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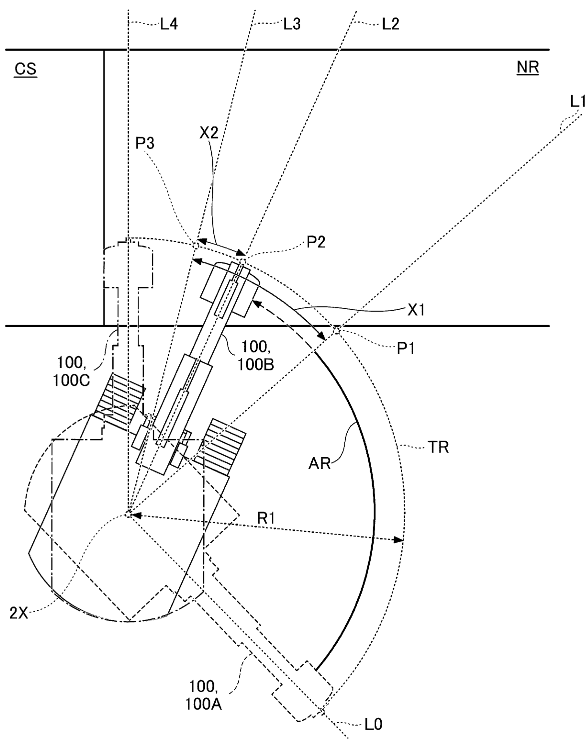
(54) **SHOVEL**

(57) A shovel includes a lower traveling body; an upper turning body that is turnably mounted on the lower traveling body; an attachment that is attached to the upper turning body; a posture detection device configured to detect a posture of the attachment; and a control device configured to determine, based on position information of a slope and a posture of the attachment, whether or not the attachment and the slope contact each other during turning of the upper turning body.

FIG.9



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Description

BACKGROUND

1. Technical Field

[0001] The present disclosure relates to shovels.

2. Description of Related Art

[0002] Shovels that enable upper turning bodies to face a slope have been known (see International Publication No. WO2022/202674) .

[0003] However, the attachment of the above shovel may contact the slope before the upper turning body faces the slope.

[0004] In view of this, it is desirable to provide a shovel that can previously provide information on whether or not the attachment and the slope will contact each other upon causing the upper turning body to face the slope.

SUMMARY

[0005] A shovel according to an embodiment of the present disclosure includes: a lower traveling body; an upper turning body that is turnably mounted on the lower traveling body; an attachment that is attached to the upper turning body; a posture detection device configured to detect a posture of the attachment; and a control device configured to determine, based on position information of a slope and a posture of the attachment, whether or not the attachment and the slope contact each other during turning of the upper turning body.

[0006] The above shovel can previously provide information on whether or not the attachment and the slope will contact each other upon causing the upper turning body to face the slope.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIG. 1 is a side view of a shovel according to an embodiment of the present disclosure;
FIG. 2 is a top view of the shovel of FIG. 1;
FIG. 3 is a view illustrating a configuration example of a hydraulic system mounted to the shovel of FIG. 1;
FIG. 4A is a view of a part of a hydraulic system in relation to operation of an arm cylinder;
FIG. 4B is a view of a part of a hydraulic system in relation to operation of a boom cylinder;
FIG. 4C is a view of a part of a hydraulic system in relation to operation of a bucket cylinder;
FIG. 4D is a view of a part of a hydraulic system in relation to operation of a turning hydraulic motor;
FIG. 4E is a view of a part of a hydraulic system in relation to operation of a left traveling hydraulic motor;
FIG. 4F is a view of a part of a hydraulic system in relation to operation of a right traveling hydraulic motor;
FIG. 5 is a diagram illustrating a configuration example of a controller;
FIG. 6 is a flowchart illustrating an example of a flow of a contact determination process;
FIG. 7 is a top view of a shovel that performs slope shaping;
FIG. 8 is a perspective view of the shovel that performs slope shaping; and
FIG. 9 is a top view of the shovel that performs slope shaping.

DETAILED DESCRIPTION

[0008] First, a shovel 100 as an excavator according to an embodiment of the present disclosure will be described with reference to FIG. 1 and FIG. 2. FIG. 1 is a side view of the shovel 100, and FIG. 2 is a top view of the shovel 100.

[0009] In the present embodiment, a lower traveling body 1 of the shovel 100 includes crawlers 1C. The crawlers 1C are driven by traveling hydraulic motors 2M as traveling actuators mounted on the lower traveling body 1. Specifically, the crawlers 1C include a left crawler 1CL and a right crawler 1CR. The left crawler 1CL is driven by a left traveling hydraulic motor 2ML, and the right crawler 1CR is driven by a right traveling hydraulic motor 2MR.

[0010] An upper turning body 3 is turnably mounted on the lower traveling body 1 via a turning mechanism 2. The turning mechanism 2 is driven by a turning hydraulic motor 2A as a turning actuator mounted on the upper turning body 3. However, the turning actuator may be a turning motor generator as an electric actuator.

[0011] A boom 4 is attached to the upper turning body 3. An arm 5 is attached to an end of the boom 4, and a bucket

6 as an end attachment is attached to an end of the arm 5. The boom 4, the arm 5, and the bucket 6 constitute an excavation attachment, which is an example of an attachment AT. The boom 4 is driven by a boom cylinder 7, the arm 5 is driven by an arm cylinder 8, and the bucket 6 is driven by a bucket cylinder 9. The boom cylinder 7, the arm cylinder 8, and the bucket cylinder 9 constitute an attachment actuator. The bucket 6 may be, for example, a slope bucket. Further, the bucket 6 may include a bucket tilt mechanism.

[0012] The boom 4 is supported so as to be vertically rotatable with respect to the upper turning body 3. A boom angle sensor S1 is attached to the boom 4. The boom angle sensor S1 can detect a boom angle θ1 which is a rotation angle of the boom 4. The boom angle θ1 is, for example, a rising angle from a state in which the boom 4 is lowered most. Therefore, the boom angle θ1 becomes maximum when the boom 4 is raised most.

[0013] The arm 5 is turnably supported with respect to the boom 4. An arm angle sensor S2 is attached to the arm 5. The arm angle sensor S2 is configured to detect an arm angle θ2 that is a rotation angle of the arm 5. The arm angle θ2 is, for example, an opening angle from a state in which the arm 5 is closed most. Therefore, the arm angle θ2 becomes maximum when the arm 5 is opened most.

[0014] The bucket 6 is turnably supported with respect to the arm 5. A bucket angle sensor S3 is attached to the bucket 6. The bucket angle sensor S3 is configured to detect a bucket angle θ3 that is a rotation angle of the bucket 6. The bucket angle θ3 is an opening angle from a state in which the bucket 6 is closed most. Therefore, the bucket angle θ3 becomes maximum when the bucket 6 is opened most.

[0015] In the embodiment of FIG. 1, each of the boom angle sensor S1, the arm angle sensor S2, and the bucket angle sensor S3 is configured by a combination of an accelerometer sensor and a gyro sensor. However, each of these angle sensors may be configured by only the acceleration sensor. The boom angle sensor S1 may be a stroke sensor attached to the boom cylinder 7, or may be a rotary encoder, a potentiometer, an inertial measurement device, or the like. The same applies to the arm angle sensor S2 and the bucket angle sensor S3.

[0016] The upper turning body 3 is provided with a cab 10 as an operator’s room, and is provided with a power source such as an engine 11 or the like. In addition, a space recognition device 70, a direction detection device 71, a position measurement device 73, a machine tilt sensor S4, a turning angular velocity sensor S5, and the like are attached to the upper turning body 3. An operation device 26, a controller 30, an information input device 72, a display device D1, a sound output device D2, and the like are provided in the cab 10. In this specification, for the sake of convenience, a side of the upper turning body 3 to which the attachment AT is attached is referred to as a front side, and a side of the upper turning body 3 to which the counterweight is attached is referred to as a back side.

