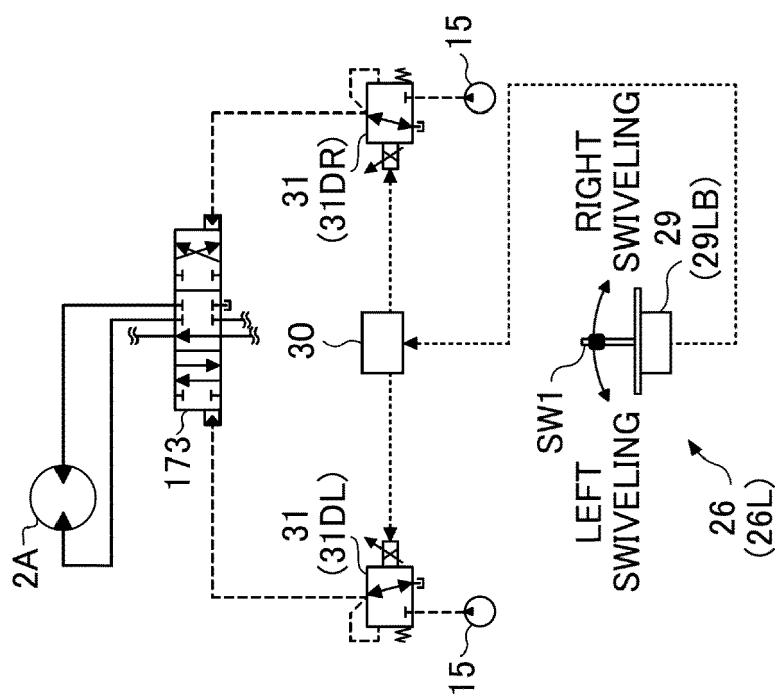


FIG. 5D



