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(71) Applicant: **Sumitomo Heavy Industries, Ltd.**
Tokyo 141-6025 (JP)

(72) Inventors:
- **HIRATE, Shoji**
  Kanagawa 237-8555, (JP)
- **HONDA, Keiji**
  Kanagawa 237-8555, (JP)
- **SANO, Yusuke**
  Kanagawa 237-8555, (JP)

(74) Representative: **Louis Pöhlau Lohrentz**
Patentanwälte
Postfach 30 55
90014 Nürnberg (DE)

(54) SHOVEL

(57) A technique that can improve the work efficiency of a shovel is provided. A shovel 100 according to an embodiment of the disclosure includes a lower travelling body 1, an upper rotating body 3 mounted rotatably on the lower travelling body 1, and an attachment AT attached to the upper rotating body 3, and moves the lower travelling body 1 and the attachment AT in conjunction with each other by moving the attachment AT in conjunction with a movement of the lower travelling body 1 or by moving the lower travelling body 1 in conjunction with a movement of the attachment AT.

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Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority of the prior Japanese Patent Applications No. 2022-210780 filed on December 27, 2022, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present disclosure relates to a shovel.

2. Description of the Related Art

[0003] For example, a shovel that works by moving an attachment has been known (see International Publication No. WO 2020/101005).

SUMMARY OF THE INVENTION

[0004] However, for example, if a lower travelling body is erroneously operated while the attachment is moved to perform work, there is a possibility that the attachment cannot move suitably with respect to the ground, which is the target of working. Moreover, for example, when performing work on a wide work area by moving only the attachment, it is necessary to repeat the procedure for performing the work by changing locations to any other uncompleted area after work on a certain partial area is completed. Hence, there is room for improvement in terms of work efficiency.

[0005] Hence, in view of the problem described above, an object is to provide a technique that can improve the work efficiency of a shovel.

[0006] To achieve the object described above, an embodiment of the present disclosure provides a shovel, including:

a lower travelling body;
an upper rotating body mounted rotatably on the lower travelling body; and
an attachment attached to the upper rotating body,
wherein the lower travelling body and the attachment are moved in conjunction with each other.

[0007] According to the embodiment described above, it is possible to improve the work efficiency of a shovel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is a side view illustrating an example of a shovel;
FIG. 2 is a top view illustrating an example of a shovel;
FIG. 3 is a drawing illustrating an example of a configuration relating to a remote operation of a shovel;
FIG. 4 is a drawing illustrating an example of a hardware configuration of a shovel;
FIG. 5 is a drawing illustrating a first example of a functional configuration of a shovel regarding driving of driving target components;
FIG. 6 is a drawing illustrating a second example of a functional configuration of a shovel regarding driving of driving target components;
FIG. 7 is a drawing illustrating a third example of a functional configuration of a shovel regarding driving of driving target components;
FIG. 8 is a view illustrating a first example of a movement of a shovel;
FIG. 9 is a view illustrating the first example of a movement of a shovel;
FIG. 10 is a view illustrating a second example of a movement of a shovel;
FIG. 11 is a view illustrating the second example of a movement of a shovel;
FIG. 12 is a view illustrating a third example of a movement of a shovel; and
FIG. 13 is a view illustrating the third example of a movement of a shovel.

DESCRIPTION OF EMBODIMENTS

[0009] Embodiments will be described below with reference to the drawings.

[Overview of shovel]

[0010] An overview of a shovel 100 according to an embodiment will be described with reference to FIG. 1 to FIG. 3.

[0011] FIG. 1 is a side view illustrating an example of the shovel 100. FIG. 2 is a top view illustrating an example of the shovel 100. FIG. 3 is a drawing illustrating an example of a configuration relating to a remote operation of the shovel 100. Hereinafter, directions of the shovel 100 or directions from the shovel 100 may be described based on the definition that the direction to which an attachment AT extends outward in the top view of the shovel 100 (i.e., the upward direction in FIG. 2) is the "front"

[0012] As illustrated in FIG. 1 and FIG. 2, the shovel 100 includes a lower travelling body 1, an upper rotating body 3, an attachment AT including: a boom 4; an arm 5; and a bucket 6, and a cabin 10.

[0013] The lower travelling body 1 causes the shovel 100 to travel, by using crawlers 1C. The crawlers 1C include a left crawler 1CL and a right crawler 1CR. The crawler 1CL is hydraulically driven by a travelling hydraulic motor 1ML. Likewise, the crawler 1CR is hydraulically driven by a travelling hydraulic motor 1MR. Hence, the lower travelling body 1 can self-propel itself.

[0014] The upper rotating body 3 is mounted rotatably (freely rotatably) on the lower travelling body 1 via a rotating mechanism 2. For example, the upper rotating body 3 rotates with respect to the lower travelling body 1 by the rotating mechanism 2 being hydraulically driven by a rotation hydraulic motor 2M.

[0015] The boom 4 is attached to the front center of the upper rotating body 3 such that the boom 4 can be at an angle of depression or elevation about a pivoting axis that is along the left-right direction. The arm 5 is attached to an end of the boom 4 such that the arm 5 can pivot about a pivoting axis that is along the left-right direction. The bucket 6 is attached to an end of the arm 5 such that the bucket 6 can pivot about a pivoting axis that is along the left-right direction.

[0016] The bucket 6 is an example of an end attachment, and is used for, for example, excavation work, work on a slope, and land preparation work.

[0017] The bucket 6 is attached to the end of the arm 5 in an appropriately exchangeable form in accordance with the content of the work performed by the shovel 100. That is, instead of the bucket 6, a bucket of a different type from the bucket 6, for example, a large-size bucket that is relatively large, a bucket for a slope, and a bucket for dredging may be attached to the end of the arm 5. Moreover, an end attachment of a different type from a bucket, for example, a stirrer, a breaker, and a crusher may be attached to the end of the arm 5. Moreover, for example, a supplementary attachment such as a quick coupling and a tilt rotator, may be attached between the arm 5 and the end attachment.

[0018] 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.

[0019] The cabin 10 is an operation chamber in which an operator rides in order to operate the shovel 100. For example, the cabin 10 is mounted on the front left of the upper rotating body 3.

[0020] For example, the shovel 100 moves driving target components such as the lower travelling body 1 (i.e., the pair of left and right crawlers 1CL and 1CR), the upper rotating body 3, the boom 4, the arm 5, and the bucket 6 in accordance with an operation performed by the operator riding in the cabin 10.

[0021] The shovel 100 may be remotely operable from outside the shovel 100 instead of or in addition to being operable by the operator riding in the cabin 10. When the shovel 100 is remotely operated, the cabin 10 may be unattended. When the shovel 100 is exclusively designed to be remotely operated, the cabin 10 may be omitted. The following description will be provided on the premise that operations of the operator include either or both of an operation performed via an operation device 26 by the operator in the cabin 10, and a remote operation performed by an operator outside the shovel 100.

[0022] For example, as illustrated in FIG. 3, a remote operation includes a mode in which the shovel 100 is operated in response to an operation input regarding an actuator of the shovel 100, the operation input being entered from a remote operation assisting device 300 that can communicate with the shovel 100 through a communication network NW. In this case, the shovel 100 is equipped with a communication device 60, and can mutually communicate with the remote operation assisting device 300 through the predetermined communication network NW.

[0023] The communication network NW includes, for example, a Local Area Network (LAN) in the work site. The communication network NW may include a Wide Area Network (WAN). The wide area network includes, for example, a mobile communication network terminated by base stations, a satellite communication network utilizing a communication satellite, and the Internet. The communication network NW may also include, for example, a close-range communication networks based on wireless communication protocols such as WiFi and Bluetooth (registered trademark).

[0024] The remote operation assisting device 300 is installed in, for example, a management center from which the work of the shovel 100 is managed from outside. The remote operation assisting device 300 may be a portable operation terminal. In this case, the operator can remotely operate the shovel 100 by closely watching the work conditions of the shovel 100 from the surroundings of the shovel 100.

[0025] For example, the shovel 100 may send an image representing the conditions in the surroundings of the shovel 100 including the space ahead of the shovel 100 (hereinafter, "surrounding image") to the remote operation assisting device 300 via the communication device 60 mounted on the shovel 100 itself, the image being based on a captured image output by an image capturing device 40 mounted on the shovel 100 itself. The shovel 100 may send a captured image output by the image capturing device 40 to the remote operation assisting device 300 via the communication device 60, and the remote operation assisting device 300 may process the captured image received from the shovel 100 and generate a surrounding image. Then, the remote operation assisting device 300 may display the surrounding image representing the conditions in the surroundings of the shovel 100 including the space ahead of the shovel 100 on a display device of its own. Various types of information images (information screens) to be displayed on an output device 50 (display device) inside the cabin 10 of the shovel 100 may likewise be displayed on the remote operation assisting device 300 (display part). Hence, for example, the operator using the remote operation assisting device 300 can remotely operate the shovel 100 while watching the display content displayed, such as an image representing the conditions in the surroundings of the shovel 100 or an information screen. Then, the shovel 100 may move actuators and drive the driving target components such as the lower travelling body 1, the upper rotating body 3, the boom 4, the arm 5, and the bucket 6 in accordance with a remote operation signal indicating the content of the remote operation, the remote operation signal being received from the remote operation assisting device 300 via the communication device 60.

[0026] The remote operation may include a mode in which the shovel 100 is operated in accordance with, for example, a sound input or a gesture input into the shovel 100 from outside by a person (e.g., a worker) in the surroundings of the shovel 100. Specifically, the shovel 100 recognizes, for example, a voice uttered by, for example, a worker in the surroundings or a gesture performed by, for example, a worker, via, for example, a sound input device (e.g., a microphone) or a gesture input device (e.g., an image capturing device) mounted on the shovel 100 itself. Then, the shovel 100 may move the actuators and drive the driving target components such as the lower travelling body 1 (left and right crawlers 1C), the upper rotating body 3, the boom 4, the arm 5, and the bucket 6 in accordance with the content of, for example, the recognized voice or gesture.

[0027] The shovel 100 may automatically move the actuators independently from the content of an operation performed by the operator. Hence, the shovel 100 can realize a function for automatically moving at least some of the driving target components such as the lower travelling body 1, the upper rotating body 3, and the attachment AT, i.e., what is generally referred to as "an automatic driving function". The automatic driving function is also referred to as "a Machine Control (MC) function".

[0028] The automatic driving function includes, for example, a semiautomatic driving function. The semiautomatic driving function is also referred to as an operation assisting-type MC function. The semiautomatic driving function is a function for automatically moving a driving target component (actuator) to be in conjunction with any other driving target component (actuator) that is the target of operating, in accordance with an operation of the operator. The automatic driving function may also include a full automatic driving function. The full automatic driving function is also referred to as a full automatic MC function. The full automatic driving function is a function for automatically moving at least some of the plurality of driving target components (hydraulic actuators) on the premise that no operation is to be performed by the operator. When the full automatic driving function is effective in the shovel 100, the cabin 10 may be unattended. When the shovel 100 is exclusively designed to move by the full automatic driving function, the cabin 10 may be omitted. What are referred to as, for example, the semiautomatic driving function and the full automatic driving function include a rule-based automatic driving function. The rule-based automatic driving function is an automatic driving function that automatically determines the contents of movements of the driving target components (actuators), which are the automatic driving targets, in accordance with previously stipulated rules. What are referred to as, for example, the semiautomatic driving function and the full automatic driving function may also include an autonomous driving function. The autonomous driving function is an automatic driving function by which the shovel 100 autonomously determines various matters and determines the contents of movements of the driving target components (hydraulic actuators), which are the automatic driving targets, in accordance with the results of the determinations.

[0029] The work of the shovel 100 may be remotely monitored. In this case, for example, a remote monitor assisting device that has the same function as that of the remote operation assisting device 300 is installed. A monitoring person, who is the user of the remote monitor assisting device, can monitor the conditions of the work of the shovel 100 while watching a surrounding image displayed on the remote monitor assisting device (display part). Moreover, for example, when determining it necessary from a safety point of view, the monitoring person can interrupt an operation performed by the operator of the shovel 100 or automatic driving, and urgently stop the shovel 100, by entering a predetermined input using the remote monitor assisting device (input part).

[Hardware configuration of shovel]

[0030] Next, the hardware configuration of the shovel 100 will be described with reference to FIG. 4 in addition to FIG. 1 to FIG. 3.

[0031] FIG. 4 is a block diagram illustrating an example of the hardware configuration of the shovel 100.

[0032] In FIG. 4, a path through which mechanical power is transmitted is denoted by a double line, paths through which a high-pressure operating oil for driving the hydraulic actuators flows are denoted by solid lines, paths through which a pilot pressure is transmitted are denoted by broken lines, and paths through which an electric signal is transmitted are denoted by dotted lines.

[0033] The shovel 100 includes components each belonging to any of, for example, a hydraulic driving system relating to hydraulic driving of the driving target components, an operation system relating to operations on the driving target components, a user interface system relating to information exchange with the user, a communication system relating to communication with external entities, and a control system relating to various controls.

<Hydraulic driving system>

[0034] As illustrated in FIG. 4, the hydraulic driving system of the shovel 100 includes the hydraulic actuators HA that hydraulically drive the respective driving target components such as the lower travelling body 1 (left and right crawlers 1C), the upper rotating body 3, the boom 4, the arm 5, and the bucket 6 as described above. The hydraulic driving system of the shovel 100 according to the present embodiment also includes an engine 11, a regulator 13, a main pump 14, and a control valve 17.

[0035] The hydraulic actuators HA include, for example, the travelling hydraulic motors 1ML and 1MR, the rotation hydraulic motor 2M, the boom cylinder 7, the arm cylinder 8, and the bucket cylinder 9.

[0036] In the shovel 100, some or all of the hydraulic actuators HA may be replaced with electric actuators. That is, the shovel 100 may be a hybrid shovel or an electric shovel.

[0037] The engine 11 is a prime mover of the shovel 100, and is a main power source for the hydraulic driving system. The engine 11 is, for example, a diesel engine fueled by a light oil. The engine 11 is situated on, for example, a rear portion of the upper rotating body 3. For example, the engine 11 rotates constantly at a previously set target rotation rate under direct or indirect control of a controller 30 described below, and drives the main pump 14 and a pilot pump 15.

[0038] Instead of or in addition to the engine 11, any other prime mover (e.g., an electric motor) may be mounted on the shovel 100.

[0039] The regulator 13 controls (regulates) the discharging amount of the main pump 14 under control of the controller 30. For example, the regulator 13 adjusts the angle (hereinafter, "tilt angle") of a swash plate of the main pump 14 in accordance with a control instruction from the controller 30.

[0040] The main pump 14 supplies the operating oil to the control valve 17 through a high-pressure hydraulic line. The main pump 14 is situated on, for example, the rear portion of the upper rotating body 3 like the engine 11. The main pump 14 is driven by the engine 11 as described above. The main pump 14 is, for example, a variable-displacement hydraulic pump. The discharging flow rate and the discharging pressure of the main pump 14 are controlled by the main pump's piston stroke length being adjusted in response to the tilt angle of the main pump's swash plate being adjusted by the regulator 13 under control of the controller 30 as described above.

[0041] The control valve 17 drives the hydraulic actuators HA in accordance with the content of an operation performed by the operator via the operation device 26 or of a remote operation, or an operation instruction corresponding to the automatic driving function. The control valve 17 is situated on, for example, a center portion of the upper rotating body 3. The control valve 17 is coupled to the main pump 14 through the high-pressure hydraulic line as described above, and supplies the operating oil supplied from the main pump 14 selectively to the respective hydraulic actuators HA in accordance with an operation performed by the operator, or an operation instruction corresponding to the automatic driving function. The control valve 17 includes direction switching valves 17A to 17F that control the flow rates and the flow directions of the operating oil to be supplied from the main pump 14 to the respective hydraulic actuators HA.

[0042] The direction switching valve 17A controls the flow rate and the flow direction of the operating oil to be supplied to the boom cylinder 7. Hence, the direction switching valve 17A can extend or contract the boom cylinder 7 at a variable speed. The direction switching valve 17A is, for example, a spool valve.