[0017] The space recognition device 70 is configured to recognize an object present in a three-dimensional space around the shovel 100. Further, the space recognition device 70 may be configured to calculate a distance from the space recognition device 70 or the shovel 100 to the recognized object. Examples of the space recognition device 70 include an ultrasonic sensor, a millimeter wave radar, an imaging device, a LIDAR sensor, a distance image sensor, an infrared sensor, or the like, or any combination thereof. The imaging device is a monocular camera, a stereo camera, or the like. In the present embodiment, the space recognition device 70 includes a front sensor 70F attached to the front end of the upper surface of the cab 10, a back sensor 70B attached to the back end of the upper surface of the upper turning body 3, a left sensor 70L attached to the left end of the upper surface of the upper turning body 3, and a right sensor 70R attached to the right end of the upper surface of the upper turning body 3. An upper sensor configured to recognize an object present in a space above the upper turning body 3 may be attached to the shovel 100.

[0018] The direction detection device 71 is configured to detect information on a relative relationship between the direction of the upper turning body 3 and the direction of the lower traveling body 1. The direction detection device 71 may be configured by, for example, a combination of a geomagnetic sensor attached to the lower traveling body 1 and a geomagnetic sensor attached to the upper turning body 3. Alternatively, the direction detection device 71 may be configured by a combination of a GNSS receiver attached to the lower traveling body 1 and a GNSS receiver attached to the upper turning body 3. The direction detection device 71 may be a rotary encoder, a rotary position sensor, or the like, or any combination thereof. In a configuration in which the upper turning body 3 is driven to turn by the turning motor generator, the direction detection device 71 may be configured by a resolver. The direction detection device 71 may be attached to, for example, a center joint provided in association with the turning mechanism 2 configured to implement the relative rotation between the lower traveling body 1 and the upper turning body 3.

[0019] The direction detection device 71 may be configured by a camera attached to the upper turning body 3. In this case, the direction detection device 71 performs known image processing on an image (input image) captured by the camera attached to the upper turning body 3 to detect an image of the lower traveling body 1 included in the input image. The direction detection device 71 detects the image of the lower traveling body 1 using a known image recognition technique, thereby identifying the longitudinal direction of the lower traveling body 1. Then, an angle formed between the direction of a front-back axis of the upper turning body 3 and the longitudinal direction of the lower traveling body 1 is derived. The direction of the front-back axis of the upper turning body 3 is derived from the mounting position of the camera. Especially, because the crawler 1C projects from the upper turning body 3, the direction detection device 71 can identify the longitudinal direction of the lower traveling body 1 by detecting the image of the crawler 1C. In this case, the direction detection device 71 may be integrated into the controller 30. The camera may be the space recognition device 70.

[0020] The information input device 72 is configured to allow an operator of the shovel to input information to the controller 30. In the present embodiment, the information input device 72 is a switch panel provided close to a display part of the display device D1. However, the information input device 72 may be a touch panel disposed on the display part of the display device D1, or may be a voice input device, such as a microphone, disposed in the cab 10. Further, the information input device 72 may be a communication device configured to obtain information from the exterior.

[0021] The position measurement device 73 is configured to measure a position of the upper turning body 3. In the present embodiment, the position measurement device 73 is a GNSS receiver, and detects the position of the upper turning body 3 and outputs the detected value to the controller 30. The position measurement device 73 may be a GNSS compass. In this case, the position measurement device 73 can detect the position and the direction of the upper turning body 3. Therefore, the position measurement device 73 also serves as the direction detection device 71.

[0022] The machine tilt sensor S4 is configured to detect a tilt of the upper turning body 3 with respect to a predetermined plane. In the present embodiment, the machine tilt sensor S4 is an acceleration sensor configured to detect a tilt angle about the front-back axis and a tilt angle about a left-right axis of the upper turning body 3 with respect to a horizontal plane. For example, the front-back axis and the left-right axis of the upper turning body 3 are orthogonal to each other and pass through a shovel center point that is a point on the turning axis of the shovel 100.

[0023] The turning angular velocity sensor S5 is configured to detect a turning angle of the upper turning body 3. In the present embodiment, the turning angular velocity sensor S5 is a gyro sensor. The turning angular velocity sensor S5 may be a resolver, a rotary encoder, or the like, or any combination thereof. The turning angular velocity sensor S5 may detect a turning speed or a turning angular speed. The turning speed may be calculated from the turning angular speed.

[0024] Hereinafter, at least one selected from the group consisting of the boom angle sensor S1, the arm angle sensor S2, the bucket angle sensor S3, the machine tilt sensor S4, and the turning angular velocity sensor S5 is also referred to as a posture detection device. The posture of the attachment AT is detected based on, for example, the outputs of the boom angle sensor S1, the arm angle sensor S2, and the bucket angle sensor S3.

[0025] The display device D1 is a device configured to display information. In the present embodiment, the display device D1 is a liquid crystal display installed in the cab 10. However, the display device D1 may be a display of a mobile terminal, such as a smartphone or the like.

[0026] The sound output device D2 is a device configured to output sound. The sound output device D2 includes either or both of: a device configured to output sound to an operator in the cab 10; and a device configured to output sound to an operator outside the cab 10. The sound output device D2 may be a speaker of a mobile terminal.

[0027] The operation device 26 is a device used by an operator to operate the actuator. The operation device 26 includes an operation lever, an operation pedal, and the like. The actuator includes a hydraulic actuator, an electric actuator, or both.

[0028] The controller 30 is a control device configured to control the shovel 100. In the present embodiment, the controller 30 is configured by a computer including a CPU, a volatile storage device, a non-volatile storage device, and the like. Then, the controller 30 reads a program corresponding to each function from the non-volatile storage device, loads the program into the volatile storage device, and causes the CPU to execute a corresponding process. The functions include: a machine guidance function that guides the operator's manual operation of the shovel 100; a machine control function that assists the operator's manual operations of the shovel 100 or causes the shovel 100 to operate automatically or autonomously; and the like. The controller 30 may include a contact avoidance function of automatically or autonomously operating or stopping the shovel 100 in order to avoid contact between the shovel 100 and an object present in a monitoring range around the shovel 100. Monitoring of objects around the shovel 100 is performed not only within the monitoring range but also outside the monitoring range.

[0029] Next, a configuration example of the hydraulic system mounted to the shovel 100 will be described with reference to FIG. 3. FIG. 3 is a view illustrating a configuration example of the hydraulic system mounted to the shovel 100. In FIG. 3, the mechanical power system, the hydraulic oil line, the pilot line, and the electric control system are illustrated with a double line, a solid line, a dashed line, and a dotted line, respectively.

[0030] The hydraulic system of the shovel 100 mainly includes, for example, the engine 11, a regulator 13, a main pump 14, a pilot pump 15, a control valve unit 17, an operation device 26, a discharge pressure sensor 28, an operation sensor 29, and the controller 30.

[0031] In FIG. 3, the hydraulic system is configured to circulate the hydraulic oil from the main pump 14 driven by the engine 11 to the hydraulic oil tank through a center bypass conduit 40 or a parallel conduit 42.

[0032] The engine 11 is a power source of the shovel 100. In the present embodiment, the engine 11 is, for example, a diesel engine that is operated to maintain a predetermined rotation speed. Output shafts of the engine 11 are coupled to respective input shafts of the main pump 14 and the pilot pump 15.

[0033] The main pump 14 is configured to feed the hydraulic oil to the control valve unit 17 through the hydraulic oil line. In the present embodiment, the main pump 14 is a swashplate variable displacement hydraulic pump.