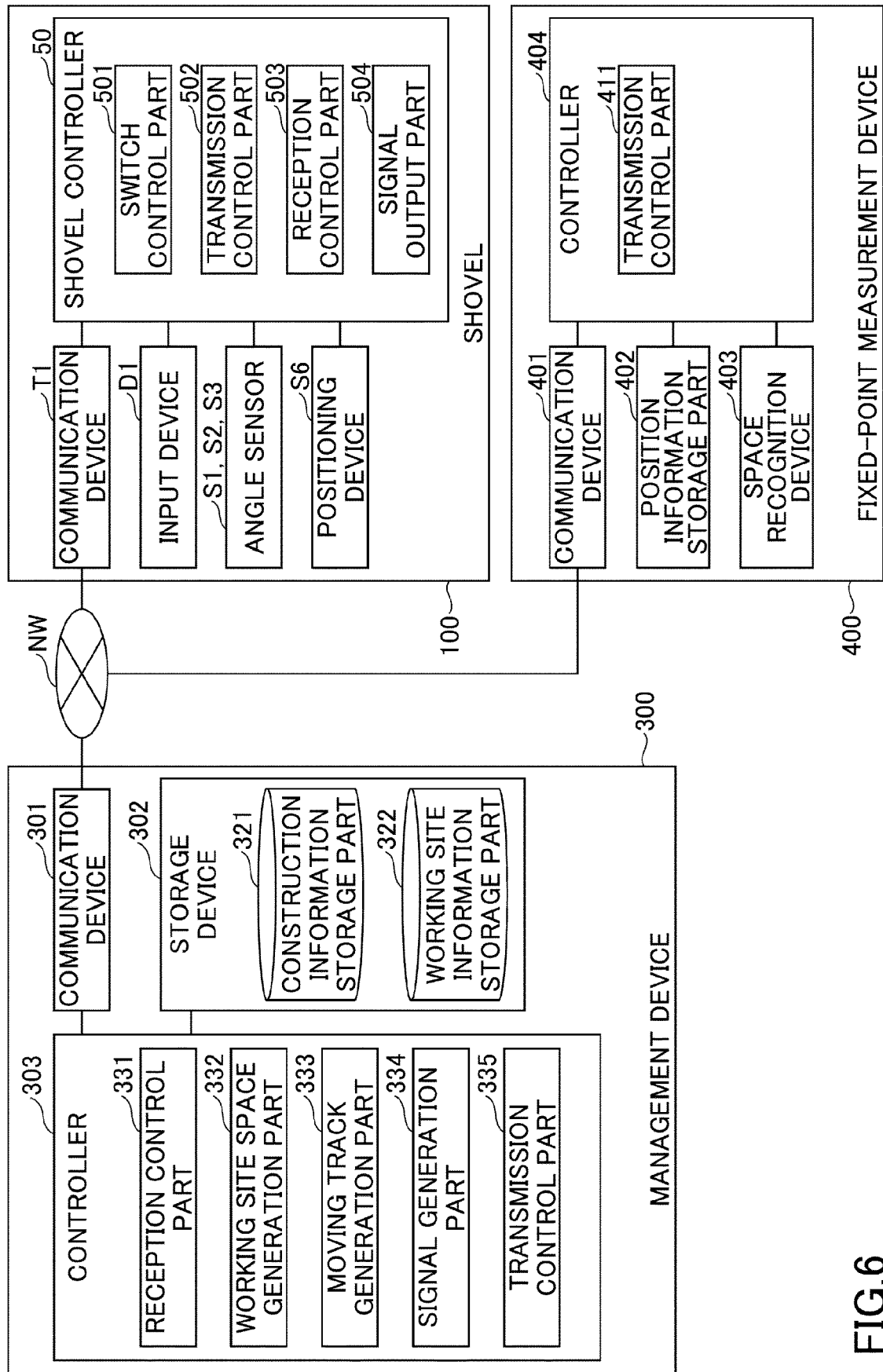


FIG.6

FIG.7