[0043] The direction switching valve 17B controls the flow rate and the flow direction of the operating oil to be supplied to the arm cylinder 8. Hence, the direction switching valve 17B can extend or contract the arm cylinder 8 at a variable speed. The direction switching valve 17B is, for example, a spool valve.

[0044] The direction switching valve 17C controls the flow rate and the flow direction of the operating oil to be supplied to the bucket cylinder 9. Hence, the direction switching valve 17C can extend or contract the bucket cylinder 9 at a variable speed. The direction switching valve 17C is, for example, a spool valve.

[0045] The direction switching valve 17D controls the flow rate and the flow direction of the operating oil to be supplied to the travelling hydraulic motor 1ML. Hence, the direction switching valve 17D can rotate the travelling hydraulic motor 1ML bidirectionally at a variable speed. The direction switching valve 17D is, for example, a spool valve.

[0046] The direction switching valve 17E controls the flow rate and the flow direction of the operating oil to be supplied to the travelling hydraulic motor 1MR. Hence, the direction switching valve 17E can rotate the travelling hydraulic motor 1MR bidirectionally at a variable speed. The direction switching valve 17E is, for example, a spool valve.

[0047] The direction switching valve 17F controls the flow rate and the flow direction of the operating oil to be supplied to the rotation hydraulic motor 2M. Hence, the direction switching valve 17F can rotate the rotation hydraulic motor 2M bidirectionally at a variable speed. The direction switching valve 17F is, for example, a spool valve.

<Operation system>

[0048] As illustrated in FIG. 4, the operation system of the shovel 100 includes the pilot pump 15, the operation device 26, and a hydraulic control valve 31.

[0049] The pilot pump 15 supplies pilot pressures to various hydraulic devices through a pilot line 25. The pilot pump 15 is situated in, for example, the rear portion of the upper rotating body 3 like the engine 11. The pilot pump 15 is, for example, a fixed-displacement hydraulic pump, and is driven by the engine 11 as described above.

[0050] The pilot pump 15 may be omitted. In this case, the operating oil discharged from the main pump 14 and having a relatively high pressure may be decompressed by a predetermined decompression valve, and the operating oil that has been through the decompression and has a relatively low pressure may be supplied to the various hydraulic devices as a pilot pressure.

[0051] The operation device 26 is situated near the cockpit in the cabin 10, and is used by the operator in order to perform operations on the various driving target components. Specifically, the operation device 26 is used by the operator in order to perform operations on the hydraulic actuators HA that drive the respective driving target components. As a result, operations by the operator on the driving target components, which are the targets of driving by the hydraulic actuators HA, can be realized. The operation device 26 includes pedal devices and lever devices (e.g., lever devices 26A to 26C described below) via which the respective driving target components (hydraulic actuators HA) are operated.

[0052] For example, as illustrated in FIG. 4, the operation device 26 is an electric type. Specifically, the operation device 26 outputs an electric signal corresponding to the content of an operation (hereinafter, "operation signal"), and the operation signal is input into the controller 30. Then, the controller 30 outputs an operation instruction corresponding to the content of the operation signal, i.e., outputs an operation instruction (control signal) corresponding to the content of the operation performed via the operation device 26 to the hydraulic control valve 31. Hence, a pilot pressure corresponding to the content of the operation performed via the operation device 26 is input into the control valve 17 from the hydraulic control valve 31, and the control valve 17 can drive a corresponding hydraulic actuator HA in accordance with the content of the operation performed via the operation device 26.

[0053] The direction switching valves 17A to 17F that are contained in the control valve 17 and drive corresponding hydraulic actuators HA may be an electromagnetic solenoid type. In this case, an operation signal output from the operation device 26 may be directly input into the control valve 17 (i.e., the electromagnetic solenoid-type direction switching valves).

[0054] The operation device 26 may be a hydraulic pilot type. Specifically, the operation device 26 outputs a pilot pressure corresponding to the content of an operation to a pilot line on its secondary side, by using the operating oil supplied from the pilot pump 15 through a pilot line. The pilot line on the secondary side is connected to the control valve 17. Hence, pilot pressures corresponding to the contents of operations on the various driving target components (hydraulic actuators HA) performed via the operation device 26 can be input into the control valve 17. Hence, the control valve 17 can drive the respective hydraulic actuators HA in accordance with the contents of the operations performed by, for example, the operator via the operation device 26. In this case, an operation state sensor that can acquire information regarding the operation state of the operation device 26 is installed, and an output from the operation state sensor is input into the controller 30. Hence, the controller 30 can know the operation state of the operation device 26. The operation state sensor is, for example, a pressure sensor that acquires information regarding a pilot pressure (operation pressure) on the pilot line on the secondary side of the operation device 26.

[0055] As described above, some or all of the hydraulic actuators HA may be replaced with electric actuators. In this case, for example, the controller 30 may output an operation instruction corresponding to the content of an operation performed via the operation device 26 or the content of a remote operation prescribed by a remote operation signal to the electric actuator or, for example, a driver that drives the electric actuator. Moreover, the electric actuator may be operable via the operation device 26, by an operation signal being input from the operation device 26 into the electric actuator or, for example, the driver.

[0056] When the shovel 100 is exclusively designed for being remotely operated or exclusively designed to move by the full automatic driving function, the operation device 26 may be omitted.

[0057] The hydraulic control valve 31 is installed per driving target component (hydraulic actuator HA) that is the target of operating via the operation device 26 and per moving direction of the driving target component (hydraulic actuator HA) (e.g., a raising direction and a lowering direction of the boom 4). For example, two hydraulic control valves 31 are installed per double-acting hydraulic actuator HA that drives, for example, the lower travelling body 1, the upper rotating body 3, the boom 4, the arm 5, or the bucket 6. For example, each hydraulic control valve 31 is situated on the pilot line between the pilot pump 15 and the control valve 17, and the flow path area (i.e., the cross-sectional area over which the operating oil can flow) of the hydraulic control valve 31 may be variable. Hence, the hydraulic control valve 31 can output a predetermined pilot pressure to the pilot line on the secondary side by using the operating oil from the pilot pump 15 supplied through the pilot line on the primary side. Hence, each hydraulic control valve 31 can cause a predetermined pilot pressure corresponding to an operation instruction from the controller 30 to act on the control valve 17. Hence, for example, the controller 30 can cause a pilot pressure corresponding to the content of an operation performed via the operation device 26 (i.e., corresponding to an operation signal) to be directly supplied to the control valve 17 from the hydraulic control valve 31, and realize a movement of the shovel 100 based on the operation performed by the operator.

[0058] The controller 30 may realize the automatic driving function of the shovel 100 by controlling the hydraulic control valves 31. Specifically, the controller 30 outputs an operation instruction corresponding to the automatic driving function to the hydraulic control valve 31. Hence, the controller 30 can realize a movement of the shovel 100 that is based on the automatic driving function.

[0059] The controller 30 may control the hydraulic control valve 31 and realize a remote operation of the shovel 100. Specifically, the controller 30 outputs an operation instruction corresponding to the content of a remote operation indicated by a remote operation signal received from the remote operation assisting device 300 via the communication device 60 to the hydraulic control valve 31. Hence, the controller 30 can cause a pilot pressure corresponding to the content of the remote operation to be supplied to the control valve 17 from the hydraulic control valve 31, and realize a movement of the shovel

100 based on the remote operation of an operator.

[0060] When the operation device 26 is the hydraulic pilot type, a shuttle valve may be installed on the pilot line between the operation device 26 and hydraulic control valve 31, and the control valve 17. The shuttle valve includes two inlet ports and one outlet port, and outputs from the output port, the operating oil having the higher pilot pressure of the pilot pressures input into the two input ports. Like the hydraulic control valve 31, the shuttle valve is installed per driving target component (hydraulic actuator HA) that is the target of operating via the operation device 26 and per moving direction of the driving target component (hydraulic actuator HA). For example, two shuttle valves are installed per double-acting hydraulic actuator HA that drives, for example, the lower travelling body 1, the upper rotating body 3, the boom 4, the arm 5, or the bucket 6. One of the two inlet ports of each shuttle valve is connected to the pilot line on the secondary side of the operation device 26 (specifically, the lever device or the pedal device described above and included in the operation device 26), and the other of the inlet ports is connected to the pilot line on the secondary side of the hydraulic control valve 31. The outlet port of the shuttle valve is connected to the pilot port of a corresponding direction switching valve of the control valve 17 through the pilot line. The corresponding direction switching valve is the direction switching valve that drives the hydraulic actuator HA that is the target of operating via the lever device or the pedal device described above and connected to the one inlet port of the shuttle valve. Hence, these shuttle valves can cause the higher one of the pilot pressure on the pilot line on the secondary side of the operation device 26 and the pilot pressure on the pilot line on the secondary side of the hydraulic control valve 31 to act on the pilot port of the corresponding direction switching valve. That is, by causing the hydraulic control valve 31 to output a pilot pressure higher than the pilot pressure on the secondary side of the operation device 26, the controller 30 can control the corresponding direction switching valve independently from the operation performed by the operator via the operation device 26. Hence, the controller 30 can control the movements of the driving target components (the lower travelling body 1, the upper rotating body 3, the boom 4, the arm 5, and the bucket 6) independently from the state of the operation performed by the operator via the operation device 26, and realize the automatic driving function and the remote operation function.

[0061] When the operation device 26 is the hydraulic pilot type, in addition to the shuttle valve, a decompression valve may be installed on the pilot line between the operation device 26 and the shuttle valve. The decompression valve operates in accordance with a control signal that is input from the controller 30, and the flow path area of the compression valve is variable. Hence, the controller 30 can forcibly decompress a pilot pressure that is output from the operation device 26 when an operation is performed by the operator via the operation device 26. Hence, even when an operation is performed via the operation device 26, the controller 30 can forcibly restrain or stop the movement of a hydraulic actuator HA corresponding to the operation performed via the operation device 26. Moreover, for example, even when an operation is performed via the operation device 26, the controller 30 can cause the pilot pressure that is output from the operation device 26 to be decompressed by the decompression valve and become lower than the pilot pressure that is output from the hydraulic control valve 31. Hence, by controlling the hydraulic control valve 31 and the decompression valve, for example, the controller 30 can reliably cause a desired pilot pressure to act on the pilot port of any direction switching valve of the control valve 17 independently from the content of the operation performed via the operation device 26. Hence, for example, by controlling the decompression valve in addition to the hydraulic control valve 31, the controller 30 can realize the automatic driving function and the remote operation function of the shovel 100 more suitably.

<User interface system>

[0062] As illustrated in FIG. 4, the user interface system of the shovel 100 includes the operation device 26, an output device 50, and an input device 52.

[0063] The output device 50 outputs various information to, for example, the user of the shovel 100 (e.g., the operator in the cabin 10 and a remotely operating operator outside) or to a person in the surroundings of the shovel 100 (e.g., a worker and a driver of a work vehicle).

[0064] For example, the output device 50 includes, for example, an illumination device and a display device 50A that output various information visually. The illumination device is, for example, a warning lamp (an indicator lamp). The display device 50A is, for example, a liquid crystal display or an Electro Luminescence (EL) display. For example, as illustrated in FIG. 1, the illumination device and the display device 50A may be situated in the cabin 10, and may output various information visually to, for example, the operator in the cabin 10. The illumination device and the display device 50A may be situated on, for example, a side surface of the upper rotating body 3, and may output various information visually to, for example, a worker in the surroundings of the shovel 100.

[0065] The output device 50 may include a sound output device 50B that outputs various information auditorily. The sound output device 50B includes, for example, a buzzer and a loudspeaker. For example, the sound output device 50B is situated either or both of inside or outside the cabin 10, and outputs various information auditorily to the operator in the cabin 10 or to a person (e.g., a worker) in the surroundings of the shovel 100.

[0066] The output device 50 may include a device that outputs various information tactually by, for example, vibrating the cockpit.

[0067] The input device 52 receives various inputs from the user of the shovel 100, and signals corresponding to the received inputs are input into the controller 30. For example, as illustrated in FIG. 2, the input device 52 is situated in the cabin 10, and receives an input from, for example, the operator in the cabin 10. The input device 52 may be situated on, for example, a side surface of the upper rotating body 3, and may receive an input from, for example, a worker in the surroundings of the shovel 100.

[0068] For example, the input device 52 includes an operation input device that receives an input based on a mechanical operation performed by the user. The operation input device may include, for example, a touch panel mounted on a display device, a touch pad that is set anywhere around a display device, a button switch, a lever, a toggle, and a knob switch situated on the operation device 26 (lever device).

[0069] The input device 52 may include a sound input device that receives a sound input from the user. The sound input device includes, for example, a microphone.

[0070] The input device 52 may also include a gesture input device that receives a gesture input from the user. The gesture input device includes, for example, an image capturing device that captures an image representing how the user is performing a gesture.

[0071] The input device 52 may also include a biological input device that receives a biological input from the user. The biological input includes, for example, an input of biological information of the user such as a fingerprint and an iris.

<Communication system>

[0072] As illustrated in FIG. 4, the communication system of the shovel 100 according to the present embodiment includes the communication device 60.

[0073] The communication device 60 connects to an external communication network NW and communicates with a device situated separately from the shovel 100. The device situated separately from the shovel 100 may include a device existing outside the shovel 100, and a portable terminal device (portable terminal) that is brought into the cabin 10 by the user of the shovel 100. The communication device 60 may include a mobile communication module based on a standard such as 4th Generation (4G) and 5th Generation (5G). The communication device 60 may include, for example, a satellite communication module. The communication device 60 may include, for example, a WiFi communication module and a Bluetooth (registered trademark) communication module. When there are a plurality of connectable communication networks NW, the communication device 60 may include a plurality of communication devices 60 suited to the types of the communication networks NW.

[0074] For example, the communication device 60 communicates with an external device such as the remote operation assisting device 300 on the work site through a local communication network that is constructed on the work site. The local communication network is, for example, a mobile communication network based on what is generally referred to as local 5G constructed on the work site, or a local network based on WiFi6.

[0075] The communication device 60 may communicate with an external device such as the remote operation assisting device 300 that is outside the work site through a communication network over a wide area including the work site, i.e., a wide area network.

[0076] For example, when the shovel 100 is not to be remotely operated or remotely monitored, the communication device 60 may be omitted.

<Control system>

[0077] As illustrated in FIG. 4, the control system of the shovel 100 includes the controller 30. The control system of the shovel 100 according to the present embodiment includes the image capturing device 40 and sensors S1 to S6.

[0078] The controller 30 performs various controls regarding the shovel 100.

[0079] The functions of the controller 30 may be realized by, for example, desirably selected hardware or a combination of desirably selected hardware and software. For example, as illustrated in FIG. 4, the controller 30 includes an auxiliary memory device 30A, a memory device 30B, a Central Processing Unit (CPU) 30C, and an interface device 30D that are connected through a bus B1.

[0080] The auxiliary memory device 30A is a nonvolatile memory, and stores programs to be installed therein, and also stores necessary files and data. The auxiliary memory device 30A is, for example, an Electrically Erasable Programmable Read-Only Memory (EEPROM) and a flash memory.

[0081] The memory device 30B loads a program stored in the auxiliary memory device 30A such that the program can be read by the CPU 30C, when, for example, an instruction to start the program is given. The memory device 30B is, for example, a Static Random Access Memory (SRAM).

[0082] For example, the CPU 30C executes the program loaded into the memory device 30B, and realizes various functions of the controller 30 in accordance with the instructions of the program.

[0083] The interface device 30D functions as, for example, a communication interface for connecting to a communication network within the shovel 100. The interface device 30D may include a plurality of different types of communication interfaces to suit to the types of communication networks to connect to.

[0084] The interface device 30D also functions as an external interface for reading data from a recording medium or writing data into the recording medium. The recording medium is, for example, a dedicated tool to be connected to a connector situated in the cabin 10 through a cable detachably attachable to the connector. The recording medium may be a general-purpose recording medium such as an SD memory card or a Universal Serial Bus (USB) memory. Hence, the program that realizes the various functions of the controller 30 can be provided in the form of a portable recording medium, and installed in the auxiliary memory device 30A of the controller 30. The program may also be downloaded from any other computer outside the shovel 100 via the communication device 60, and installed in the auxiliary memory device 30A.