[0034] The regulator 13 is configured to control the discharge amount of the main pump 14. In the present embodiment, the regulator 13 controls the discharge amount of the main pump 14 by adjusting the swashplate tilting angle of the main pump 14 in response to a control command from the controller 30.

[0035] The pilot pump 15 is one example of a pilot pressure generating device configured to generate a pilot pressure that is a control pressure applied to a pilot port of each of control valves 171 to 176, and to feed the hydraulic oil to a hydraulic pressure control device through the pilot line. In the present embodiment, the pilot pump 15 is a fixed displacement hydraulic pump. However, the pilot pressure generating device may be achieved by the main pump 14. That is, the main pump 14 may have a function of feeding the hydraulic oil to various hydraulic control devices through the pilot line, in addition to the function of feeding the hydraulic oil to the control valve unit 17 through the hydraulic oil line. In this case, the pilot pump 15 may be omitted.

[0036] The control valve unit 17 is a hydraulic control device that controls the hydraulic system in the shovel 100. In the present embodiment, the control valve unit 17 includes control valves 171 to 176. The control valve 175 includes a control valve 175L and a control valve 175R, and the control valve 176 includes a control valve 176L and a control valve 176R. The control valve unit 17 is configured to selectively feed the hydraulic oil discharged by the main pump 14 to one or more hydraulic actuators through the control valves 171 to 176. The control valves 171 to 176 control, for example, the flow rate of the hydraulic oil flowing from the main pump 14 to the hydraulic actuator and the flow rate of the hydraulic oil flowing from the hydraulic actuator to the hydraulic oil tank. The hydraulic actuator includes the boom cylinder 7, the arm cylinder 8, the bucket cylinder 9, the left traveling hydraulic motor 2ML, the right traveling hydraulic motor 2MR, and the turning hydraulic motor 2A.

[0037] The operation device 26 is configured so that the operator can operate the actuator. In the present embodiment, the operation device 26 includes a hydraulic actuator operation device configured so that the operator can operate the hydraulic actuator. Specifically, the hydraulic actuator operation device is configured to feed, using a solenoid valve, the hydraulic oil discharged by the pilot pump 15 to the pilot port of the corresponding control valve in the control valve unit 17. The pressure (pilot pressure) of the hydraulic oil fed to each of the pilot ports is a pressure in accordance with the direction and the amount of operation of the operation device 26 corresponding to each of the hydraulic actuators.

[0038] The discharge pressure sensor 28 is configured to detect the discharge pressure of the main pump 14. In the present embodiment, the discharge pressure sensor 28 outputs a detected value to the controller 30.

[0039] The operation sensor 29 is configured to detect an operation content of the operator using the operation device 26. In the present embodiment, the operation sensor 29 detects the direction and the amount of operation of the operation device 26 corresponding to each of the actuators, and outputs a detected value to the controller 30. In the illustrated example, the operation sensor 29 is an operation angle sensor configured to detect an operation angle of an operation lever.

[0040] The main pump 14 includes a left main pump 14L and a right main pump 14R. The left main pump 14L circulates the hydraulic oil to the hydraulic oil tank through a left center bypass conduit 40L or a left parallel conduit 42L, and the right main pump 14R circulates the hydraulic oil to the hydraulic oil tank through a right center bypass conduit 40R or a right parallel conduit 42R.

[0041] The left center bypass conduit 40L is a hydraulic oil line passing through the control valves 171, 173, 175L, and 176L disposed in the control valve unit 17. The right center bypass conduit 40R is a hydraulic oil line passing through the control valves 172, 174, 175R, and 176R disposed in the control valve unit 17.

[0042] The control valve 171 is a spool valve that feeds the hydraulic oil discharged by the left main pump 14L to the left traveling hydraulic motor 2ML, and switches the flow of the hydraulic oil for discharging the hydraulic oil discharged by the left traveling hydraulic motor 2ML to the hydraulic oil tank.

[0043] The control valve 172 is a spool valve that feeds the hydraulic oil discharged by the right main pump 14R to the right traveling hydraulic motor 2MR, and switches the flow of the hydraulic oil for discharging the hydraulic oil discharged by the right traveling hydraulic motor 2MR to the hydraulic oil tank.

[0044] The control valve 173 is a spool valve that feeds the hydraulic oil discharged by the left main pump 14L to the turning hydraulic motor 2A, and switches the flow of the hydraulic oil for discharging the hydraulic oil discharged by the turning hydraulic motor 2A to the hydraulic oil tank.

[0045] The control valve 174 is a spool valve that feeds the hydraulic oil discharged by the right main pump 14R to the bucket cylinder 9, and switches the flow of the hydraulic oil for discharging the hydraulic oil in the bucket cylinder 9 to the hydraulic oil tank.

[0046] The control valve 175L is a spool valve that switches the flow of the hydraulic oil for feeding the hydraulic oil discharged by the left main pump 14L to the boom cylinder 7. The control valve 175R is a spool valve that feeds the hydraulic oil discharged by the right main pump 14R to the boom cylinder 7, and switches the flow of the hydraulic oil for discharging the hydraulic oil in the boom cylinder 7 to the hydraulic oil tank.

[0047] The control valve 176L is a spool valve that feeds the hydraulic oil discharged by the left main pump 14L to the arm cylinder 8, and switches the flow of the hydraulic oil for discharging the hydraulic oil in the arm cylinder 8 to the hydraulic oil tank.

[0048] The control valve 176R is a spool valve that feeds the hydraulic oil discharged by the right main pump 14R to the arm cylinder 8, and switches the flow of the hydraulic oil for discharging the hydraulic oil in the arm cylinder 8 to the hydraulic oil tank.

[0049] The left parallel conduit 42L is a hydraulic oil line parallel to the left center bypass conduit 40L. The left parallel conduit 42L can feed the hydraulic oil to a downstream control valve when the flow of the hydraulic oil passing through the left center bypass conduit 40L is restricted or blocked by the control valve 171, 173, or 175L. The right parallel conduit 42R is a hydraulic oil line parallel to the right center bypass conduit 40R. The right parallel conduit 42R can feed the hydraulic oil to a downstream control valve when the flow of the hydraulic oil passing through the right center bypass conduit 40R is restricted or blocked by the control valve 172, 174, or 175R.

[0050] The regulator 13 includes a left regulator 13L and a right regulator 13R. The left regulator 13L controls the discharge amount of the left main pump 14L by adjusting the swashplate tilting angle of the left main pump 14L in accordance with the discharge pressure of the left main pump 14L. Specifically, the left regulator 13L, for example, adjusts the swashplate tilting angle of the left main pump 14L in accordance with an increase in the discharge pressure of the left main pump 14L to reduce the discharge amount. The same applies to the right regulator 13R. This is to prevent absorption power (absorption horsepower) of the main pump 14, which is represented as a product of the discharge pressure and the discharge amount, from exceeding output power (output horsepower) of the engine 11.

[0051] The operation device 26 includes a left operation lever 26L, a right operation lever 26R, and a traveling lever 26D. The traveling lever 26D includes a left traveling lever 26DL and a right traveling lever 26DR.

[0052] The left operation lever 26L is used for the turn operation and the operation of the arm 5. The left operation lever 26L, when operated in the forward and backward directions, utilizes the hydraulic oil discharged by the pilot pump 15 to introduce a control pressure in accordance with the amount of the lever operation into the pilot port of the control valve 176. When operated in the leftward and rightward directions, the hydraulic oil discharged by the pilot pump 15 is used to introduce the control pressure in accordance with the amount of the lever operation into the pilot port of the control valve 173.