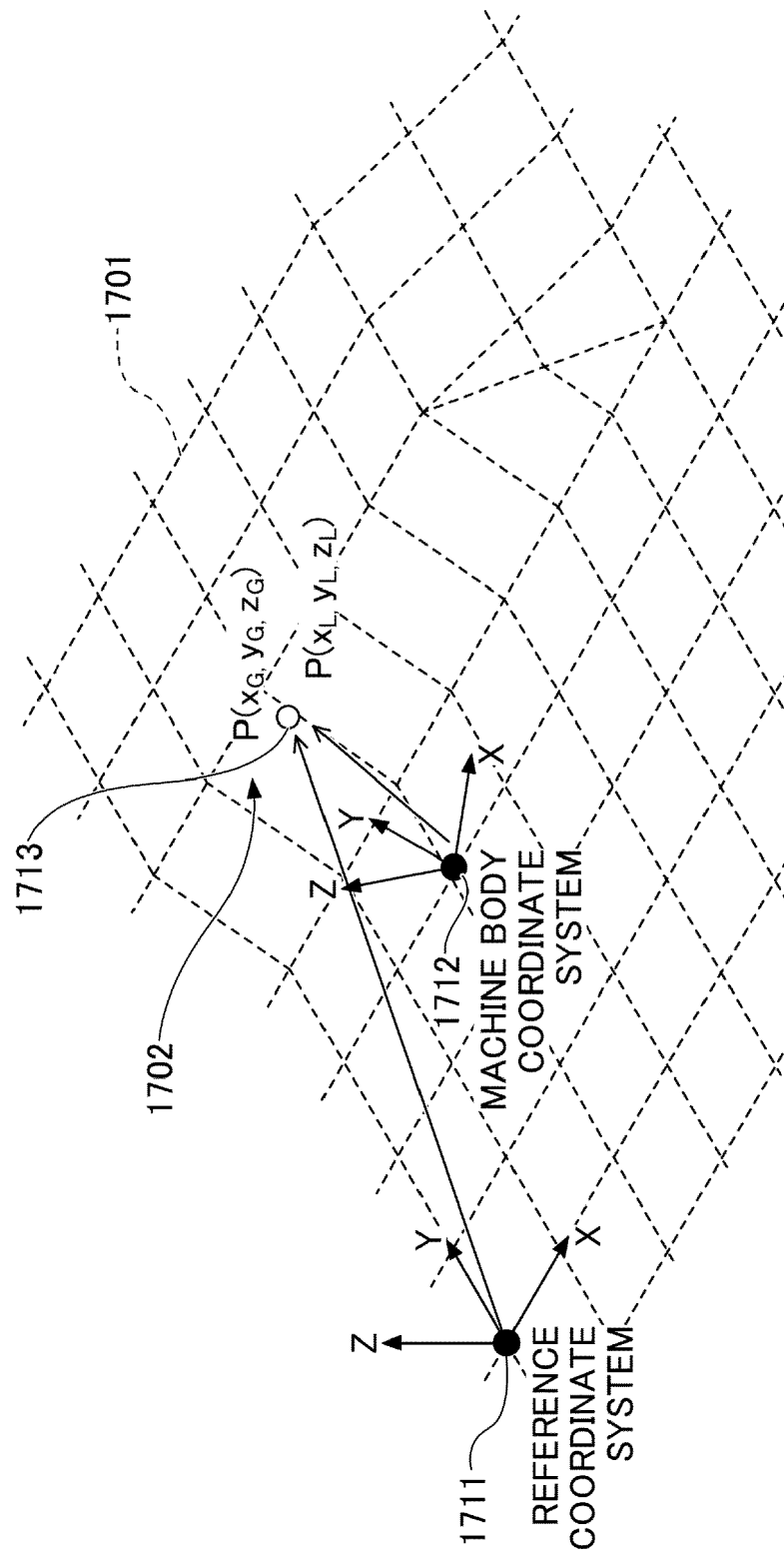


FIG.8