[0085] Some of the functions of the controller 30 may be realized by any other controller (control device). That is, the functions of the controller 30 may be realized in a distributed manner by a plurality of controllers mounted on the shovel 100.

[0086] The image capturing device 40 acquires an image representing the conditions in the surroundings of the shovel 100. The image capturing device 40 may acquire (generate) three-dimensional data indicating the position and the contour of an object existing in the surroundings of the shovel 100 within the image capturing range (angle of view) (hereinafter, simply "three-dimensional data of an object") based on an acquired image and data regarding a distance described below. The three-dimensional data of an object existing in the surroundings of the shovel 100 is, for example, data representing the coordinates information of dots representing the surface of the object, and data representing a range image.

[0087] For example, as illustrated in FIG. 1 and FIG. 2, the image capturing device 40 includes a front camera 40F that captures an image of the space ahead of the upper rotating body 3. The image capturing device 40 may include, for example, a back camera 40B that captures an image of the space behind the upper rotating body 3, a left camera 40L that captures an image of the space on the left of the upper rotating body 3, and a right camera 40R that captures an image of the space on the right of the upper rotating body 3. Hence, the image capturing device 40 can capture images of the whole surroundings of the shovel 100 in the top view of the shovel 100, i.e., a range covering the 360-degree angular directions. The operator can view surrounding images that are based on the captured images of the left camera 40L, the right camera 40R, and the back camera 40B via the output device 50 or the display part of the remote operation assisting device 300, and confirm the conditions on the left, right, and back of the upper rotating body 3. Moreover, by viewing a surrounding image that is based on the front camera 40F via the display part of the remote operation assisting device 300, the operator can remotely operate the shovel 100 while confirming the movement of the attachment AT including the bucket 6.

[0088] The image capturing device 40 is, for example, a monocular camera. The image capturing device 40 may also be able to acquire data regarding a distance (depth) in addition to a two-dimensional image, like, for example, a stereo camera and a Time-Of-Flight (TOF) camera (hereinafter, referred to as "3D camera" all-inclusively).

[0089] Output data (e.g., image data and three-dimensional data of an object existing in the surroundings of the shovel 100) of the image capturing device 40 is input into the controller 30 through a one-to-one communication network or a vehicle-mounted network. Hence, for example, the controller 30 can monitor the object existing in the surroundings of the shovel 100 based on the output data of the image capturing device 40. Moreover, for example, the controller 30 can determine the surrounding environment of the shovel 100 based on the output data of the image capturing device 40. Moreover, for example, the controller 30 can determine the attitudinal state of the attachment AT reflected in a captured image based on the output data of the image capturing device 40 (front camera). Moreover, for example, the controller 30 can determine the attitudinal state of the body of the shovel 100 (upper rotating body 3) as measured from the object existing in the surroundings of the shovel 100 based on the output data of the image capturing device 40.

[0090] Instead of or in addition to the image capturing device 40, a range sensor may be situated on the upper rotating body 3. For example, the range sensor is situated on an upper portion of the upper rotating body 3, and acquires data regarding the distance and the direction of the object existing in the surroundings as measured from the shovel 100. The range sensor may acquire (generate) three-dimensional data of the object existing in the surroundings of the shovel 100 within a sensing range (e.g., data representing coordinates information of dots) based on the acquired data. The range sensor is, for example, a Light Detection and Ranging (LIDAR) sensor. The range sensor may also be, for example, a millimeter wave radar, an ultrasonic sensor, and an infrared sensor.

[0091] Depending on the use of the image capturing device 40, some of the front camera 40F, the back camera 40B, the left camera 40L, and the right camera 40R may be omitted. Moreover, when, for example, the shovel 100 is not to be remotely operated or an object existing in the surroundings of the shovel 100 is not to be monitored, the image capturing device 40 may be omitted.

[0092] The sensor S1 is situated on the boom 4, and measures the attitudinal state of the boom 4. The sensor S1 outputs measurement data representing the attitudinal state of the boom 4. The attitudinal state of the boom 4 is, for example, an attitude angle (hereinafter, "boom angle") of a base end of the boom 4 about the pivoting axis, the base end corresponding to a joining portion at which the boom 4 and the upper rotating body 3 are joined. The sensor S1 includes, for example, a rotary potentiometer, a rotary encoder, an accelerometer, an angular acceleration sensor, a six-axis sensor, and an Inertial Measurement Unit (IMU). Hereinafter, the same may apply to the sensors S2 to S4. The sensor S1 may also include a cylinder sensor that detects the extension or contraction position of the boom cylinder 7. Hereinafter, the same may apply to the sensors S2 and S3. An output (measurement data representing the attitudinal state of the boom 4) from the sensor S1 is input into the controller 30. Hence, the controller 30 can know the attitudinal state of the boom 4.

[0093] The sensor S2 is situated on the arm 5 and measures the attitudinal state of the arm 5. The sensor S2 outputs measurement data representing the attitudinal state of the arm 5. The attitudinal state of the arm 5 is, for example, an attitude angle (hereinafter, "arm angle") of a base end of the arm 5 about the pivoting axis, the base end corresponding to a joining portion at which the arm 5 and the boom 4 are joined. An output (measurement data representing the attitudinal state of the arm 5) from the sensor S2 is input into the controller 30. Hence, the controller 30 can know the attitudinal state of the arm 5.

[0094] The sensor S3 is situated on the bucket 6 and measures the attitudinal state of the bucket 6. The sensor S3 outputs measurement data representing the attitudinal state of the bucket 6. The attitudinal state of the bucket 6 is, for example, an attitude angle (hereinafter, "bucket angle") of a base end of the bucket 6 about the pivoting axis, the base end corresponding to a joining portion at which the bucket 6 and the arm 5 are joined. An output (measurement data representing the attitudinal state of the bucket 6) from the sensor S3 is input into the controller 30. Hence, the controller 30 can know the attitudinal state of the bucket 6.

[0095] The sensor S4 measures the attitudinal state of the body of the shovel 100 (e.g., the upper rotating body 3). The sensor S4 outputs measurement data representing the attitudinal state of the body of the shovel 100. The attitudinal state of the body of the shovel 100 is, for example, an inclination state of the body with respect to a predetermined reference plane (e.g., a horizontal plane). For example, the sensor S4 is situated on the upper rotating body 3, and measures the inclination angles (hereinafter, "front-rear inclination angle" and "left-right inclination angle") of the shovel 100 about two axes that are in the front-rear direction and in the left-right direction. An output (measurement data representing the attitudinal state of the body of the shovel 100) from the sensor S4 is input into the controller 30. Hence, the controller 30 can know the attitudinal state (inclination state) of the body (upper rotating body 3).

[0096] The senor S5 is situated on the upper rotating body 3, and measures the rotation state of the upper rotating body 3. The sensor S5 outputs measurement data representing the rotation state of the upper rotating body 3. The sensor S5 measures, for example, the rotation angular velocity and the rotation angle of the upper rotating body 3. The sensor S5 includes, for example, a gyro sensor, a resolver, and a rotary encoder. An output (measurement data representing the rotation state of the upper rotating body 3) from the sensor S5 is input into the controller 30. Hence, the controller 30 can know the rotation state, such as the rotation angle, of the upper rotating body 3.

[0097] For example, the controller 30 can know (estimate) the position of the end (bucket 6) of the attachment AT based on the outputs from the sensors S1 to S5. Hence, the controller 30 can control a movement of the shovel 100 based on the automatic driving function, while having a rough estimate of the position of the end of the attachment AT.

[0098] When the sensor S4 includes, for example, a gyro sensor, a six-axis sensor, and an IMU that can detect angular velocities about three axes, the rotation state (e.g., rotation angular velocity) of the upper rotating body 3 may be detected based on a detection signal of the sensor S4. In this case, the sensor S5 may be omitted.

[0099] The sensor S6 measures the position of the shovel 100. The sensor S6 may measure the position based on a world (global) coordinate system, or may measure the position based on a local coordinate system on the work site. In the former case, the sensor S6 is, for example, a Global Navigation Satellite System (GNSS) sensor. In the latter case, the sensor S6 is a transceiver that can communicate with a device serving as the positional reference of the work site, and output a signal corresponding to a position measured with respect to the reference. An output from the sensor S6 is input into the controller 30.

[0100] When the shovel 100 is not equipped with the automatic driving function, the sensors S1 to S6 may be omitted.

[Functional configuration of shovel regarding driving of driving target components]

[0101] Next, the functional configuration of the shovel 100 regarding driving of the driving target components will be described with reference to FIG. 5 to FIG. 7 in addition to FIG. 1 to FIG. 4.

<First example>

[0102] FIG. 5 is a drawing illustrating a first example of the functional configuration of the shovel regarding driving of the driving target components.

[0103] In the present example, the attachment AT of the shovel 100 moves by the semiautomatic driving function. Specifically, in response to operations performed by the operator on any one (in the present example, the arm 5) selected from the boom 4, the arm 5, and the end attachment (bucket 6), and on the lower travelling body 1, the attachment AT performs a predetermined movement such that the two movements, which are the targets of operating, and other two movements are in conjunction with each other. The predetermined movement is, for example, a digging movement, a horizontally towing movement, and a surface compaction movement.

[0104] As illustrated in FIG. 5, the controller 30 includes an attitude detecting part 301, a travelling position/attitude/speed detecting part 302, a target trajectory generating part 303, a travel predicting part 304, an arm movement predicting part 305, a control reference position/speed detecting part 306, a movement instruction generating part 307, and an operation instruction generating part 308.

[0105] The attitude detecting part 301 detects (calculates) the attitude of the attachment AT based on outputs from the sensors S1 to S3. The attitude detecting part 301 includes a boom attitude detecting part 301A, an arm attitude detecting part 301B, and a bucket attitude detecting part 301C.

[0106] The boom attitude detecting part 301A detects (calculates) the attitude angle (boom angle) of the boom 4 based on an output from the sensor S1. The boom attitude detecting part 301A may detect the velocity at which the attitude angle of the boom 4 changes (a relative angular velocity of the boom 4 with respect to the upper rotating body 3).

[0107] The arm attitude detecting part 301B detects (calculates) the attitude angle (arm angle) of the arm 5 based on an output from the sensor S2. The arm attitude detecting part 301B may detect the velocity at which the attitude angle of the arm 5 changes (a relative angular velocity of the arm 5 with respect to the boom 4).

[0108] The bucket attitude detecting part 301C detects (calculates) the attitude angle (bucket angle) of the bucket 6 based on an output from the sensor S3. The bucket attitude detecting part 301C may detect the velocity at which the attitude angle of the bucket 6 changes (a relative angular velocity of the bucket 6 with respect to the arm 5).

[0109] The travelling position/attitude/speed detecting part 302 detects the travelling positions, the attitudes, and the travelling speeds of the body of the shovel 100 including the lower travelling body 1 and the upper rotating body 3 based on outputs from the sensors S4 to S6. The travelling positions and the speeds of the body are the positions and the speeds of reference points of the body, the reference points being defined on, for example, the lower travelling body 1 and the upper rotating body 3. The attitudes of the body are, for example, the inclination angle of the upper rotating body 3, and the rotation angle of the upper rotating body 3 with respect to the lower travelling body 1.

[0110] The target trajectory generating part 303 generates a target trajectory of a working part (bucket 6) of the attachment AT in a predetermined movement of the shovel 100. Specifically, the target trajectory generating part 303 generates a target trajectory of a control target point of the bucket 6. For example, when the shovel 100 performs a digging movement or a horizontally towing movement, the control target point is a point on the edge of a claw (blade edge) of the bucket 6. The point on the edge of a claw of the bucket 6 may be a point on the edge of a width direction (left-right direction) center claw of the bucket 6, or may be a point on the edge of any one of left and right end claws. For example, when the shovel 100 performs a surface compaction movement, the control target point is a predetermined point on the back surface of the bucket 6.

[0111] For example, the target trajectory generating part 303 generates the target trajectory of the control target point of the bucket 6 based on information regarding a target work surface and an output from the image capturing device 40. For example, the information regarding the target work surface is input by the operator via the input device 52. The information regarding the target work surface may be input (received) from outside the shovel 100 via the communication device 60. Specifically, the target trajectory generating part 303 may recognize the current shape of the ground that is the target of working based on an output from the image capturing device 40. Then, the target trajectory generating part 303 may generate the target trajectory of the control target point of the bucket 6 based on the difference between the target work surface and the current shape of the ground that is the target of working. More specifically, when the shortest distance between the target work surface and the current shape of the ground that is the target of working is greater than a predetermined reference, the target trajectory generating part 303 may generate a target trajectory of the control target point (a point on the edge of a claw) of the bucket 6 for roughly digging the soil that is above the target work surface. On the other hand, when the shortest distance between the target work surface and the current shape of the ground that is the target of working is less than or equal to the predetermined reference, the target trajectory generating part 303 may generate a target trajectory of the control target point of the bucket 6 such that the control target point of the bucket 6 will pass above the target work surface.

[0112] The travel predicting part 304 predicts a future travel by the lower travelling body 1 of the shovel 100 based on the contents of operations on the crawlers 1CL and 1CR (travelling hydraulic motors 1ML and 1MR), and the current travelling position, attitude, and travelling speed of the body. The contents of operations on the lower travelling body 1 are acquired from, for example, outputs (operation signals) from pedal devices 26D and 26E that are used for operating the crawler 1CL (travelling hydraulic motor 1ML) and the crawler 1CR (travelling hydraulic motor 1MR). When the shovel 100 is remotely operated, the contents of operations on the lower travelling body 1 may be acquired from a remote operation signal received via the communication device 60. For example, the travel predicting part 304 predicts a travelling state of the body including, for example, the position, attitude, and travelling speed per each control cycle from the control cycle to come next (later by 1) to the control cycle later by N times (N: an integer equal to or greater than 2). A control cycle corresponds to a cycle according to which the controller 30 outputs an operation instruction to the hydraulic control valve 31. The prediction cycle of the travel predicting part 304 is, for example, longer than the control cycle of the controller 30 regarding driving of the driving target components, and amounts to M control cycles (M = N + 1). Hence, it is possible to reduce the processing load on the controller 30 due to the process performed by the travel predicting part 304.

[0113] The arm movement predicting part 305 predicts a future movement of the arm 5 based on the content of an operation on the arm 5 (arm cylinder 8), the current arm angle, and the velocity at which the arm angle changes. The content of an operation on the arm 5 (arm cylinder 8) is acquired from, for example, an output (operation signal) from the lever device 26B. When the shovel 100 is remotely operated, the content of an operation on the arm 5 (arm cylinder 8) may be acquired from a remote operation signal received via the communication device 60. For example, the arm movement predicting part 305 predicts a movement state of the arm 5 including, for example, the attitude angle and the velocity at which the attitude angle changes per control cycle from the control cycle to come next (later by 1) to the control cycle later by N times. The prediction cycle of the arm movement predicting part 305 is, for example, longer than the control cycle of the controller 30 regarding driving of the driving target components, and amounts to M control cycles. Hence, it is possible to reduce the processing load on the controller 30 due to the process performed by the arm movement predicting part 305.

[0114] The control reference position/speed detecting part 306 detects the current position and travelling speed of the control target point of the bucket 6 based on outputs from the boom attitude detecting part 301A, the arm attitude detecting part 301B, the bucket attitude detecting part 301C, and the travelling position/attitude/speed detecting part 302.

[0115] The movement instruction generating part 307 generates an instruction (hereinafter, "movement instruction") indicating a movement of the attachment AT based on the target trajectory of the control target point of the bucket 6, the prediction results of the travel predicting part 304 and the arm movement predicting part 305, and the current position and speed of the control target point of the bucket 6. Specifically, the movement instruction generating part 307 generates movement instructions regarding the boom 4 and the bucket 6, which are other than the arm 5 that is the target of operating by the operator, among the boom 4, the arm 5, and the bucket 6 included in the attachment AT.