[0053] Specifically, the left operation lever 26L introduces the hydraulic oil to the right pilot port of the control valve 176L and introduces the hydraulic oil to the left pilot port of the control valve 176R when operated in an arm closing direction. The left operation lever 26L, when operated in an arm opening direction, introduces the hydraulic oil to the left pilot port of the control valve 176L and introduces the hydraulic oil to the right pilot port of the control valve 176R. The left operation lever 26L introduces the hydraulic oil to the left pilot port of the control valve 173 when operated in a leftward turning direction and introduces the hydraulic oil to the right pilot port of the control valve 173 when operated in a rightward turning direction.

[0054] In the example as illustrated in FIG. 3, the left operation lever 26L serves as an arm operation lever when operated in the forward and backward directions, and serves as a turning operation lever when operated in the leftward and rightward directions.

[0055] The right operation lever 26R is used to operate the boom 4 and the bucket 6. The right operation lever 26R utilizes the hydraulic oil discharged by the pilot pump 15 when operated in the forward and backward directions to introduce a control pressure in accordance with the amount of the lever operation into the pilot port of the control valve 175. When operated in the leftward and rightward directions, the hydraulic oil discharged by the pilot pump 15 is used to introduce the control pressure in accordance with the amount of the lever operation into the pilot port of the control valve 174.

[0056] Specifically, the right operation lever 26R introduces the hydraulic oil to the left pilot port of the control valve 175R when operated in the boom lowering direction. The right operation lever 26R, when operated in a boom raising direction, introduces the hydraulic oil to the right pilot port of the control valve 175L and introduces the hydraulic oil to the left pilot port of the control valve 175R. The right operation lever 26R introduces the hydraulic oil to the right pilot port of the control valve 174 when operated in the bucket closing direction, and introduces the hydraulic oil to the left pilot port of the control valve 174 when operated in the bucket opening direction.

[0057] In the example as illustrated in FIG. 3, the right operation lever 26R serves as a boom operation lever when operated in the forward and backward directions, and serves as a bucket operation lever when operated in the leftward and rightward directions.

[0058] The traveling lever 26D is used to operate a crawler 1C. Specifically, the left traveling lever 26DL is used to operate a left crawler 1CL. It may be configured to interlock with the left traveling pedal. The left traveling lever 26DL, when operated in the forward and backward directions, utilizes the hydraulic oil discharged by the pilot pump 15 to introduce the control pressure in accordance with the amount of the lever operation into the pilot port of the control valve 171. The right traveling lever 26DR is used to operate a right crawler 1CR. It may be configured to interlock with the right traveling pedal. The right traveling lever 26DR, when operated in the forward and backward directions, utilizes the hydraulic oil discharged by the pilot pump 15 to introduce the control pressure in accordance with the amount of the lever operation into the pilot port of the control valve 172.

[0059] The discharge pressure sensor 28 includes a discharge pressure sensor 28L and a discharge pressure sensor 28R. The discharge pressure sensor 28L detects the discharge pressure of the left main pump 14L and outputs a detected value to the controller 30. The same applies to the discharge pressure sensor 28R.

[0060] The operation sensor 29 includes operation sensors 29LA, 29LB, 29RA, 29RB, 29DL, and 29DR. The operation sensor 29LA detects the content of the operation in the forward and backward directions by the operator relative to the left operation lever 26L and outputs a detected value to the controller 30. The content of the operation is, for example, the direction of the lever operation and the amount of the lever operation (angle of the lever operation).

[0061] Similarly, the operation sensor 29LB detects the content of the operation by the operator in the leftward and rightward directions relative to the left operation lever 26L and outputs a detected value to the controller 30. The operation sensor 29RA detects the content of the operation by the operator in the forward and backward directions relative to the right operation lever 26R and outputs a detected value to the controller 30. The operation sensor 29RB detects the content of the operation by the operator in the leftward and rightward directions relative to the right operation lever 26R and outputs a detected value to the controller 30. The operation sensor 29DL detects the content of the operation by the operator in the forward and backward directions relative to the left traveling lever 26DL and outputs a detected value to the controller 30. The operation sensor 29DR detects the content of the operation by the operator in the forward and backward directions relative to the right traveling lever 26DR and outputs a detected value to the controller 30.

[0062] The controller 30 receives the output of the operation sensor 29 and outputs a control command to the regulator 13 as needed to change the discharge amount of the main pump 14. The controller 30 receives an output of a control pressure sensor 19 disposed upstream of a restrictor 18, and outputs a control command to the regulator 13 as needed to change the discharge amount of the main pump 14. The restrictor 18 includes a left restrictor 18L and a right restrictor 18R, and the control pressure sensor 19 includes a left control pressure sensor 19L and a right control pressure sensor 19R.

[0063] In the left center bypass conduit 40L, the left restrictor 18L is disposed between the control valve 176L, which is located the most downstream, and the hydraulic oil tank. Therefore, the flow of hydraulic oil discharged by the left main pump 14L is limited by the left restrictor 18L. The left restrictor 18L generates a control pressure for controlling the left regulator 13L. The left control pressure sensor 19L is a sensor for detecting this control pressure and outputs a detected value to the controller 30. The controller 30 controls the discharge amount of the left main pump 14L by adjusting the tilting angle of the swashplate of the left main pump 14L in accordance with the control pressure. The controller 30 decreases the discharge amount of the left main pump 14L as the control pressure increases, and increases the discharge amount of the left main pump 14L as the control pressure decreases. The discharge amount of the right main pump 14R is controlled in the same manner.

[0064] Specifically, when none of the hydraulic actuators of the shovel 100 is in the standby state as illustrated in FIG. 3, the hydraulic oil discharged by the left main pump 14L passes through the left center bypass conduit 40L and reaches the left restrictor 18L. The flow of the hydraulic oil discharged by the left main pump 14L increases the control pressure generated upstream of the left restrictor 18L. As a result, the controller 30 reduces the discharge amount from the left main pump 14L to the allowable minimum discharge amount and suppresses the pressure loss (pumping loss) when the discharged hydraulic oil passes through the left center bypass conduit 40L. On the other hand, when any of the hydraulic actuators is operated, the hydraulic oil discharged by the left main pump 14L flows into the hydraulic actuator to be operated through a control valve corresponding to the hydraulic actuator to be operated. The flow of the hydraulic oil discharged by the left main pump 14L decreases or extinguishes the amount reaching the left restrictor 18L, thereby reducing the control pressure generated upstream of the left restrictor 18L. As a result, the controller 30 increases the discharge rate of the left main pump 14L to circulate sufficient hydraulic oil in the hydraulic actuator to be operated to ensure drive of the hydraulic actuator to be operated. The controller 30 controls the discharge amount of the right main pump 14R in the same manner.

[0065] With the above-described configuration, the hydraulic system of FIG. 3 can reduce wasteful energy consumption at the main pump 14 in standby conditions. The wasteful energy consumption includes pumping losses caused by the hydraulic oil discharged by the main pump 14 in the center bypass conduit 40. The hydraulic system of FIG. 3 ensures that when the hydraulic actuator is operated, sufficient hydraulic fluid is fed from the main pump 14 to the hydraulic actuator to be actuated.

[0066] A boom rod pressure sensor S7R and a boom bottom pressure sensor S7B are attached to the boom cylinder 7. An arm rod pressure sensor S8R and an arm bottom pressure sensor S8B are attached to the arm cylinder 8. A bucket rod pressure sensor S9R and a bucket bottom pressure sensor S9B are attached to the bucket cylinder 9. The boom rod pressure sensor S7R, the boom bottom pressure sensor S7B, the arm rod pressure sensor S8R, the arm bottom pressure sensor S8B, the bucket rod pressure sensor S9R, and the bucket bottom pressure sensor S9B are also collectively referred to as "cylinder pressure sensors". A left turning pressure sensor S10L and a right turning pressure sensor S10R are attached to the turning hydraulic motor 2A.