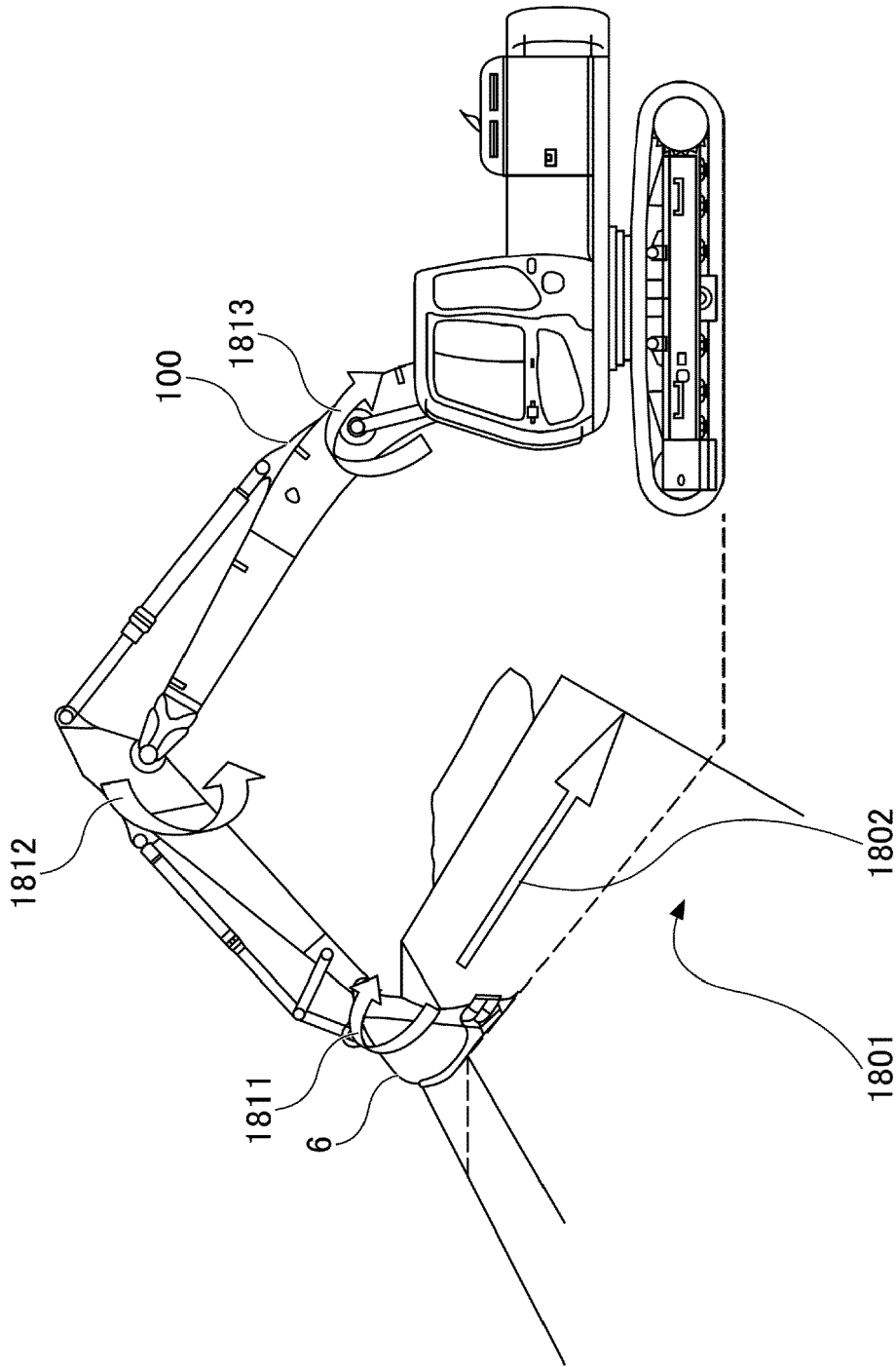


FIG.9

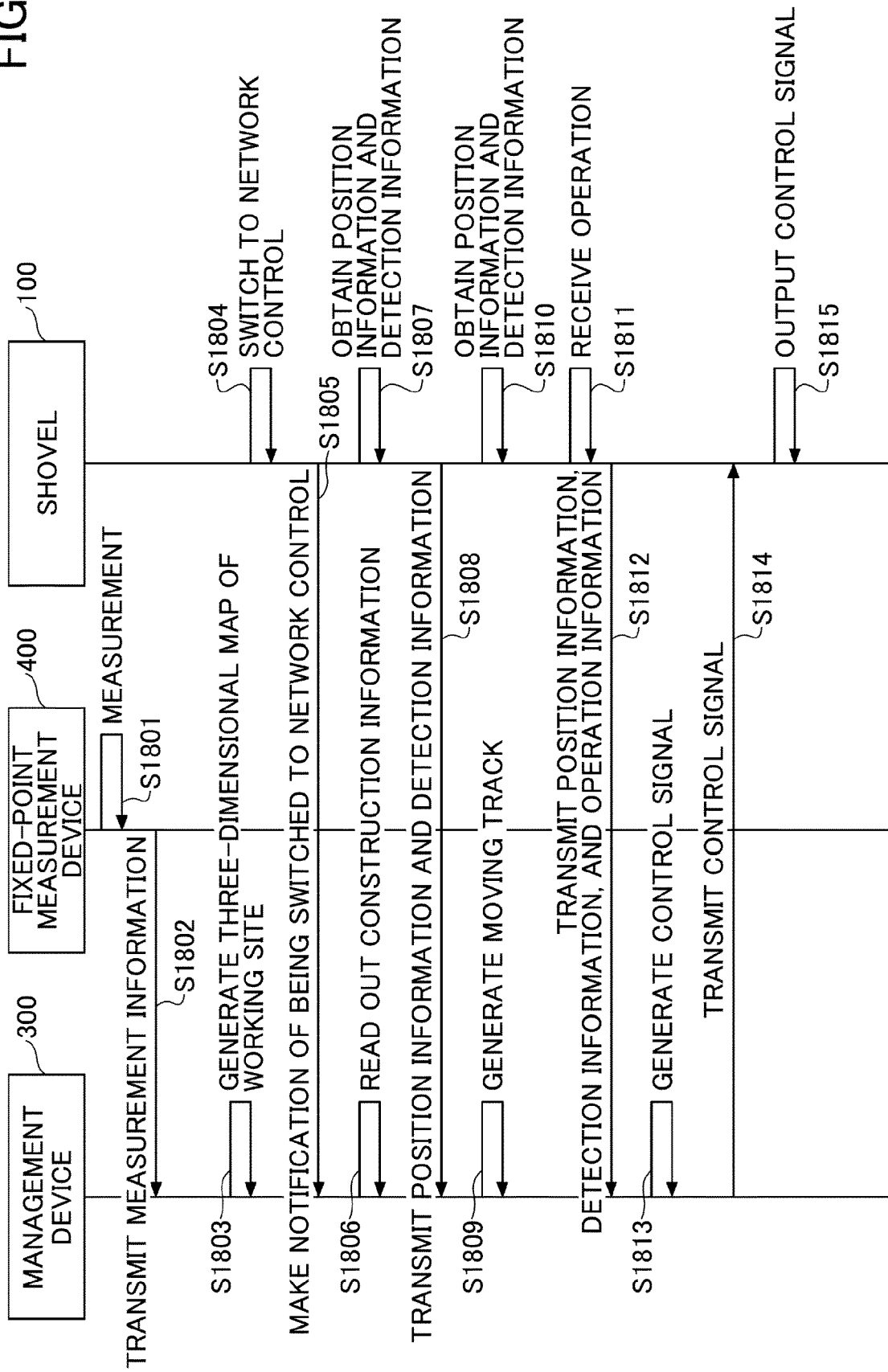