[0116] For example, when the lower travelling body 1 is not travelling, the movement instruction generating part 307 generates movement instructions for the boom 4 and the bucket 6 such that the control target point of the bucket 6 travels along the target trajectory, in conjunction with a movement of the arm 5 corresponding to the prediction result of the arm movement predicting part 305. On the other hand, when the lower travelling body 1 is travelling, the movement instruction generating part 307 generates movement instructions for the boom 4 and the bucket 6 such that the bucket 6 does not overstep the target trajectory (target work surface). Hence, for example, even if the operator performs an erroneous operation on the lower travelling body 1, the controller 30 can avoid a situation in which the bucket 6 oversteps the target work surface, provided that the semiautomatic driving function based on an operation performed by the operator on the arm 5 is the premise. Therefore, for example, it is possible to inhibit a work efficiency drop due to adjustments entailed by the bucket 6 performing, for example, a digging movement overstepping the target work surface.

[0117] The movement instruction generating part 307 may generate movement instructions for the boom 4 and the bucket 6 such that the control target point of the bucket 6 travels along the target trajectory, in conjunction with a travel of the shovel 100 and a movement of the arm 5 that correspond to the prediction results of the travel predicting part 304 and the arm movement predicting part 305. Hence, the controller 30 can cause the control target point of the bucket 6 to travel along the target trajectory by moving the attachment AT while causing the shovel 100 to travel. Hence, the controller 30 can expand the work range per one predetermined movement of the shovel 100, and can improve the work efficiency of the shovel 100 as a result.

[0118] For example, the movement instruction generating part 307 generates movement instructions for the boom 4 and the bucket 6 per control cycle from the current control cycle to the control cycle later by N times. The generation cycle of the movement instruction generating part 307 amounts to, for example, M control cycles, like the prediction cycles of the travel predicting part 304 and the arm movement predicting part 305. Hence, it is possible to reduce the processing load on the controller 30 due to the process performed by the movement instruction generating part 307. The movement instructions for the boom 4 and the bucket 6 are command values of the attitude angles of the boom 4 and the bucket 6, and of the velocities at which the attitude angles change.

[0119] The operation instruction generating part 308 generates operation instructions for the hydraulic control valves 31 corresponding to the hydraulic actuators HA that drive the driving target components. For example, the operation instruction generating part 308 generates operation instructions for hydraulic control valves 31A to 31E.

[0120] Hydraulic control valves 31A supply pilot pressures to the pilot port of the direction switching valve 17A. Specifically, as described above, there are two hydraulic control valves 31A that correspond to the extending direction and the contracting direction of the boom cylinder 7, respectively.

[0121] Hydraulic control valves 31B output pilot pressures to the pilot port of the direction switching valve 17B. Specifically, as described above, there are two hydraulic control valves 31B that correspond to the extending direction and the contracting direction of the arm cylinder 8, respectively.

[0122] Hydraulic control valves 31C output pilot pressures to the pilot port of the direction switching valve 17C. Specifically, as described above, there are two hydraulic control valves 31C that correspond to the extending direction and the contracting direction of the bucket cylinder 9, respectively.

[0123] Hydraulic control valves 31D output pilot pressures to the pilot port of the direction switching valve 17D. Specifically, as described above, there are two hydraulic control valves 31D that correspond to the rotation directions (two directions) of the travelling hydraulic motor 1ML, respectively.

[0124] Hydraulic control valves 31E output pilot pressures to the pilot port of the direction switching valve 17E. Specifically, as described above, there are two hydraulic control valves 31E that correspond to the rotation directions (two directions) of the travelling hydraulic motor 1MR, respectively.

[0125] The operation instruction generating part 308 includes operation instruction generating parts 308A to 308C.

[0126] The operation instruction generating part 308A generates an operation instruction for the hydraulic control valve 31B based on the content of an operation performed by the operator on the arm 5.

[0127] For example, the operation instruction generating part 308A generates an operation instruction for the hydraulic control valve 31B based on an operation signal from the lever device 26B.

[0128] The operation instruction generating part 308A may generate an operation instruction for the hydraulic control valve 31B in accordance with the content of an operation on the arm 5 (arm cylinder 8) that is indicated by a remote operation signal received via the communication device 60.

[0129] The operation instruction generating part 308B generates operation instructions for the hydraulic control valves 31D and 31E based on the contents of operations performed by the operator on the crawlers 1CL and 1CR (travelling hydraulic motors 1ML and 1MR), respectively.

[0130] For example, the operation instruction generating part 308B generates an operation instruction for the hydraulic control valve 31D based on an operation signal from the pedal device 26D. Likewise, the operation instruction generating part 308B generates an operation instruction for the hydraulic control valve 31E based on an operation signal from the pedal device 26E.

[0131] The operation instruction generating part 308B may generate an operation instruction for the hydraulic control valve 31D in accordance with the content of an operation on the crawler 1CL that is indicated by a remote operation signal received via the communication device 60. Likewise, the operation instruction generating part 308B may generate an operation instruction for the hydraulic control valve 31E in accordance with the content of an operation on the crawler 1CL that is indicated by a remote operation signal received via the communication device 60.

[0132] The operation instruction generating part 308C generates operation instructions for the hydraulic control valves 31 corresponding to the boom 4 and the bucket 6, the operation instructions being in conjunction with the lower travelling body 1 and the arm 5 that are the targets of operating by the operator. Specifically, the operation instruction generating part 308C generates an operation instruction for the hydraulic control valve 31A corresponding to the boom cylinder 7 based on a movement instruction for the boom 4 that is generated by the movement instruction generating part 307. Likewise, the operation instruction generating part 308C generates an operation instruction for the hydraulic control valve 31C corresponding to the bucket cylinder 9 based on a movement instruction for the bucket 6 that is generated by the movement instruction generating part 307.

[0133] Hence, in the present example, the controller 30 can move the boom 4 and the bucket 6 in conjunction with the movements of the lower travelling body 1 and the arm 5 that are in accordance with operations performed by the operator on the lower travelling body 1 and the arm 5. Hence, the shovel 100 can perform a predetermined movement using the attachment AT by moving the lower travelling body 1 and the attachment AT in conjunction with each other. Hence, it is possible to improve the work efficiency of the shovel 100.

<Second example>

[0134] FIG. 6 is a drawing illustrating a second example of the functional configuration of the shovel 100 regarding driving of the driving target components.

[0135] In the following description, the components that are the same as or correspond to those in the first example described above will be denoted by the same reference numerals, and particulars that are not shared with the first example described above will mainly be described, and any particulars that are the same as or correspond to those in the first example described above may be briefly described or omitted.

[0136] In the present example, the shovel 100 moves by the semiautomatic driving function as in the first example described above. Specifically, in response to an operation performed by the operator on any one (in the present example, the arm 5) selected from the boom 4, the arm 5, and the end attachment (bucket 6), the shovel 100 performs a predetermined movement such that the one movement, which is the target of operating, other two movements, and a movement of the lower travelling body 1 are in conjunction with one another.

[0137] As illustrated in FIG. 6, the controller 30 includes an attitude detecting part 301, a travelling position/attitude/speed detecting part 302, a target trajectory generating part 303, an arm movement predicting part 305, a control reference position/speed detecting part 306, a movement instruction generating part 307, and an operation instruction generating part 308.

[0138] The movement instruction generating part 307 generates instructions (movement instructions) indicating movements of the attachment AT and the lower travelling body 1 based on, for example, a target trajectory of the control target point of the bucket 6, a prediction result of the arm movement predicting part 305, and the current position and speed of the control target point of the bucket 6. Specifically, the movement instruction generating part 307 generates movement instructions for the boom 4 and the bucket 6, which are other than the arm 5 that is the target of operating by the operator among the boom 4, the arm 5, and the bucket 6 included in the attachment AT, and for the crawlers 1CL and 1CR.

[0139] For example, the movement instruction generating part 307 generates movement instructions for the boom 4 and the bucket 6, and the crawlers 1CL and 1CR such that the control target point of the bucket 6 travels along the target trajectory, in conjunction with the movement of the arm 5 corresponding to the prediction result of the arm movement predicting part 305. Hence, the controller 30 can cause the control target point of the bucket 6 to travel along the target trajectory by moving the attachment AT while causing the shovel 100 to travel in conjunction with the movement of the arm 5. Hence, the controller 30 can expand the work range per one predetermined movement of the shovel 100, and can improve the work efficiency of the shovel 100 as a result.

[0140] The operation instruction generating part 308 generates operation instructions for the hydraulic control valves 31 corresponding to the hydraulic actuators HA that drive the driving target components as in the first example described above.

[0141] The operation instruction generating part 308 includes operation instruction generating parts 308A and 308D.

[0142] The operation instruction generating part 308A generates an operation instruction for the hydraulic control valve 31B based on the content of an operation performed by the operator on the arm 5 as in the first example described above.

[0143] The operation instruction generating part 308D generates operation instructions for the hydraulic control valves 31 corresponding to the other driving target components, the operation instructions being in conjunction with the arm 5 that is the target of operating by the operator. Specifically, the operation instruction generating part 308D generates an operation instruction for the hydraulic control valve 31A based on a movement instruction for the boom 4 that is generated by the movement instruction generating part 307. Likewise, the operation instruction generating part 308D generates an operation instruction for the hydraulic control valve 31C based on a movement instruction for the bucket 6 that is generated by the movement instruction generating part 307. Likewise, the operation instruction generating part 308D generates an operation instruction for the hydraulic control valve 31D based on a movement instruction for the crawler 1CL that is generated by the movement instruction generating part 307. Likewise, the operation instruction generating part 308D generates an operation instruction for the hydraulic control valve 31E based on a movement instruction for the crawler 1CR that is generated by the movement instruction generating part 307.

[0144] As described, in the present example, the controller 30 can move the boom 4 and the bucket 6, and the lower travelling body 1 in conjunction with the movement of the arm 5 that corresponds to an operation performed by the operator on the arm 5. Hence, as in the first example described above, the shovel 100 can perform a predetermined movement using the attachment AT, by moving the lower travelling body 1 and the attachment AT in conjunction with each other. Hence, it is possible to improve the work efficiency of the shovel 100.

[0145] Moreover, in the present example, the controller 30 can move the attachment AT and the lower travelling body 1 in conjunction with each other in response to only an operation performed by the operator on the arm 5. Hence, it is possible to improve the convenience for the operator, and to further improve the work efficiency of the shovel 100.

<Third example>

[0146] FIG. 7 is a drawing illustrating a third example of the functional configuration of the shovel regarding driving of the driving target components.

[0147] In the following description, the components that are the same as or correspond to those in the first example and the second example described above will be denoted by the same reference numerals, and particulars that are not shared with the first example and the second example described above will mainly be described, and any particulars that are the same as or correspond to those in the first example and the second example described above may be briefly described or omitted.

[0148] In the present example, the shovel 100 moves by the semiautomatic driving function as in the first example described above. Specifically, in response to an operation performed by the operator on the lower travelling body 1, the shovel 100 performs a predetermined movement such that the movement of the lower travelling body 1, which is the target of operating, and a movement of the attachment AT (i.e., the boom 4, the arm 5, and the bucket 6) are in conjunction with each other.

[0149] As illustrated in FIG. 7, the controller 30 includes an attitude detecting part 301, a travelling position/attitude/speed detecting part 302, a target trajectory generating part 303, a travel predicting part 304, a control reference position/speed detecting part 306, a movement instruction generating part 307, and an operation instruction generating part 308.

[0150] The movement instruction generating part 307 generates an instruction (movement instruction) indicating a movement of the attachment AT based on, for example, a target trajectory of the control target point of the bucket 6, a prediction result of the travel predicting part 304, and the current position and speed of the control target point of the bucket 6. Specifically, the movement instruction generating part 307 generates a movement instruction for each of the boom 4, the arm 5, and the bucket 6 included in the attachment AT.

[0151] For example, the movement instruction generating part 307 generates movement instructions for the boom 4, the arm 5, and the bucket 6 such that the control target point of the bucket 6 travels along the target trajectory, in conjunction with a travel of the shovel 100 (lower travelling body 1) that corresponds to a prediction result of the travel predicting part 304. Hence, the controller 30 can cause the control target point of the bucket 6 to travel along the target trajectory by moving the attachment AT while causing the shovel 100 to travel in conjunction with the movement of the lower travelling body 1. Hence, the controller 30 can expand the work range per one predetermined movement of the shovel 100, and can improve the work efficiency of the shovel 100 as a result.

[0152] The operation instruction generating part 308 generates operation instructions for the hydraulic control valves 31 corresponding to the hydraulic actuators HA that drive the driving target components as in the first example and the second example described above.

[0153] The operation instruction generating part 308 includes operation instruction generating parts 308B and 308E.

[0154] The operation instruction generating part 308B generates operation instructions for the hydraulic control valves 31D and 31E based on the contents of operations performed by the operator on the crawlers 1CL and 1CR (travelling hydraulic motors 1ML and 1MR), respectively, as in the first example described above.

[0155] The operation instruction generating part 308E generates operation instructions for the hydraulic control valves 31 corresponding to the attachment AT (i.e., the boom 4, the arm 5, and the bucket 6), the operation instructions being in conjunction with the lower travelling body 1 that is the target of operating by the operator. Specifically, the operation instruction generating part 308E generates an operation instruction for the hydraulic control valve 31A corresponding to the boom cylinder 7 based on a movement instruction for the boom 4 that is generated by the movement instruction generating part 307. Likewise, the operation instruction generating part 308E generates an operation instruction for the hydraulic control valve 31B corresponding to the arm cylinder 8 based on a movement instruction for the arm 5 that is generated by the movement instruction generating part 307. Likewise, the operation instruction generating part 308E generates an operation instruction for the hydraulic control valve 31C corresponding to the bucket cylinder 9 based on a movement instruction for the bucket 6 that is generated by the movement instruction generating part 307.

[0156] As described, in the present example, the controller 30 can move the boom 4, the arm 5, and the bucket 6 in conjunction with the movement of the lower travelling body 1 that corresponds to an operation performed by the operator on the lower travelling body 1. Hence, as in the first example described above, the shovel 100 can perform a predetermined movement using the attachment AT, by moving the lower travelling body 1 and the attachment AT in conjunction with each other. Hence, it is possible to improve the work efficiency of the shovel 100.

[0157] Moreover, in the present example, the controller 30 can move the lower travelling body 1 and the attachment AT in conjunction with each other in response to only an operation performed by the operator on the lower travelling body 1. Hence, it is possible to improve the convenience for the operator, and to further improve the work efficiency of the shovel 100.

<Other examples>

[0158] The controller 30 may move the attachment AT and the lower travelling body 1 in conjunction with each other as in the case of the semiautomatic driving function described above, when performing work using the attachment AT by the full automatic driving function.

[0159] In this case, the controller 30 has the same functions as the attitude detecting part 301, the travelling position/attitude/speed detecting part 302, the target trajectory generating part 303, the control reference position/speed detecting part 306, the movement instruction generating part 307, and the operation instruction generating part 308 described above.

[0160] For example, the controller 30 moves the lower travelling body 1 and the attachment AT in conjunction with each other such that the control target point of the bucket 6 travels along the target trajectory by the full automatic driving function independently from operations performed by the operator on the lower travelling body 1 and the attachment AT. Hence, as in the first example to the third example described above, the shovel 100 can perform a predetermined movement using the attachment AT by moving the lower travelling body 1 and the attachment AT in conjunction with each other. Hence, it is possible to improve the work efficiency of the shovel 100.

[Specific examples of the movement of the shovel]

[0161] Next, specific examples of the movement of the shovel 100 according to the present embodiment will be described with reference to FIG. 8 to FIG. 13.

<First example>

[0162] FIG. 8 and FIG. 9 are views illustrating a first example of the movement of the shovel 100.

[0163] In the present example, the premise of the movement of the shovel 100 is the above-described first example (FIG. 5) of the functional configuration regarding driving of the driving target components.