[0067] The boom rod pressure sensor S7R is configured to detect the pressure of an oil chamber on the rod side of the boom cylinder 7 (hereinafter referred to as a "boom rod pressure"). The boom bottom pressure sensor S7B is configured to detect the pressure of an oil chamber on the bottom side of the boom cylinder 7 (hereinafter referred to as a "boom bottom pressure"). The arm rod pressure sensor S8R is configured to detect the pressure of an oil chamber on the rod side of the arm cylinder 8 (hereinafter referred to as an "arm rod pressure"). The arm bottom pressure sensor S8B is configured to detect the pressure of an oil chamber on the bottom side of the arm cylinder 8 (hereinafter referred to as an "arm bottom pressure"). The bucket rod pressure sensor S9R is configured to detect the pressure of an oil chamber on the rod side of the bucket cylinder 9 (hereinafter referred to as a "bucket rod pressure"). The bucket bottom pressure sensor S9B is configured to detect the pressure of an oil chamber on the bottom side of the bucket cylinder 9 (hereinafter referred to as a "bucket bottom pressure"). The left turning pressure sensor S10L is configured to detect the pressure of the hydraulic oil in the left-hand port of the turning hydraulic motor 2A. The right turning pressure sensor S10R is configured to detect the pressure of the hydraulic oil in the right-hand port of the turning hydraulic motor 2A. The value detected by each of the sensors is transmitted to the controller 30.

[0068] Next, a configuration for the controller 30 to operate the actuators will be described with reference to FIG. 4A to FIG. 4F. FIG. 4A to FIG. 4F are views of parts extracted from the hydraulic system. Specifically, FIG. 4A is a view of a part extracted from the hydraulic system in relation to the operation of the arm cylinder 8. FIG. 4B is a view of a part extracted from the hydraulic system in relation to the operation of the boom cylinder 7. FIG. 4C is a view of a part extracted from the hydraulic system in relation to the operation of the bucket cylinder 9. FIG. 4D is a view of a part extracted from the hydraulic system in relation to the operation of the turning hydraulic motor 2A. FIG. 4E is a view of a part extracted from the hydraulic system in relation to the operation of the left traveling hydraulic motor 2ML. FIG. 4F is a view of a part extracted from the hydraulic system in relation to the operation of the right traveling hydraulic motor 2MR.

[0069] As illustrated in FIG. 4A to FIG. 4F, the hydraulic system includes the solenoid valve 31. The solenoid valve 31 includes solenoid valves 31AL to 31FL and solenoid valves 31AR to 31FR.

[0070] The solenoid valve 31 is disposed in a conduit connecting the pilot pump 15 to the pilot port of the corresponding control valve in the control valve unit 17, and is configured to change the opening area of the conduit to change the flow path area of the conduit. In the present embodiment, the solenoid valve 31 is a solenoid proportional valve and operates in response to a control command output by the controller 30. Thus, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the pilot port of the corresponding control valve in the control valve unit 17 through the solenoid valve 31, in response to the operation of the operation device 26 by the operator or independently of the operation of the operation device 26 by the operator. The controller 30 can apply a pilot pressure generated by the solenoid valve 31 to the pilot port of the corresponding control valve.

[0071] With this configuration, in addition to when an operation is being performed on the specific operation device 26, even if no operation is being performed on the specific operation device 26, the controller 30 can operate the hydraulic actuator corresponding to the specific operation device 26. Also, even if an operation is being performed on the specific operation device 26, the controller 30 can forcibly stop the operation of the hydraulic actuator corresponding to the specific operation device 26.

[0072] For example, as illustrated in FIG. 4A, the left operation lever 26L is used to operate the arm 5. Specifically, the left operation lever 26L utilizes the pilot oil discharged by the pilot pump 15 to apply a pilot pressure to the pilot port of the control valve 176 in response to the operation in the forward and backward directions. More specifically, the left operation lever 26L, when operated in the arm closing direction (backward direction), applies a pilot pressure in accordance with the amount of operation to the right pilot port of the control valve 176L and the left pilot port of the control valve 176R. The left operation lever 26L, when operated in the arm opening direction (forward direction), applies a pilot pressure in accordance with the amount of operation to the left pilot port of the control valve 176L and the right pilot port of the control valve 176R.

[0073] The left operation lever 26L is provided with a switch NS. In the present embodiment, the switch NS is a push-button switch provided at the end of the left operation lever 26L. The operator can operate the left operation lever 26L while pressing the switch NS. The switch NS may be provided at the right operation lever 26R or at other locations within the cab 10.

[0074] The operation sensor 29LA detects the content of the operation in the forward and backward directions by the operator relative to the left operation lever 26L and outputs a detected value to the controller 30.

[0075] The solenoid valve 31AL operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the pilot oil introduced from the pilot pump 15 to the right pilot port of the control valve 176L and the left pilot port of the control valve 176R through the solenoid valve 31AL. The solenoid valve 31AR operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the pilot oil introduced from the pilot pump 15 to the left pilot port of the control valve 176L and the right pilot port of the control valve 176R through the solenoid valve 31AR. The solenoid valve 31AL can adjust the pilot pressure so that the control valve 176L and the control valve 176R can be stopped at a given valve position. Similarly, the solenoid valve 31AR can adjust the pilot pressure so that the control valve 176L and the control valve 176R can be stopped at a given valve position.

[0076] With this configuration, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the right pilot port of the control valve 176L and the left pilot port of the control valve 176R through the solenoid valve 31AL in response to the arm closing operation by the operator. Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the right pilot port of the control valve 176L and the left pilot port of the control valve 176R through the solenoid valve 31AL independently of the arm closing operation by the operator. That is, the controller 30 can close the arm 5 in response to the arm closing operation by the operator or independently of the arm closing operation by the operator. In this manner, the solenoid valve 31AL serves as an "arm solenoid valve" or a "solenoid valve for arm closing".

[0077] Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the left pilot port of the control valve 176L and the right pilot port of the control valve 176R through the solenoid valve 31AR in response to the arm opening operation by the operator. Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the left pilot port of the control valve 176L and the right pilot port of the control valve 176R through the solenoid valve 31AR independently of the arm opening operation by the operator. That is, the controller 30 can open the arm 5 in response to the arm opening operation by the operator or independently of the arm opening operation by the operator. In this manner, the solenoid valve 31AR serves as an "arm solenoid valve" or a "solenoid valve for arm opening".

[0078] With this configuration, even if the arm closing operation is being performed by the operator, the controller 30, as needed, can reduce the pilot pressure applied to the pilot port on the closing side of the control valve 176 (the left pilot port of the control valve 176L and the right pilot port of the control valve 176R) and forcibly stop the closing movement of the arm 5. The same applies to the case of forcibly stopping the opening movement of the arm 5 when the arm opening operation is performed by the operator.

[0079] Alternatively, even if the arm closing operation is being performed by the operator, the controller 30, as needed, may forcibly stop the closing movement of the arm 5 by controlling the solenoid valve 31AR to increase the pilot pressure applied to the pilot port on the opening side of the control valve 176, which is located opposite to the pilot port on the closing side of the control valve 176, (the right pilot port of the control valve 176L and the left pilot port of the control valve 176R), thereby forcibly returning the control valve 176 to a neutral position. The same applies to the case of forcibly stopping the opening movement of the arm 5 when the arm opening operation is performed by the operator.