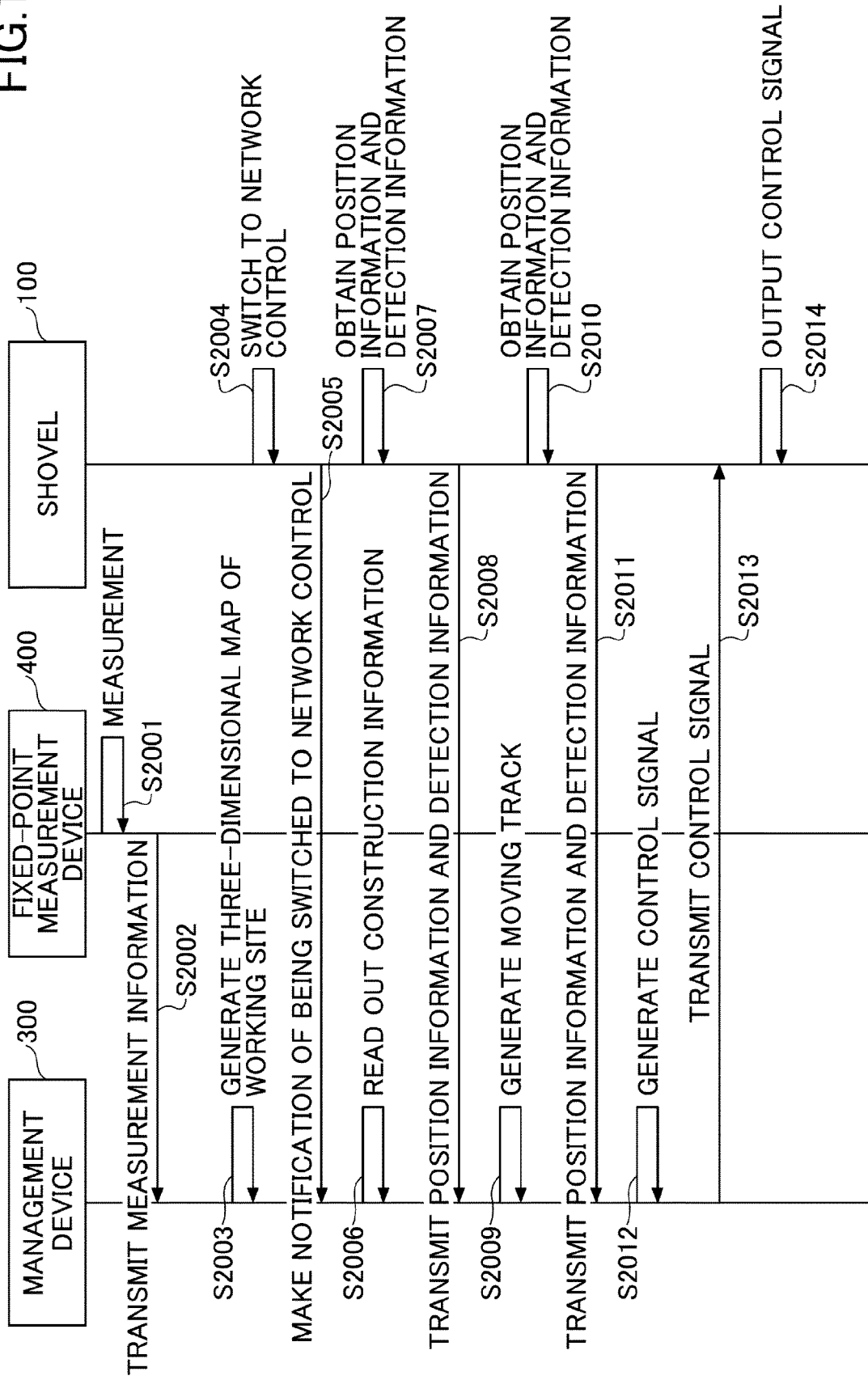