[0164] As illustrated in FIG. 8, the shovel 100 is working the slope BS from the top TS of the slope BS by moving the attachment AT by the semiautomatic driving function. Specifically, the shovel 100 is finishing the slope BS by moving the attachment AT such that the bucket 6 travels along the target work surface TP from the top TS of the slope to the toe FS of the slope (see the black arrow in the drawing) in response to an operation performed by the operator on the arm 5.

[0165] In the present example, by performing an operation on the arm 5, the operator can operate the attachment AT such that the control target point of the bucket 6 travels along the target work surface TP. Hence, when the attachment AT fails to move in conjunction with the movement of the lower travelling body 1, an erroneous operation performed by the operator on the lower travelling body 1 (crawlers 1CL and 1CR) changes the relative relationship between the bucket 6 and the target work surface TP. Particularly, an operation that may cause the lower travelling body 1 to travel frontward causes the bucket 6 to travel in a direction to become closer to the slope BS, and may incur a situation in which the bucket 6 oversteps the target work surface TP (see the outlined white arrow in the drawing).

[0166] In this regard, in the present example, the shovel 100 moves the attachment AT in conjunction with the movement of the lower travelling body 1. Hence, as illustrated in FIG. 9, the shovel 100 can move the attachment AT in conjunction with the movement of the lower travelling body 1 such that the bucket 6 does not overstep the target work surface TP. In the present example, under control of the controller 30, the shovel 100 causes the attachment AT to travel in a direction in which the bucket 6 becomes apart from the target work surface TP, by moving the boom 4 relatively largely in the raising direction in conjunction with the travel of the lower travelling body 1 to become closer to the slope BS. Hence, even in a case where the operator performs an erroneous operation on the lower travelling body 1, the shovel 100 can avoid a situation in which the bucket 6 oversteps the target work surface TP, and can mitigate reduction in the work efficiency of the shovel 100 due to, for example, adjustments of the finishing work.

<Second example>

[0167] FIG. 10 and FIG. 11 are views illustrating a second example of the movement of the shovel 100.

[0168] In the present example, the premise of the movement of the shovel 100 is the above-described second example (FIG. 6) of the functional configuration regarding driving of the driving target components.

[0169] As illustrated in FIG. 10 and FIG. 11, the shovel 100 is working the slope BS from the top TS of the slope BS by moving the attachment AT by the semiautomatic driving function. Specifically, the shovel 100 is finishing the slope BS by moving the attachment AT such that the bucket 6 travels along the target work surface TP from the top TS of the slope to the toe FS of the slope (see the black arrow in the drawing) in response to an operation performed by the operator on the arm 5.

[0170] In the present example, by performing an operation on the arm 5, the operator can operate the attachment AT and the lower travelling body 1 such that the control target point of the bucket 6 travels along the target work surface TP. Hence, as illustrated in FIG. 10 and FIG. 11, the shovel 100 can cause the bucket 6 to travel along the target work surface TP from the top TS of the slope BS to the toe FS of the slope BS while travelling in a direction to be apart from the slope BS.

[0171] As illustrated in FIG. 10, in the present example, in order to adjust the bucket 6 to come to the top TS of the slope BS, it is necessary to highly raise the boom 4 and largely open the arm 5 in a state in which the body is brought close to a certain degree to the toe FS of the slope BS. Hence, if the attachment AT is moved while the position of the body is fixed, the bucket 6 cannot be caused to travel along the target work surface TP to the toe FS of the slope BS due to the restrictions on the relative attitude angles between the boom 4, the arm 5, and the bucket 6. Hence, it is necessary to divide the range expanding from the top TS of the slope BS to the toe FS of the slope BS into a plurality of sections, and cause the shovel 100 to travel in a direction to be apart from the slope BS at the turn of each section to repeat the flow for performing work on the next section. This may reduce the work efficiency of the shovel 100.

[0172] In this regard, in the present example, the shovel 100 can cause the bucket 6 to travel along the target work surface TP by moving the attachment AT while causing the lower travelling body 1 to travel in a direction to be apart from the slope BS. Hence, the shovel 100 can continuously change the positional relationship between the shovel 100 and the slope BS while causing the control target point of the bucket 6 to travel along the target work surface TP from the top TS of the slope to the toe FS of the slope. As a result, as illustrated in FIG. 10 and FIG. 11, the shovel 100 can cause the bucket 6 to finish the full range from the top TS of the slope to the toe FS of the slope along the target work surface TP by one movement. Hence, it is possible to improve the work efficiency of the shovel 100.

[0173] The movement of the shovel 100 that is the same as in the present example can be realized also in a case where, for example, the above-described first example (FIG. 5) or third example (FIG. 7) of the functional configuration regarding driving of the driving target components is the premise.

<Third example>

[0174] FIG. 12 and FIG. 13 are views illustrating a third example of the movement of the shovel 100.

[0175] In the present example, the premise of the movement of the shovel 100 is the above-described third example (FIG. 7) of the functional configuration regarding driving of the driving target components.

[0176] As illustrated in FIG. 12, in the present example, the shovel 100 is finishing the slope BS by moving the attachment AT such that the bucket 6 travels along the target work surface from the top TS of the slope to the toe FS of the slope. The slope BS includes a region CS in which the finishing work has been completed, and a region NS in which the finishing work has not been completed.

[0177] As illustrated in FIG. 12, soil SL scraped away by the bucket 6 when the bucket 6 is caused to travel along the target work surface is deposited on the toe FS of the slope of the region NS. Hence, in the present example, a work to form a toe FS of slope corresponding to the corner between the slope BS and the ground GS on which the shovel 100 is positioned is needed during the finishing work on the slope BS.

[0178] As illustrated in FIG. 13, in the present example, the shovel 100 is positioned such that the crawlers 1C are in a state close to being parallel with a target line FSE corresponding to the toe FS of slope and such that the left end LE of the blade edge of the bucket 6 is positioned on the target line FSE corresponding to the toe FS of slope. Then, the shovel 100 moves the lower travelling body 1 and the attachment AT in conjunction with each other in response to an operation performed by the operator on the lower travelling body 1, such that the left end LE of the blade edge corresponding to the control target point of the bucket 6 travels along the target line FSE. Specifically, while travelling to the left in the drawing (see the outlined white arrow in the drawing), the shovel 100 moves the attachment AT in conjunction with the travelling of the lower travelling body 1, such that the left end LE of the blade edge of the bucket 6 travels along the target line FSE. Although there is no need to move the attachment AT when the target line FSE and the travelling direction of the crawlers 1C are completely parallel, it is substantially impossible to bring the target line FSE and the travelling direction of the crawlers 1C into a completely parallel state. Moreover, even if the crawlers 1C of the shovel 100 can be brought to be parallel with the target line FSE, there is a possibility that the target line FSE and the travelling direction of the crawlers 1C come out of the parallel state during travel of the shovel 100, due to bumps or slants of the ground GS. Hence, by moving the attachment AT in conjunction with the travelling of the lower travelling body 1, the shovel 100 can cause the left end LE of the blade edge of the bucket 6 to travel along the target line FSE. As a result, the shovel 100 can form the toe FS of slope and complete the finishing work on the region CS.

[Works]

[0179] Next, the works of the shovel according to the present embodiment will be described.

[0180] In the present embodiment, a shovel includes a lower travelling body, an upper rotating body, and an attachment. The shovel is, for example, the shovel 100 described above. The lower travelling body is, for example, the lower travelling body 1 described above. The upper rotating body is, for example, the upper rotating body 3 described above. The attachment is, for example, the attachment AT described above. Specifically, the upper rotating body is mounted rotatably on the lower travelling body. The attachment is attached to the upper rotating body. The shovel moves the lower travelling body and the attachment in conjunction with each other.

[0181] Hence, the shovel can perform work by moving the lower travelling body and the attachment in conjunction with each other. Hence, for example, the position of the working part of the attachment travels along with travelling of the lower travelling body, and the shovel can expand the work range per one predetermined movement as a result. Moreover, for example, the shovel can move the attachment, taking into consideration any displacement of the position of the working part of the attachment due to an erroneous operation on the lower travelling body. As a result, the shovel can mitigate, for example, reduction in the work quality and redoing of the work due to an inappropriate movement of the attachment accompanying the erroneous operation on the lower travelling body. Hence, the shovel can improve the work efficiency.

[0182] In the present embodiment, the shovel may move the attachment in conjunction with a movement of the lower travelling body that follows an operation performed by the operator.

[0183] Hence, the shovel can move the lower travelling body and the attachment in conjunction with each other in the form of moving the attachment in conjunction with a movement of the lower travelling body that follows an operation performed by the operator.

[0184] In the present embodiment, the attachment may include a boom attached to the upper rotating body, an arm attached to an end of the boom, and an end attachment attached to an end of the arm. The boom is, for example, the boom 4 described above. The arm is, for example, the arm 5 described above. The end attachment is, for example, the bucket 6 described above. Then, the shovel may move the boom and the end attachment in conjunction with movements of the arm and the lower travelling body that follow operations performed by the operator.

[0185] Hence, the shovel can move the lower travelling body and the attachment in conjunction with each other in the form of moving the boom and the end attachment in conjunction with movements of the arm and the lower travelling body that follow operations performed by the operator.

[0186] In the present embodiment, the shovel may automatically move the attachment in conjunction with a movement of the lower travelling body that follows an operation performed by the operator.

[0187] Hence, the shovel can automatically move the lower travelling body and the attachment in conjunction with each other in response to an operation performed by the operator on the lower travelling body.

[0188] In the present embodiment, the shovel may move the attachment (i.e., the boom and the end attachment that move in conjunction with a movement of the arm) in conjunction with a movement of the lower travelling body that follows an operation performed by the operator, such that the working part of the attachment does not overstep a target work surface. The working part is, for example, the bucket 6. The target work surface is, for example, the target work surface TP described above.

[0189] Hence, the shovel can move the attachment such that the working part does not overstep the target work surface, even when there is a risk of the working part of the attachment travelling in a direction to be closer to the target work surface due to an erroneous operation performed by the operator on the lower travelling body. Hence, it is possible to mitigate, for example, reduction in the work quality and redoing of the work due to the working part overstepping the target work surface, and to improve the work efficiency of the shovel.

[0190] In the present embodiment, the shovel may automatically move the attachment in conjunction with a movement of the lower travelling body that follows an operation performed by the operator, such that an end of the working part of the attachment travels along a target line. The target line is, for example, a toe FS of a slope or a top TS of a slope.

[0191] Hence, the shovel can cause the end of the working part of the attachment to travel along the target line by moving the lower travelling body and the attachment in conjunction with each other in response to an operation performed by the operator on the lower travelling body.

[0192] In the present embodiment, the shovel may move the attachment in conjunction with a movement of the lower travelling body that follows an operation performed by the operator, such that the working part of the attachment travels along the target work surface.

[0193] Hence, the shovel can cause the working part of the attachment to travel along the target work surface, by moving the lower travelling body and the attachment in conjunction with each other in response to an operation performed by the operator on the lower travelling body.

[0194] In the present embodiment, the shovel may include a control device. The control device is, for example, the controller 30 described above. Specifically, the control device may predict a travelling state of the attachment, the travelling state accompanying a movement of the lower travelling body, based on the movement state of the lower travelling body, and may move the attachment based on the prediction result.

[0195] Hence, the shovel can move the attachment in conjunction with a movement of the lower travelling body.

[0196] In the present embodiment, the shovel may move the lower travelling body in conjunction with a movement of the attachment that follows an operation performed by the operator.

[0197] Hence, the shovel can move the lower travelling body and the attachment in conjunction with each other in the form of moving the lower travelling body in conjunction with a movement of the attachment that follows an operation performed by the operator.

[0198] In the present embodiment, the attachment may include a boom attached to the upper rotating body, an arm attached to an end of the boom, and an end attachment attached to an end of the arm. Then, the shovel may automatically move the boom and the end attachment, and the lower travelling body in conjunction with a movement of the arm that follows an operation performed by the operator.

[0199] Hence, the shovel can move the lower travelling body and the attachment in conjunction with each other in the form of moving the boom and the end attachment, and the lower travelling body in conjunction with a movement of the arm that follows an operation performed by the operator.

[0200] In the present embodiment, the shovel may automatically move the boom and the end attachment, and the lower travelling body such that the working part of the end attachment travels along the target work surface.

[0201] Hence, the shovel can cause the working part of the end attachment to travel along the target work surface by moving the boom and the end attachment, and the lower travelling body in response to an operation performed by the operator on the arm.

[0202] The embodiment has been described in detail above. The present disclosure is not limited to the specific embodiment, and various modifications and changes are applicable within the scope of the spirit described in the claims.

Claims

1. A shovel, comprising:

a lower travelling body;
an upper rotating body mounted rotatably on the lower travelling body; and
an attachment attached to the upper rotating body,
wherein the lower travelling body and the attachment are moved in conjunction with each other.

2. The shovel according to claim 1,
wherein the attachment is moved in conjunction with a movement of the lower travelling body, the movement following an operation performed by an operator.

3. The shovel according to claim 2,

wherein the attachment includes a boom attached to the upper rotating body, an arm attached to an end of the boom, and an end attachment attached to an end of the arm, and
the boom and the end attachment are moved in conjunction with movements of the arm and the lower travelling body, the movements following operations performed by the operator.

4. The shovel according to claim 2, wherein the attachment is automatically moved in conjunction with the movement of the lower travelling body following the operation performed by the operator.

5. The shovel according to claim 3, wherein the boom and the end attachment are moved in conjunction with the movement of the lower travelling body following the operation performed by the operator, such that a working part of the attachment is excluded from overstepping a target work surface.

6. The shovel according to claim 4, wherein the attachment is automatically moved in conjunction with the movement of the lower travelling body following the operation performed by the operator, such that an end of a working part of the attachment travels along a target line.

7. The shovel according to any one of claims 2 to 4, wherein the attachment is moved in conjunction with the movement of the lower travelling body following the operation performed by the operator, such that a working part of the attachment travels along a target work surface.

8. The shovel according to any one of claims 2 to 6, further comprising:
a control device that predicts a travelling state of the attachment accompanying the movement of the lower travelling body based on a state of the movement of the lower travelling body, and moves the attachment based on a result of the predicting.

9. The shovel according to claim 1, wherein the lower travelling body is moved in conjunction with a movement of the attachment, the movement following an operation performed by an operator.

10. The shovel according to claim 9,

wherein the attachment includes a boom attached to the upper rotating body, an arm attached to an end of the boom, and an end attachment attached to an end of the arm, and
the boom and the end attachment, and the lower travelling body are automatically moved in conjunction with a movement of the arm, the movement following an operation performed by the operator.

11. The shovel according to claim 10, wherein the boom and the end attachment, and the lower travelling body are automatically moved such that a working part of the end attachment travels along a target work surface.