[0080] Although description with reference to FIG. 4B to FIG. 4F is omitted in the following, the same applies to: the case of forcibly stopping the movement of the boom 4 when a boom raising operation or a boom lowering operation is being performed by the operator; the case of forcibly stopping the movement of the bucket 6 when a bucket closing operation or a bucket opening operation is being performed by the operator; and the case of forcibly stopping the turning movement of the upper turning body 3 when a turning operation is being performed by the operator. Also, the same applies to the case of forcibly stopping a traveling movement of the lower traveling body 1 when a traveling operation is being performed by the operator.

[0081] Also, in order to improve responsiveness of the arm operation (arm closing operation and arm opening operation), the controller 30 may be configured to apply a trace amount of pilot pressure to the pilot ports on both sides of the control valve 176 even before the arm operation is performed. The same applies to other operations, such as boom operations (boom raising operation and boom lowering operation) and the like. That is, the controller 30 can increase responsiveness of the hydraulic actuators by increased use of the pilot oil.

[0082] Also, as illustrated in FIG. 4B, the right operation lever 26R is used to operate the boom 4. Specifically, the right operation lever 26R utilizes the pilot oil discharged by the pilot pump 15 to apply a pilot pressure to the pilot port of the control valve 175 in response to the operation in the forward and backward directions. More specifically, the right operation lever 26R, when operated in the boom raising direction (backward direction), applies a pilot pressure in accordance with the amount of operation to the right pilot port of the control valve 175L and the left pilot port of the control valve 175R. The right operation lever 26R, when operated in a boom lowering direction (forward direction), applies a pilot pressure in accordance with the amount of operation to the right pilot port of the control valve 175R.

[0083] The operation sensor 29RA detects the content of the operation in the forward and backward directions by the operator relative to the right operation lever 26R and outputs a detected value to the controller 30.

[0084] The solenoid valve 31BL operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the pilot oil introduced from the pilot pump 15 to the right pilot port of the control valve 175L and the left pilot port of the control valve 175R through the solenoid valve 31BL. The solenoid valve 31BR operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the pilot oil introduced from the pilot pump 15 to the right pilot port of the control valve 175R through the solenoid valve 31BR. The solenoid valve 31BL can adjust the pilot pressure so that the control valve 175L and the control valve 175R can be stopped at a given valve position. Also, the solenoid valve 31BR can adjust the pilot pressure so that the control valve 175R can be stopped at a given valve position.

[0085] With this configuration, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the right pilot port of the control valve 175L and the left pilot port of the control valve 175R through the solenoid valve 31BL in response to the boom raising operation by the operator. Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the right pilot port of the control valve 175L and the left pilot port of the control valve 175R through the solenoid valve 31BL independently of the boom raising operation by the operator. That is, the controller 30 can raise the boom

4 in response to the boom raising operation by the operator or independently of the boom raising operation by the operator. In this manner, the solenoid valve 31BL serves as a "boom solenoid valve" or a "solenoid valve for boom raising".

[0086] Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the right pilot port of the control valve 175R through the solenoid valve 31BR in response to the boom lowering operation by the operator. Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the right pilot port of the control valve 175R through the solenoid valve 31BR independently of the boom lowering operation by the operator. That is, the controller 30 can lower the boom 4 in response to the boom lowering operation by the operator or independently of the boom lowering operation by the operator. In this manner, the solenoid valve 31BR serves as a "boom solenoid valve" or a "solenoid valve for boom lowering".

[0087] As illustrated in FIG. 4C, the right operation lever 26R is used to operate the bucket 6. Specifically, the right operation lever 26R utilizes the pilot oil discharged by the pilot pump 15 to apply a pilot pressure to the pilot port of the control valve 174 in response to the operation in the leftward and rightward directions. More specifically, the right operation lever 26R, when operated in the bucket closing direction (leftward direction), applies a pilot pressure in accordance with the amount of operation to the left pilot port of the control valve 174. The right operation lever 26R, when operated in the bucket opening direction (rightward direction), applies a pilot pressure in accordance with the amount of operation to the right pilot port of the control valve 174.

[0088] The operation sensor 29RB detects the content of the operation in the leftward and rightward directions by the operator relative to the right operation lever 26R and outputs a detected value to the controller 30. The controller 30 may estimate a bucket angle based on the output of the operation sensor 29RB when a bucket angle sensor is omitted.

[0089] The solenoid valve 31CL operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the pilot oil introduced from the pilot pump 15 to the left pilot port of the control valve 174 through the solenoid valve 31CL. The solenoid valve 31CR operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the pilot oil introduced from the pilot pump 15 to the right pilot port of the control valve 174 through the solenoid valve 31CR. The solenoid valve 31CL can adjust the pilot pressure so that the control valve 174 can be stopped at a given valve position. Similarly, the solenoid valve 31CR can adjust the pilot pressure so that the control valve 174 can be stopped at a given valve position.

[0090] With this configuration, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the left pilot port of the control valve 174 through the solenoid valve 31CL in response to the bucket closing operation by the operator. Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the left pilot port of the control valve 174 through the solenoid valve 31CL independently of the bucket closing operation by the operator. That is, the controller 30 can close the bucket 6 in response to the bucket closing operation by the operator or independently of the bucket closing operation by the operator. In this manner, the solenoid valve 31CL serves as a "bucket solenoid valve" or a "solenoid valve for bucket closing".

[0091] Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the right pilot port of the control valve 174 through the solenoid valve 31CR in response to the bucket opening operation by the operator. Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the right pilot port of the control valve 174 through the solenoid valve 31CR independently of the bucket opening operation by the operator. That is, the controller 30 can open the bucket 6 in response to the bucket opening operation by the operator or independently of the bucket opening operation by the operator. In this manner, the solenoid valve 31CR serves as a "bucket solenoid valve" or a "solenoid valve for bucket opening".

[0092] As illustrated in FIG. 4D, the left operation lever 26L is used to operate the turning mechanism 2. Specifically, the left operation lever 26L utilizes the pilot oil discharged by the pilot pump 15 to apply a pilot pressure to the pilot port of the control valve 173 in response to the operation in the leftward and rightward directions. More specifically, the left operation lever 26L, when operated in the leftward turning direction (leftward direction), applies a pilot pressure in accordance with the amount of operation to the left pilot port of the control valve 173. The left operation lever 26L, when operated in the rightward turning direction (rightward direction), applies a pilot pressure in accordance with the amount of operation to the right pilot port of the control valve 173.

[0093] The operation sensor 29LB detects the content of the operation in the leftward and rightward directions by the operator relative to the left operation lever 26L and outputs a detected value to the controller 30.

[0094] The solenoid valve 31DL operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the pilot oil introduced from the pilot pump 15 to the left pilot port of the control valve 173 through the solenoid valve 31DL. The solenoid valve 31DR operates in response to a control command (electric current command) output by the controller 30, thereby adjusting the pilot pressure of the pilot oil introduced from the pilot pump 15 to the right pilot port of the control valve 173 through the solenoid valve 31DR. The solenoid valve 31DL can adjust the pilot pressure so that the control valve 173 can be stopped at a given valve position. Similarly, the solenoid valve 31DR can adjust the pilot pressure so that the control valve 173 can be stopped at a given valve position.

[0095] With this configuration, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the left pilot port of the control valve 173 through the solenoid valve 31DL in response to the left turning operation by the operator. Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the left pilot port of the control valve 173 through the solenoid valve 31DL independently of the left turning operation by the operator. That is, the controller 30 can turn the turning mechanism 2 leftward in response to the left turning operation by the operator or independently of the left turning operation by the operator. In this manner, the solenoid valve 31DL serves as a "turning solenoid valve" or a "solenoid valve for leftward turning".