FIG.10



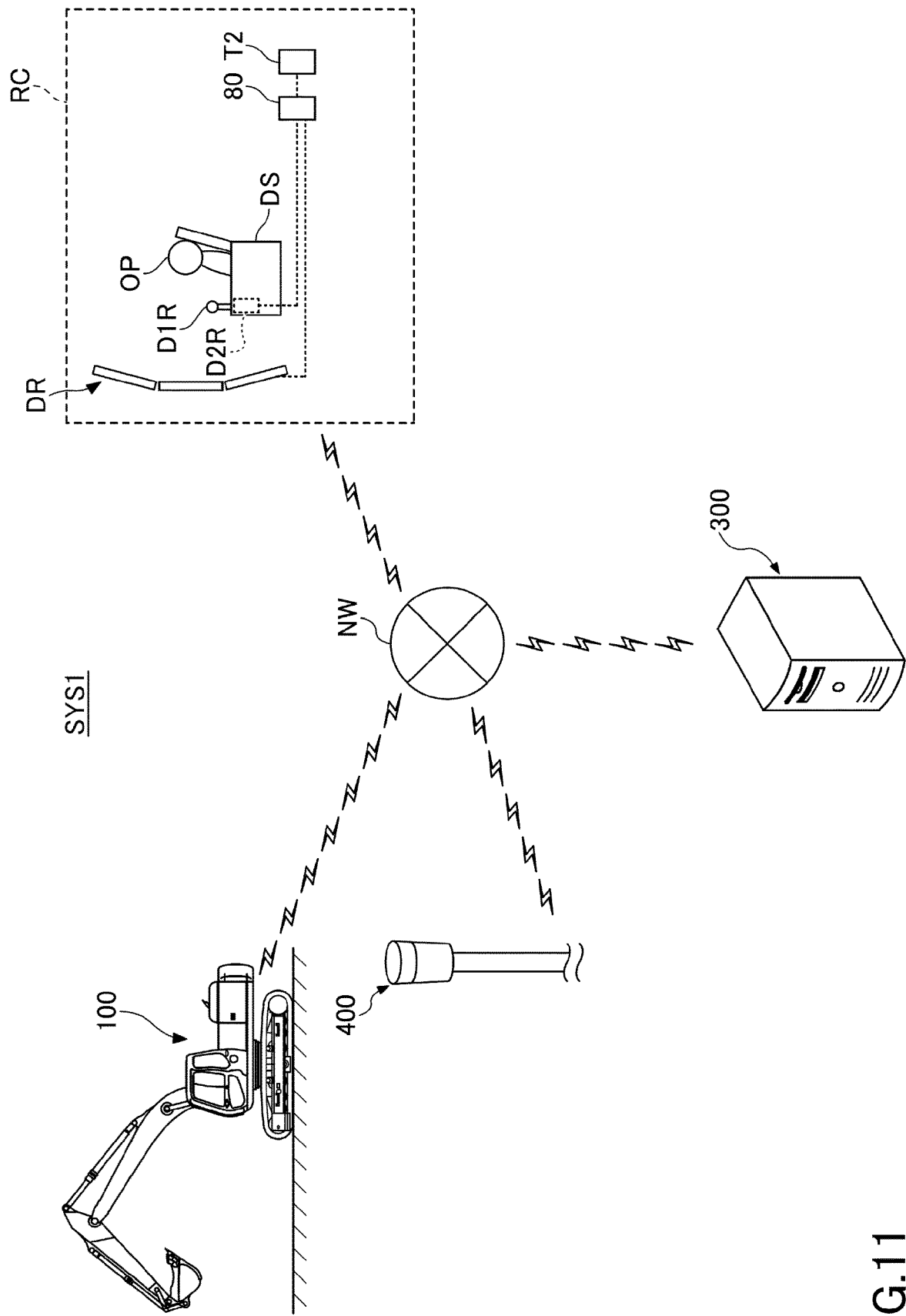