FIG.1

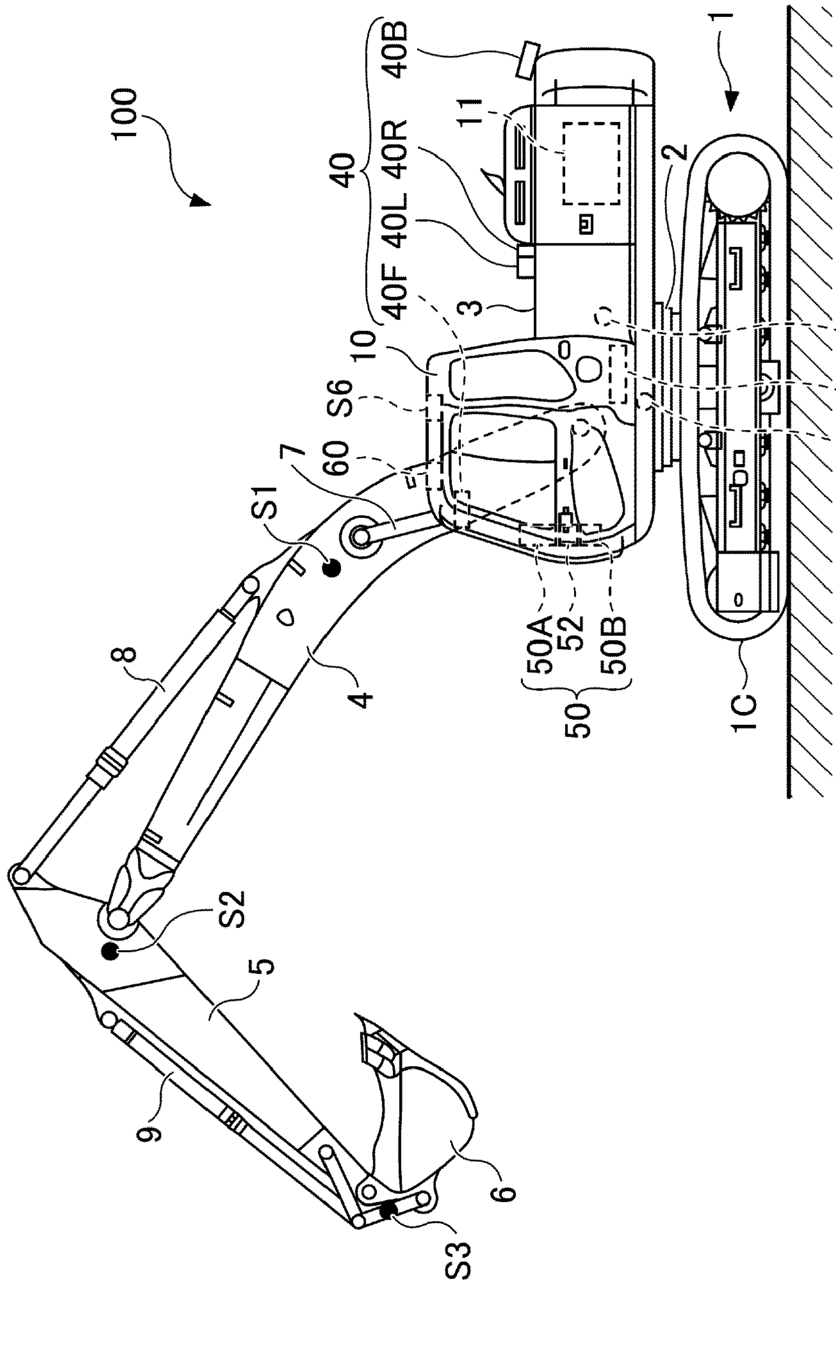
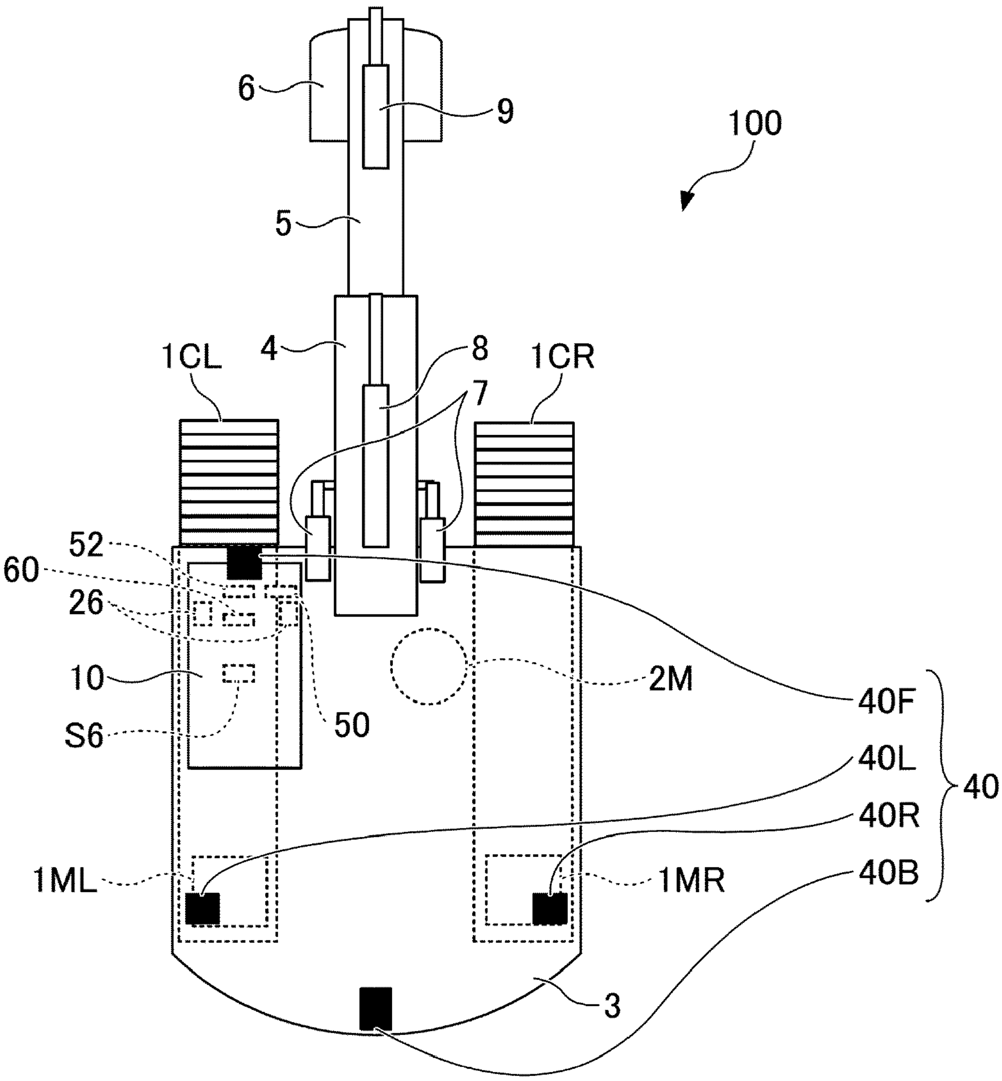

100
40
40F
40L
40R
40B
11
1
2
3
10
S6
60
7
S1
S4
30
S5
50A
52
50B
50
1C
8
4
S2
5
9
6
S3

FIG.2


6
9
100
5
4
8
7
1CL
1CR
52
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26
10
S6
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2M
40F
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40B
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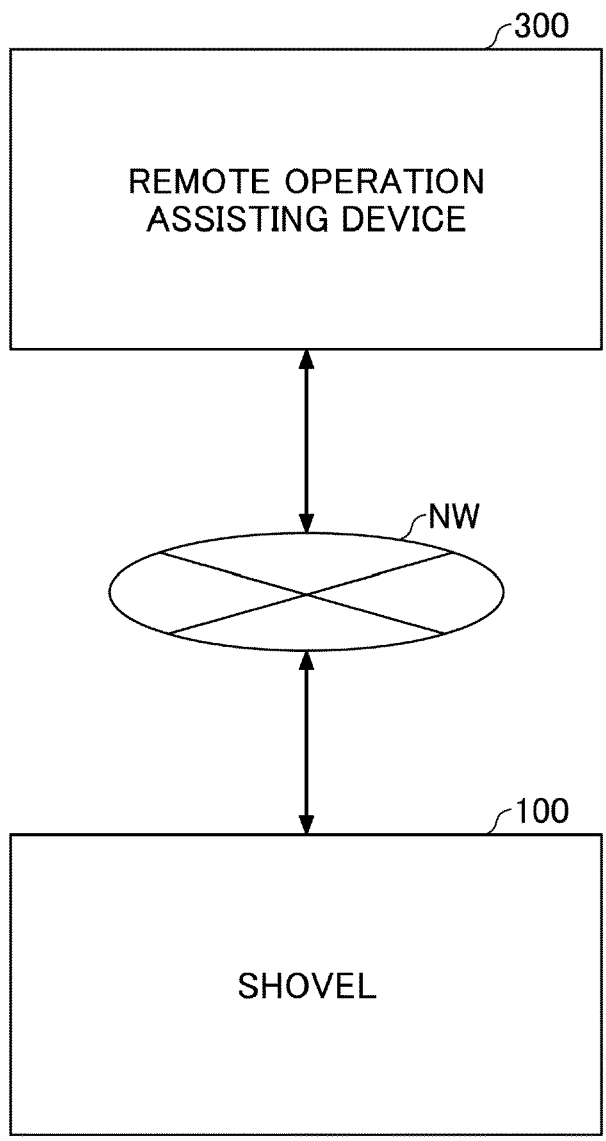
1ML
1MR
3

FIG.3



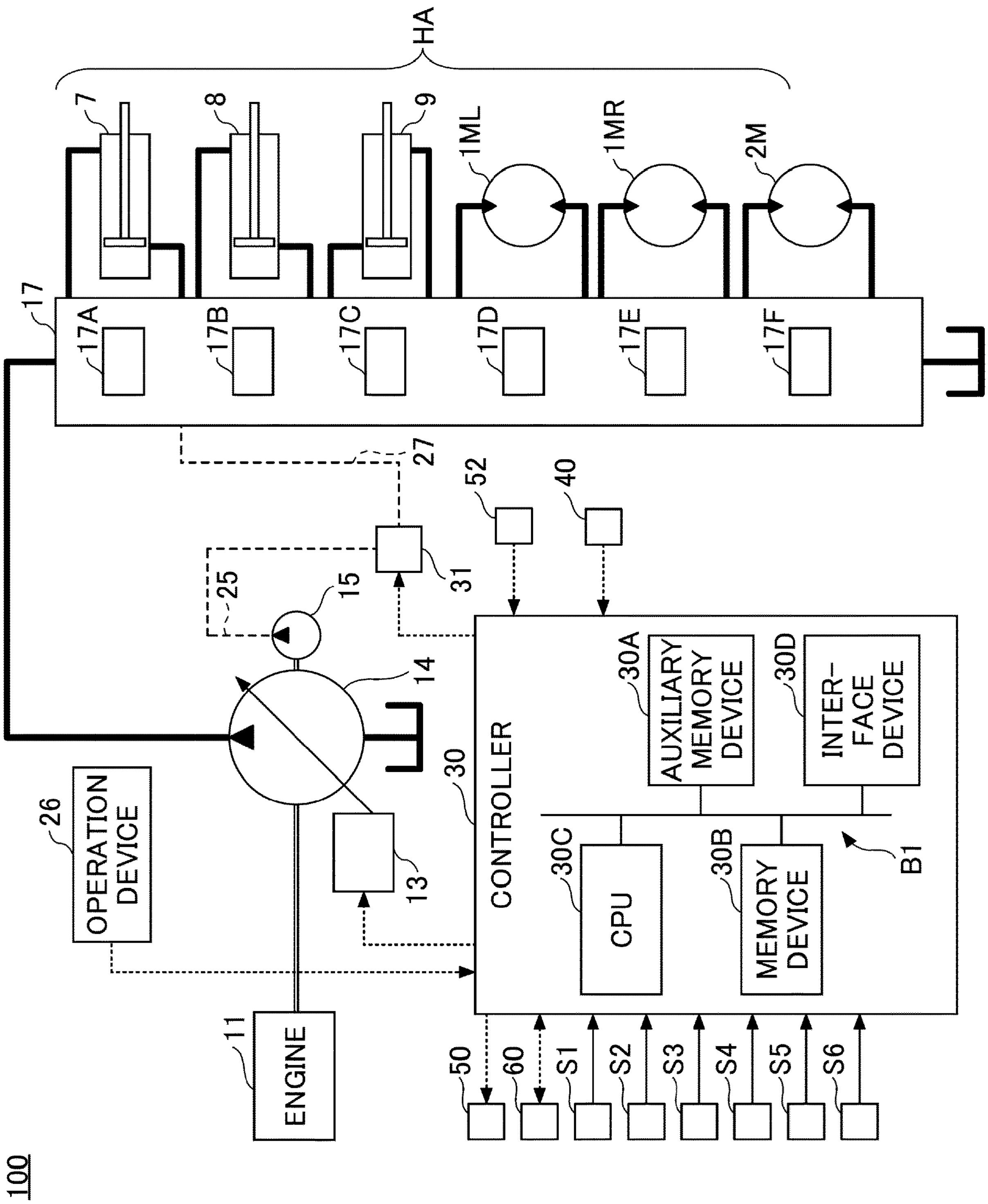

HA
7
8
9
1ML
1MR
2M
17
17A
17B
17C
17D
17E
17F
27
52
40
25
15
31
14
OPERATION DEVICE
26
CONTROLLER
30
30A
AUXILIARY MEMORY DEVICE
30D
INTER-FACE DEVICE
30C
CPU
30B
MEMORY DEVICE
B1
13
ENGINE
11
50
60
S1
S2
S3
S4
S5
S6
100