[0096] Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the right pilot port of the control valve 173 through the solenoid valve 31DR in response to the right turning operation by the operator. Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the right pilot port of the control valve 173 through the solenoid valve 31DR independently of the right turning operation by the operator. That is, the controller 30 can turn the turning mechanism 2 rightward in response to the right turning operation by the operator or independently of the right turning operation by the operator. In this manner, the solenoid valve 31DR serves as a "turning solenoid valve" or a "solenoid valve for rightward turning".

[0097] Also, as illustrated in FIG. 4E, the left traveling lever 26DL is used to operate the left crawler 1CL. Specifically, the left traveling lever 26DL utilizes the pilot oil discharged by the pilot pump 15 to apply a pilot pressure in accordance with the operation in the forward and backward directions to the pilot port of the control valve 171. More specifically, the left traveling lever 26DL, when operated in the traveling forward direction (forward direction), applies the pilot pressure in accordance with the amount of operation to the left pilot port of the control valve 171. Also, the left traveling lever 26DL, when operated in the backward traveling direction (backward direction), applies the pilot pressure in accordance with the amount of operation to the right pilot port of the control valve 171.

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

[0099] The solenoid valve 31EL operates in response to an electric current command output by the controller 30. The solenoid valve 31EL adjusts the pilot pressure of the pilot oil introduced from the pilot pump 15 to the left pilot port of the control valve 171 through the solenoid valve 31EL. The solenoid valve 31ER operates in response to an electric current command output by the controller 30. The solenoid valve 31ER adjusts the pilot pressure of the pilot oil introduced from the pilot pump 15 to the right pilot port of the control valve 171 through the solenoid valve 31ER. The solenoid valves 31EL and 31ER can adjust the pilot pressure so that the control valve 171 can be stopped at a given valve position.

[0100] With this configuration, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the left pilot port of the control valve 171 through the solenoid valve 31EL independently of the forward left traveling operation by the operator. That is, the left crawler 1CL can be caused to travel forward. Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the right pilot port of the control valve 171 through the solenoid valve 31ER independently of the left traveling backward operation by the operator. That is, the left crawler 1CL can be caused to travel backward. In this manner, the solenoid valve 31EL serves as a "left traveling solenoid valve" or a "solenoid valve for left forward traveling", and the solenoid valve 31ER serves as a "left traveling solenoid valve" or a "solenoid valve for left backward traveling".

[0101] Also, as illustrated in FIG. 4F, the right traveling lever 26DR is used to operate the right crawler 1CR. Specifically, the right traveling lever 26DR utilizes the pilot oil discharged by the pilot pump 15 to apply a pilot pressure in accordance with the operation in the forward and backward directions to the pilot port of the control valve 172. More specifically, the right traveling lever 26DR, when operated in the traveling forward direction (forward direction), applies the pilot pressure in accordance with the amount of operation to the right pilot port of the control valve 172. Also, the right traveling lever 26DR, when operated in the backward traveling direction (the backward direction), applies the pilot pressure in accordance with the amount of operation to the right pilot port of the control valve 172.

[0102] The operation sensor 29DR electrically detects the content of the operation by the operator in the forward and backward directions relative to the right traveling lever 26DR and outputs a detected value to the controller 30.

[0103] The solenoid valve 31FL operates in response to an electric current command output by the controller 30. The solenoid valve 31FL adjusts the pilot pressure of the pilot oil introduced from the pilot pump 15 to the left pilot port of the control valve 172 through the solenoid valve 31FL. The solenoid valve 31FR operates in response to an electric current command output by the controller 30. The solenoid valve 31FR adjusts the pilot pressure of the pilot oil introduced from the pilot pump 15 to the right pilot port of the control valve 172 through the solenoid valve 31FR. The solenoid valves 31FL and 31FR can adjust the pilot pressure so that the control valve 172 can be stopped at a given valve position.

[0104] With this configuration, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the right pilot port of the control valve 172 through the solenoid valve 31FL independently of the forward right traveling operation by the operator. That is, the right crawler 1CR can be caused to travel forward. Also, the controller 30 can feed the pilot oil discharged by the pilot pump 15 to the left pilot port of the control valve 172 through the solenoid valve 31FR independently of the right traveling backward operation by the operator. That is, the right crawler 1CR can be caused to travel backward. In this manner, the solenoid valve 31FL serves as a "right traveling solenoid valve" or a "solenoid valve for right forward traveling", and the solenoid valve 31FR serves as a "right traveling solenoid valve" or a "solenoid valve for right backward traveling".

[0105] Also, the shovel 100 may include a structure configured to automatically operate a bucket tilt mechanism. In this case, a part of the hydraulic system in relation to a bucket tilt cylinder forming the bucket tilt mechanism may be configured in the same manner as in, for example, the part of the hydraulic system in relation to the operation of the boom cylinder 7.

[0106] Although the operation device 26 that is an electric operation lever has been described, the operation device 26 may be a hydraulic operation lever rather than the electric operation lever. In this case, the amount of operation of the hydraulic operation lever may be detected by a pressure sensor in the form of pressure and input to the controller 30. Also, a solenoid valve may be disposed between the operation device 26 that is the hydraulic operation lever, and the pilot port of each of the control valves. The solenoid valve is configured to operate in response to an electric signal from the controller 30. With this configuration, in response to manually operating the operation device 26 that is the hydraulic operation lever, the operation device 26 increases or decreases a pilot pressure in accordance with the amount of operation, thereby moving each of the control valves. Also, each of the control valves may be configured with a solenoid spool valve. In this case, the solenoid spool valve operates in response to an electric signal from the controller 30 corresponding to the amount of operation of the electric operation lever.

[0107] Next, a configuration example of the controller 30 will be described with reference to FIG. 5. FIG. 5 is a diagram illustrating the configuration example of the controller 30. In FIG. 5, the controller 30 is configured to: receive a signal that is output by the posture detection device, the operation device 26, the space recognition device 70, the direction detection device 71, the information input device 72, the position measurement device 73, the switch NS, or the like, or any combination thereof; perform various calculations; and output a control command to the solenoid valve 31, the display device D1, the sound output device D2, or the like, or any combination thereof. The posture detection device includes the boom angle sensor S1, the arm angle sensor S2, the bucket angle sensor S3, the machine tilt sensor S4, and the turning angular velocity sensor S5. The controller 30 includes a position calculation part 30A, a track generation part 30B, an automatic control part 30C, and a determination part 30D, as functional elements. Each of the functional elements may be composed of hardware, software, or a combination of hardware and software. The position calculation part 30A, the track generation part 30B, the automatic control part 30C, and the determination part 30D are separately illustrated for the sake of convenience. However, these parts do not need to be physically separated and may be composed entirely or partially of common software components, hardware components, or combinations thereof.

[0108] The position calculation part 30A is configured to calculate the position of the position measurement target. In the present embodiment, the position calculation part 30A calculates a coordinate point, in a reference coordinate system, of one or more predetermined portions of the attachment AT. In the illustrated example, the predetermined portion is a portion that can contact a slope when the upper turning body 3 is turned, e.g., a claw tip of the bucket 6. Specifically, the claw tip of the bucket 6 is a tip of the center-, left-, or right-claw of a plurality of claws attached to the tip of the bucket 6. Alternatively, the predetermined portion may be a single point or a plurality of points on a ridge (intersection line) between a back surface 6B and a side surface 6S of the bucket 6. That is, the predetermined portion may be a single point or a plurality of points on ridges between: the back surface 6B of the bucket 6; and a left side surface 6SL and a right side surface 6SR of the bucket 6. The origin of the reference coordinate system is, for example, the intersection between the turning axis and the ground surface in contact with the shovel 100. The ground surface in contact with the shovel 100 is, for example, an imaginary plane corresponding to the ground in contact with the lower traveling body 1. The reference coordinate system is, for example, an XYZ orthogonal coordinate system and has an X axis parallel to the front-back axis of the lower traveling body 1, a Y axis parallel to the left-right axis of the lower traveling body 1, and a Z axis parallel to the turning axis of the shovel 100. The position calculation part 30A calculates a coordinate point of the predetermined portion of the bucket 6, such as the claw tip or the like, for example, from the rotation angles of the boom 4, the arm 5, and the bucket 6. In this case, the position calculation part 30A may utilize an output of the machine tilt sensor S4, the turning angular velocity sensor S5, or both.