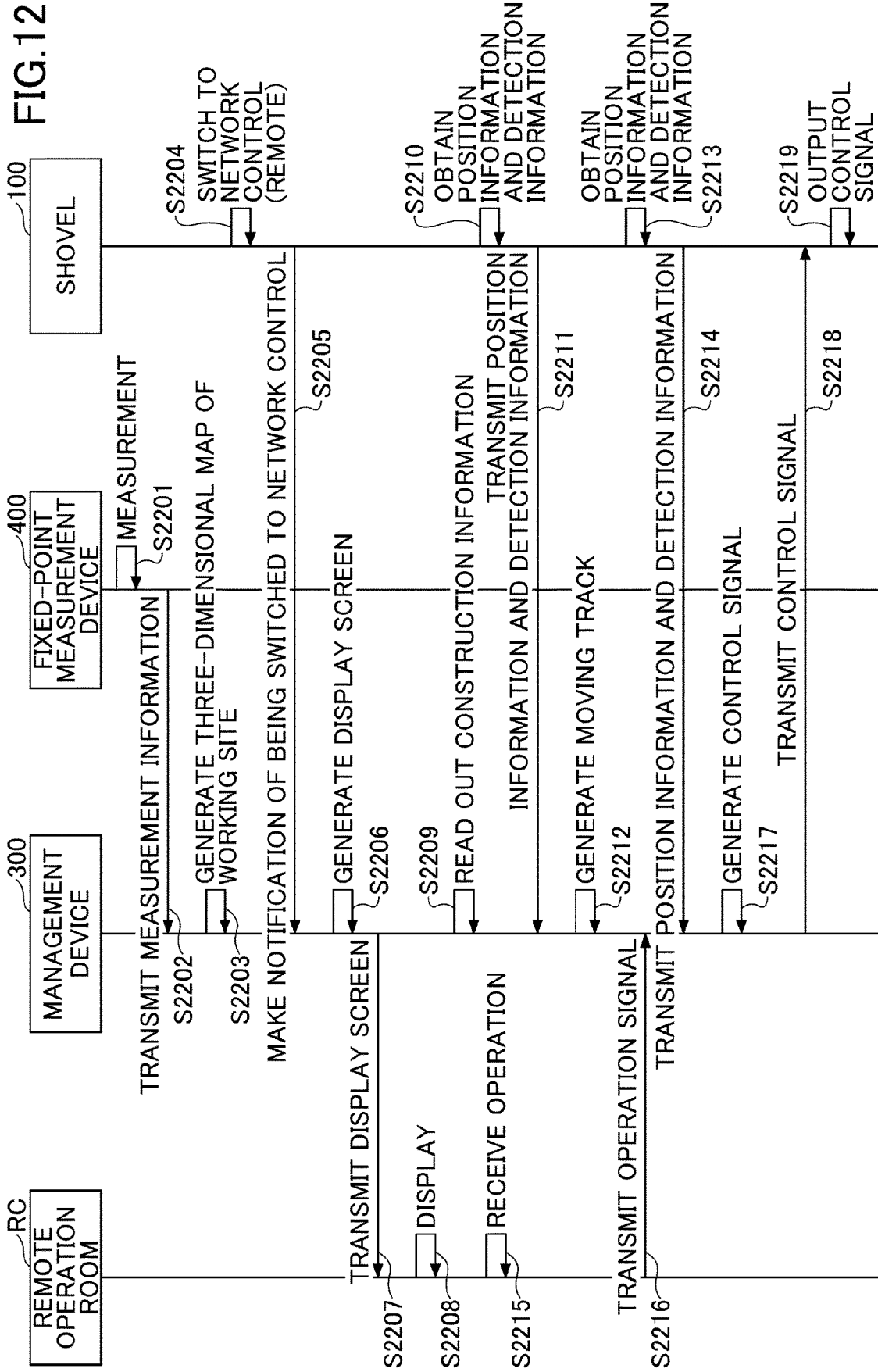