FIG.4

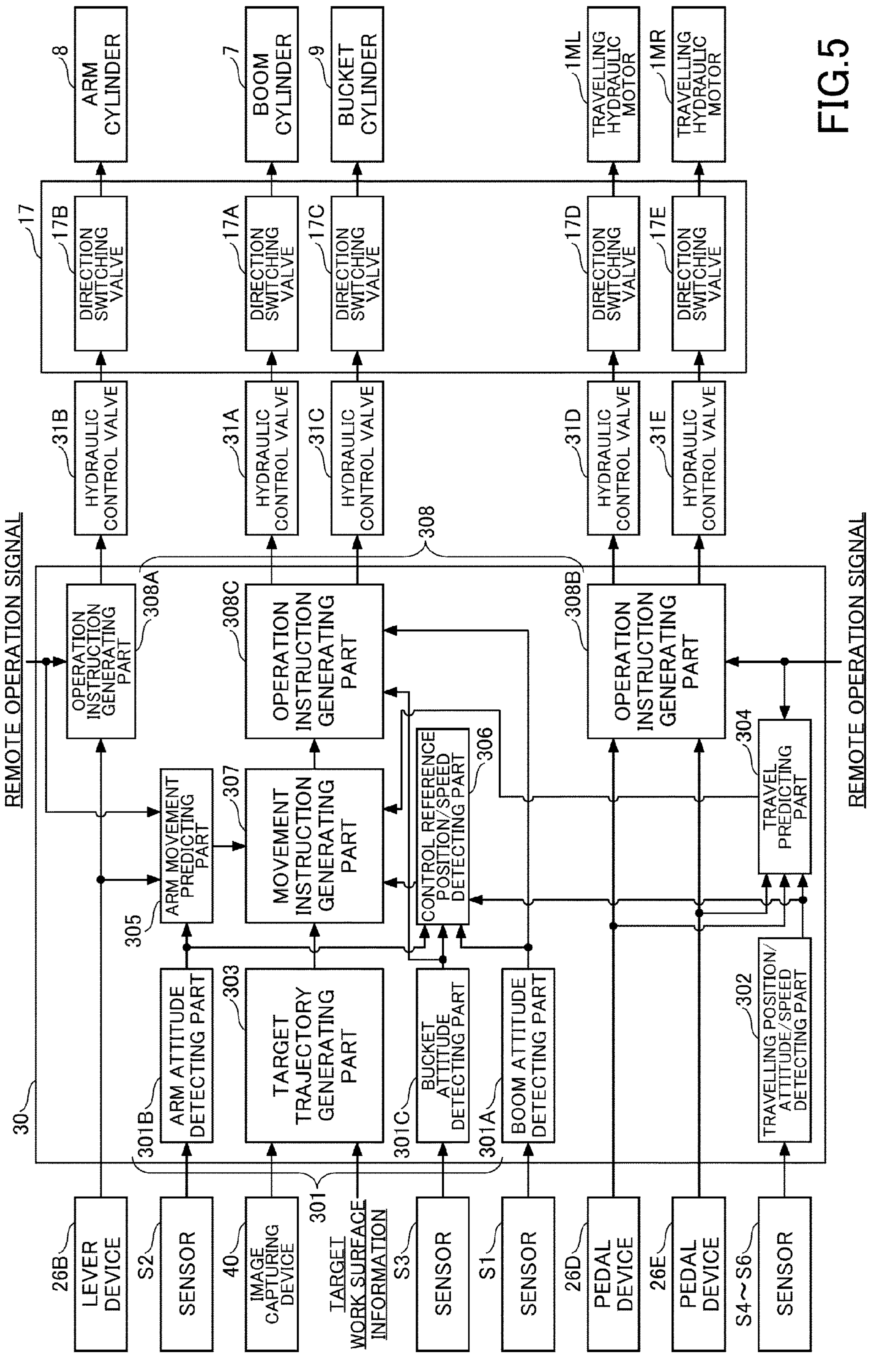
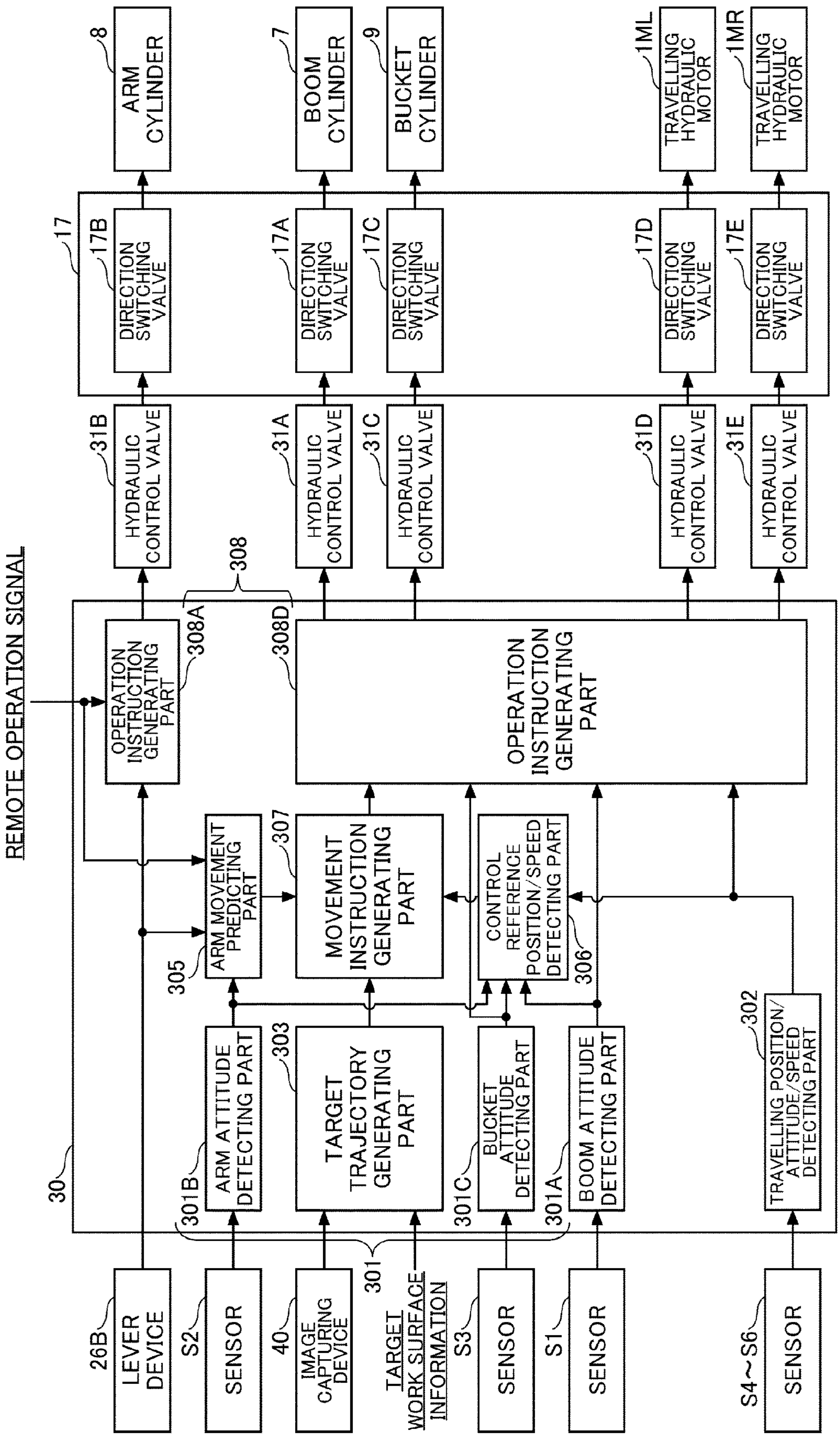

REMOTE OPERATION SIGNAL
REMOTE OPERATION SIGNAL
26B LEVER DEVICE
S2 SENSOR
40 IMAGE CAPTURING DEVICE
TARGET WORK SURFACE INFORMATION
S3 SENSOR
S1 SENSOR
26D PEDAL DEVICE
26E PEDAL DEVICE
S4~S6 SENSOR
30
301
301B ARM ATTITUDE DETECTING PART
303 TARGET TRAJECTORY GENERATING PART
301C BUCKET ATTITUDE DETECTING PART
301A BOOM ATTITUDE DETECTING PART
302 TRAVELLING POSITION/ ATTITUDE/SPEED DETECTING PART
305 ARM MOVEMENT PREDICTING PART
307 MOVEMENT INSTRUCTION GENERATING PART
306 CONTROL REFERENCE POSITION/SPEED DETECTING PART
304 TRAVEL PREDICTING PART
308
308A OPERATION INSTRUCTION GENERATING PART
308C OPERATION INSTRUCTION GENERATING PART
308B OPERATION INSTRUCTION GENERATING PART
31B HYDRAULIC CONTROL VALVE
31A HYDRAULIC CONTROL VALVE
31C HYDRAULIC CONTROL VALVE
31D HYDRAULIC CONTROL VALVE
31E HYDRAULIC CONTROL VALVE
17
17B DIRECTION SWITCHING VALVE
17A DIRECTION SWITCHING VALVE
17C DIRECTION SWITCHING VALVE
17D DIRECTION SWITCHING VALVE
17E DIRECTION SWITCHING VALVE
8 ARM CYLINDER
7 BOOM CYLINDER
9 BUCKET CYLINDER
1ML TRAVELLING HYDRAULIC MOTOR
1MR TRAVELLING HYDRAULIC MOTOR

FIG.5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26B
LEVER DEVICE
S2
SENSOR
40
IMAGE CAPTURING DEVICE
TARGET WORK SURFACE INFORMATION
S3
SENSOR
S1
SENSOR
S4～S6
SENSOR
301
30
301B
ARM ATTITUDE DETECTING PART
303
TARGET TRAJECTORY GENERATING PART
301C
BUCKET ATTITUDE DETECTING PART
301A
BOOM ATTITUDE DETECTING PART
302
TRAVELLING POSITION/ ATTITUDE/SPEED DETECTING PART
305
ARM MOVEMENT PREDICTING PART
307
MOVEMENT INSTRUCTION GENERATING PART
306
CONTROL REFERENCE POSITION/SPEED DETECTING PART
308
308A
OPERATION INSTRUCTION GENERATING PART
308D
OPERATION INSTRUCTION GENERATING PART
31B
HYDRAULIC CONTROL VALVE
31A
HYDRAULIC CONTROL VALVE
31C
HYDRAULIC CONTROL VALVE
31D
HYDRAULIC CONTROL VALVE
31E
HYDRAULIC CONTROL VALVE
17
17B
DIRECTION SWITCHING VALVE
17A
DIRECTION SWITCHING VALVE
17C
DIRECTION SWITCHING VALVE
17D
DIRECTION SWITCHING VALVE
17E
DIRECTION SWITCHING VALVE
8
ARM CYLINDER
7
BOOM CYLINDER
9
BUCKET CYLINDER
1ML
TRAVELLING HYDRAULIC MOTOR
1MR
TRAVELLING HYDRAULIC MOTOR

FIG.6

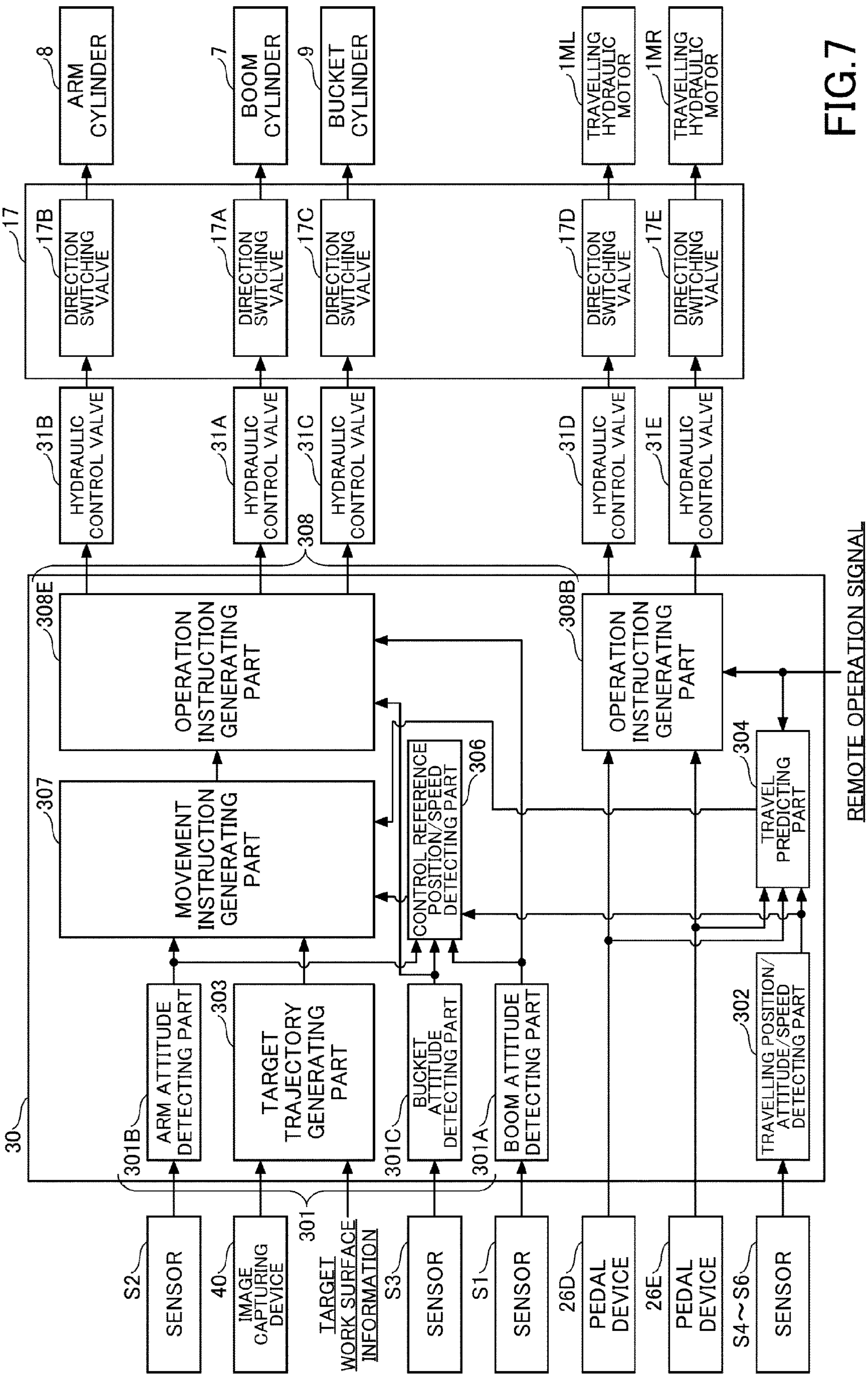

SENSOR
S2
IMAGE CAPTURING DEVICE
40
TARGET WORK SURFACE INFORMATION
301
SENSOR
S3
SENSOR
S1
PEDAL DEVICE
26D
PEDAL DEVICE
26E
SENSOR
S4~S6
30
301B
ARM ATTITUDE DETECTING PART
303
TARGET TRAJECTORY GENERATING PART
301C
BUCKET ATTITUDE DETECTING PART
301A
BOOM ATTITUDE DETECTING PART
302
TRAVELLING POSITION/ ATTITUDE/SPEED DETECTING PART
307
MOVEMENT INSTRUCTION GENERATING PART
306
CONTROL REFERENCE POSITION/SPEED DETECTING PART
304
TRAVEL PREDICTING PART
308E
OPERATION INSTRUCTION GENERATING PART
308B
OPERATION INSTRUCTION GENERATING PART
308
REMOTE OPERATION SIGNAL
31B
HYDRAULIC CONTROL VALVE
31A
HYDRAULIC CONTROL VALVE
31C
HYDRAULIC CONTROL VALVE
31D
HYDRAULIC CONTROL VALVE
31E
HYDRAULIC CONTROL VALVE
17
17B
DIRECTION SWITCHING VALVE
17A
DIRECTION SWITCHING VALVE
17C
DIRECTION SWITCHING VALVE
17D
DIRECTION SWITCHING VALVE
17E
DIRECTION SWITCHING VALVE
8
ARM CYLINDER
7
BOOM CYLINDER
9
BUCKET CYLINDER
1ML
TRAVELLING HYDRAULIC MOTOR
1MR
TRAVELLING HYDRAULIC MOTOR

FIG.7

FIG.8

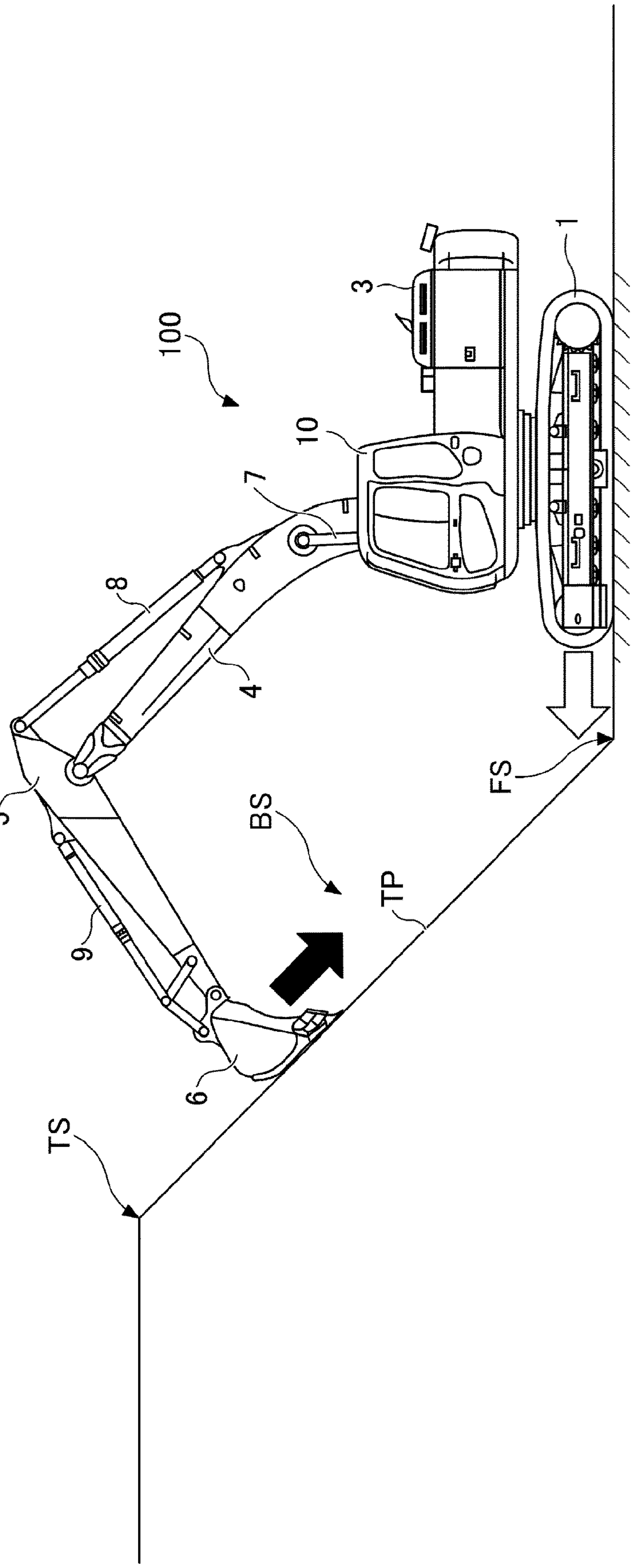


FIG.9

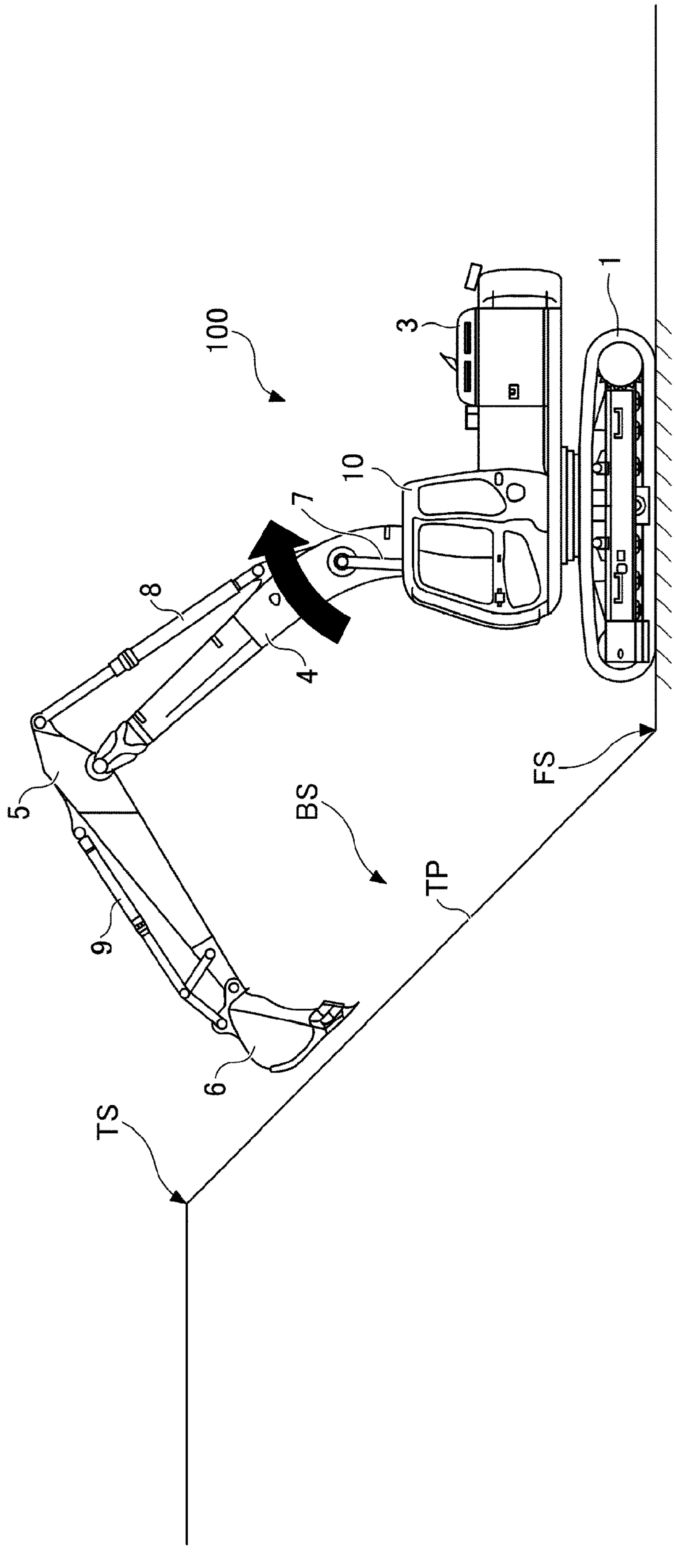


FIG.10

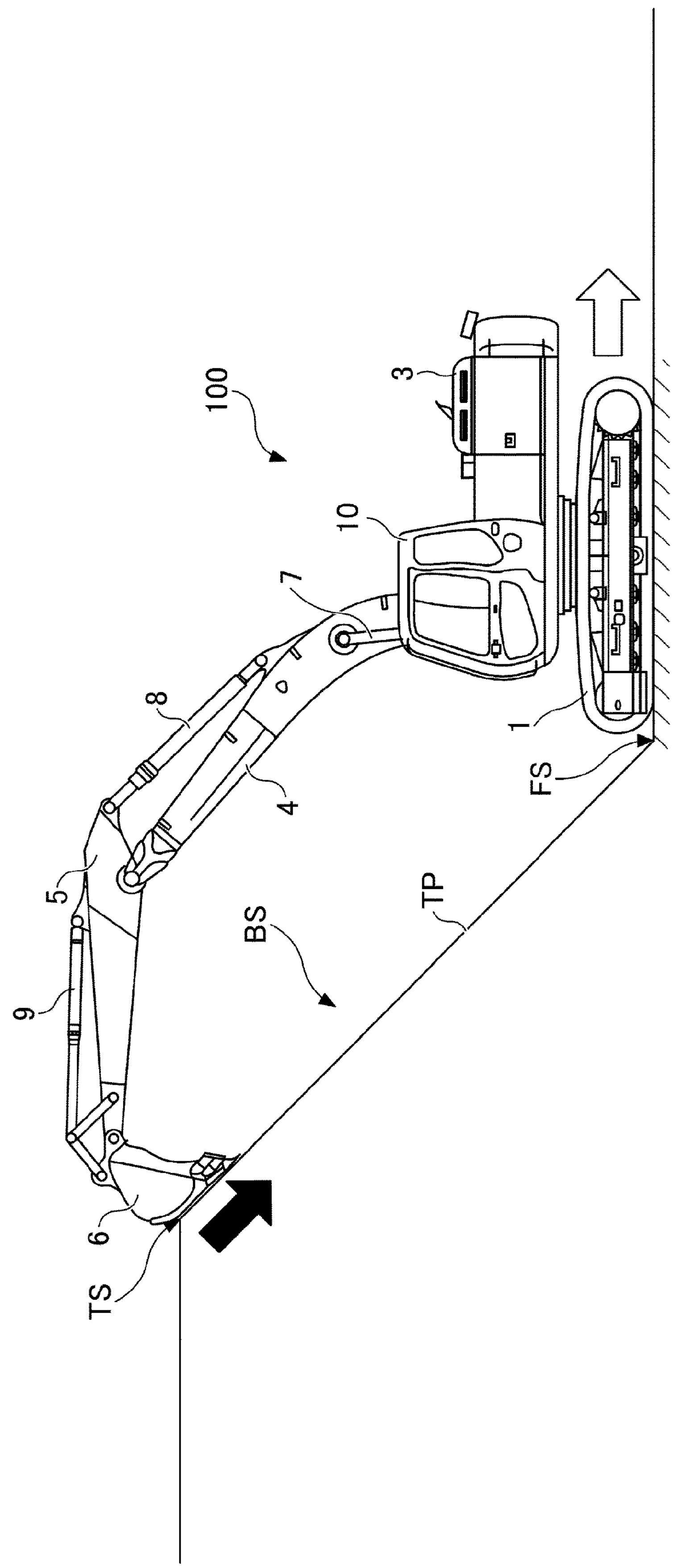


FIG.11

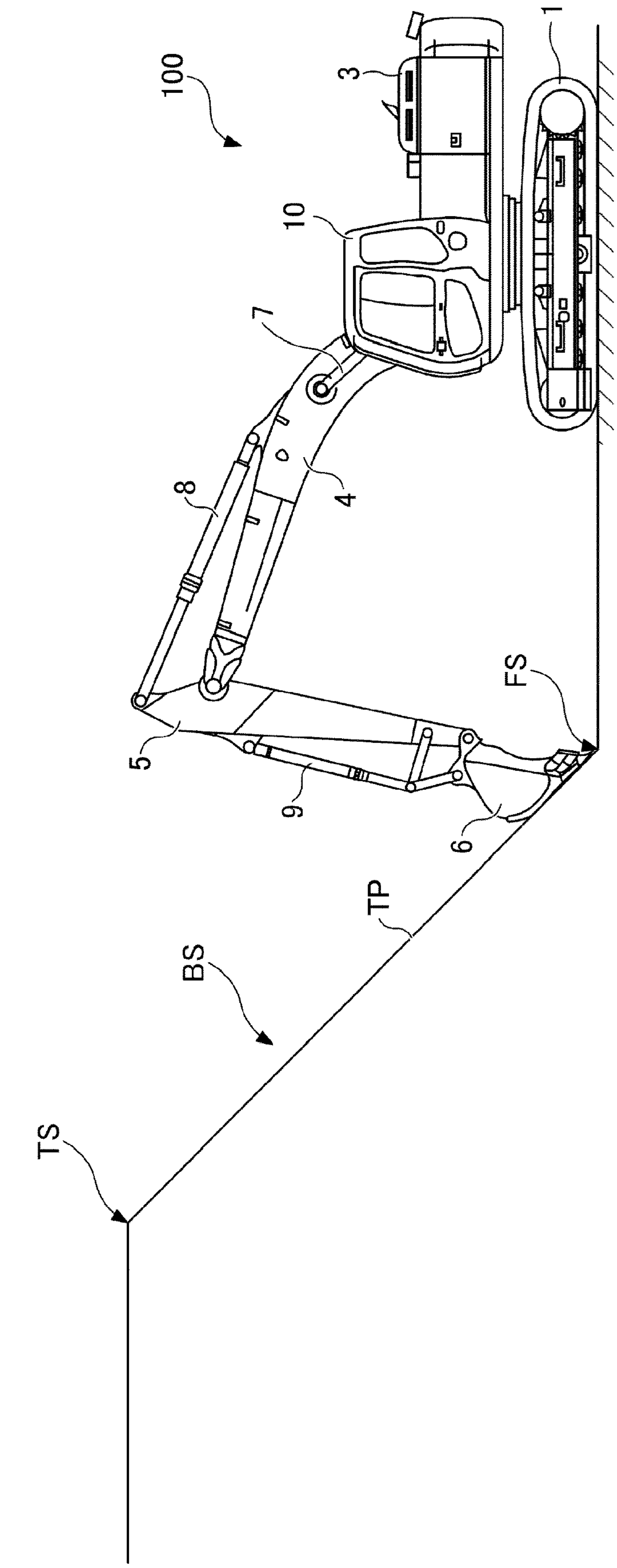


FIG.12

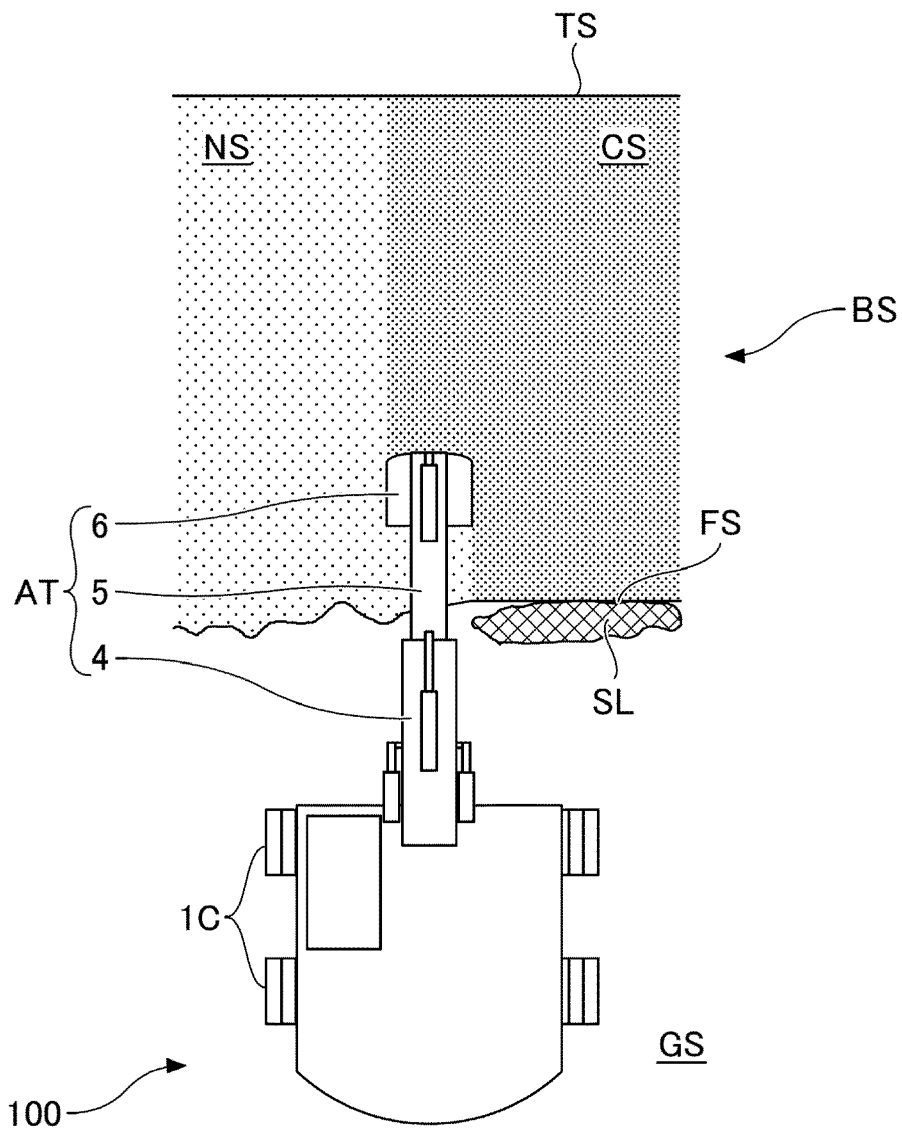
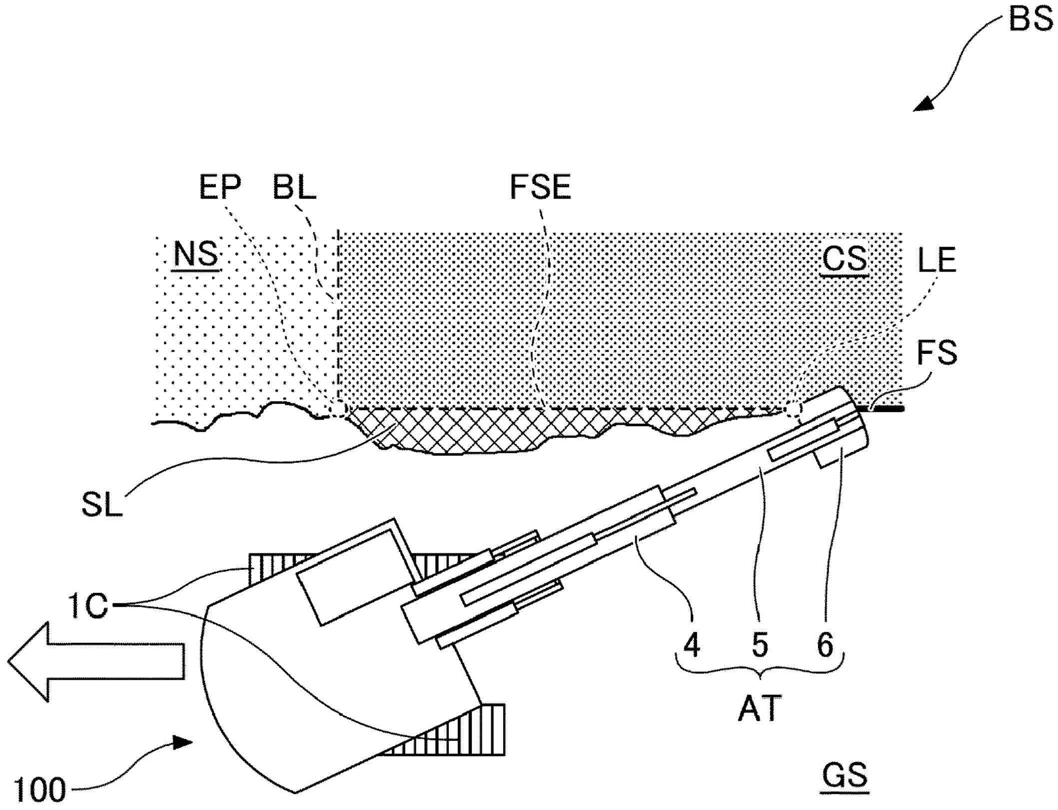


FIG.13



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