FIG.11

FIG.12





EUROPEAN SEARCH REPORT

Application Number

EP 23 20 5954

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2020/325650 A1 (TSUKAMOTO HIROYUKI [JP] ET AL) 15 October 2020 (2020-10-15) * the whole document *	1-8	INV. E02F3/43 E02F9/20 E02F9/26
A,D	WO 2018/164152 A1 (SUMITOMO SHI CONSTR MACH CO [JP]) 13 September 2018 (2018-09-13) * the whole document *	1-8	
A	US 2017/328030 A1 (YAMADA HIROYUKI [JP] ET AL) 16 November 2017 (2017-11-16) * abstract; figures 1-12 *	1-8	
A	EP 4 043 646 A1 (KOBELCO CONSTR MACH CO LTD [JP]) 17 August 2022 (2022-08-17) * abstract; figures 1-5 *	1-8	

TECHNICAL FIELDS
SEARCHED (IPC)

E02F

The present search report has been drawn up for all claims

1

Place of search

Munich

Date of completion of the search

10 April 2024

Examiner

Ferrien, Yann

CATEGORY OF CITED DOCUMENTS

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ON EUROPEAN PATENT APPLICATION NO.**

EP 23 20 5954

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

10-04-2024

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50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2020325650 A1	15-10-2020	CN 111108249 A	05-05-2020
		EP 3733978 A1	04-11-2020
		JP WO2019131980 A1	17-12-2020
		KR 20200100599 A	26-08-2020
		US 2020325650 A1	15-10-2020
		WO 2019131980 A1	04-07-2019
WO 2018164152 A1	13-09-2018	CN 110291256 A	27-09-2019
		EP 3594416 A1	15-01-2020
		JP 6838137 B2	03-03-2021
		JP WO2018164152 A1	16-01-2020
		KR 20190122662 A	30-10-2019
		US 2019360178 A1	28-11-2019
US 2017328030 A1	16-11-2017	WO 2018164152 A1	13-09-2018
		JP 6424238 B2	14-11-2018
		JP WO2016121010 A1	28-09-2017
		US 2017328030 A1	16-11-2017
EP 4043646 A1	17-08-2022	WO 2016121010 A1	04-08-2016
		CN 115003888 A	02-09-2022
		EP 4043646 A1	17-08-2022
		JP 7341396 B2	11-09-2023
		JP 2021088835 A	10-06-2021
		US 2022412047 A1	29-12-2022
		WO 2021111677 A1	10-06-2021

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2018164152 A [0002] [0003]