[0109] The track generation part 30B is configured to generate the target track that is a track to be followed by the predetermined portion of the attachment AT upon automatically operating the shovel 100. In the present embodiment, the track generation part 30B generates the target track to be used when the automatic control part 30C automatically operates the shovel 100. Specifically, the track generation part 30B generates the target track based on, for example, data in relation to a design surface stored in a storage device, such as a nonvolatile storage device or the like. The track generation part 30B may generate the target track based on information on geographical features around the shovel 100 that are recognized by the space recognition device 70. Alternatively, the track generation part 30B may derive information on the past track of the predetermined portion from the past output of the posture detection device stored in the storage device, and generate the target track based on that information. Alternatively, the track generation part 30B may generate the target track based on the current position of the predetermined portion of the attachment AT and data in relation to the design surface.

[0110] The automatic control part 30C is configured to automatically operate the shovel 100. In the present embodiment, the automatic control part 30C is configured to automatically operate the shovel 100 when a predetermined start condition is satisfied. Specifically, the automatic control part 30C is configured to assist the operator's manual operations of the shovel by automatically operating the actuators.

[0111] In the illustrated example, when the switch NS is pressed, the automatic control part 30C automatically turns the upper turning body 3 so as to cause the shovel 100 to face the slope. The recitation of "causing the shovel 100 to face the slope" means, for example, that the upper turning body 3 is turned about a turning axis 2X so that the back surface 6B of the bucket 6 and the slope (design surface) can be made parallel. However, when the shovel 100 is caused to face the slope, the back surface 6B of the bucket 6 and the slope (design surface) do not need to be parallel, as long as the back surface 6B of the bucket 6 and the slope (design surface) can be made parallel by moving the attachment after the shovel 100 is caused to face the slope.

[0112] The term "slope" is an artificial slanting surface formed by excavation or embankment, or the like, and may be a slanting surface before completion of construction (a slanting surface having a surface profile (irregularities, such as convex or concave surfaces) different from that of a design surface) or may be a slanting surface after completion of construction (a slanting surface having the same surface profile (irregularities) as that of a design surface). The slanting surface after completion of construction may be an imaginary slanting surface that has not yet been formed (hereinafter referred to as an "imaginary slanting surface").

[0113] In the illustrated example, the automatic control part 30C automatically operates the shovel 100 so that the predetermined portion of the attachment AT moves along the design surface when the arm operation lever is operated with the switch NS being pressed.

[0114] Specifically, the automatic control part 30C may automatically extend or contract the boom cylinder 7, the arm cylinder 8, the bucket cylinder 9, or any combination thereof such that the target track generated by the track generation part 30B coincides with the position of a predetermined point on the back surface 6B of the bucket 6 when the operator is manually performing the arm closing operation while pressing the switch NS. In this case, the target track is generated so as to be along the slope (design surface). Then, for example, simply by operating the left operation lever 26L in the arm closing direction, the operator can close the arm 5 while causing the back surface 6B of the bucket 6 to coincide with the design surface.

[0115] More specifically, the automatic control part 30C provides the solenoid valve 31 with a control command (electric current command) and individually adjusts the pilot pressure applied to the control valve corresponding to each actuator, and can automatically operate each actuator. For example, the automatic control part 30C can operate the boom cylinder 7, the bucket cylinder 9, or both regardless of whether or not the right operation lever 26R is tilted.

[0116] The determination part 30D is configured to perform various determinations. In the present embodiment, the determination part 30D is configured to determine whether or not the attachment AT and the slope contact each other upon turning of the upper turning body 3 with the current posture of the attachment AT being maintained in order to cause the shovel 100 to face the slope.

[0117] In the illustrated example, the determination part 30D is configured to determine whether or not the attachment AT and the slope contact each other during turning of the upper turning body 3, based on the position information of the slope and the posture of the attachment AT. The position information of the slope is obtained, for example, based on an output of the space recognition device 70 or design data stored in a storage device or received through a communication device. For example, the position information of an existing slanting surface (the slanting surface before completion of construction and the slanting surface after completion of construction) is obtained based on the output of the space recognition device 70, and the position information of the slanting surface after completion of construction (the existing slanting surface and the imaginary slanting surface) is obtained based on the design data stored in the storage device or received through the communication device.

[0118] Also, the determination part 30D may determine the following two separately from each other: whether or not the attachment AT and the existing slanting surface (the slanting surface before completion of construction) contact each other upon turning of the upper turning body 3 with the current posture of the attachment AT being maintained; and whether or not the attachment AT and the imaginary slanting surface after completion of construction contact each other upon turning of the upper turning body 3 with the current posture of the attachment AT being maintained.

[0119] In this case, when the determination part 30D determines that the attachment AT and the imaginary slanting surface after completion of construction do not contact each other even if the upper turning body 3 is turned with the current posture of the attachment AT being maintained, the controller 30 may be configured so as not to restrict the movement of the turning actuator even if the determination part 30D determines that the attachment AT and the slanting surface before completion of construction contact each other. That is, the controller 30 may enable continuation of turning without causing the automatic control part 30C to restrict the turning until the upper turning body 3 faces the imaginary slanting surface. In this case, the controller 30 continues the turning while causing a part of the attachment AT (bucket 6) to contact the slanting surface before completion of construction. This case typically occurs when the imaginary slanting surface (design surface) is buried in the slanting surface before completion of construction and is not exposed.

[0120] Also, even if the determination part 30D determines that the attachment AT and the imaginary slanting surface after completion of construction contact each other by turning the upper turning body 3 with the current posture of the attachment AT being maintained, the controller 30 may be configured so that the automatic control part 30C does not restrict the movement of the turning actuator when the determination part 30D determines that the attachment AT and the slanting surface before completion of construction do not contact each other. That is, the controller 30 may enable continuation of turning without causing the automatic control part 30C to restrict the turning until the upper turning body 3 faces the slanting surface before completion of construction. This case typically occurs when the imaginary slanting surface (design surface) is to be formed outward of the slanting surface before completion of construction, i.e., earth and sand is to be piled on the slanting surface before completion of construction.

[0121] Further, after identifying whether the turning direction is a leftward turning direction or a rightward turning direction, the determination part 30D may determine whether or not the attachment AT and the slope contact each other by turning the upper turning body 3 in the identified turning direction with the current posture of the attachment AT being maintained. For example, when determining whether or not the attachment AT and the slanting surface before completion of construction contact each other, a determination result may differ in accordance with the turning direction.

[0122] In this case, when the turning operation lever is operated, the determination part 30D identifies the turning direction based on the operation direction of the turning operation lever. When the turning operation lever is not operated, the determination part 30D may identify the turning direction based on the operation history of the operation device 26, the output of the position measurement device 73 (the current position of the shovel 100 with respect to the position of the slope to be constructed), the output of the space recognition device 70, or the like. For example, when the determination part 30D can determine, based on the operation history of the operation device 26, that the current state of the shovel 100 is a state after slope excavation (rough excavation), rightward turning, and discharging of earth and sand are performed, the determination part 30D can determine that there is a high probability that leftward turning will be performed next. In this case, the determination part 30D may determine whether or not the attachment AT and the slope contact each other when the upper turning body 3 is turned in the leftward turning direction with the current posture of the attachment AT being maintained.

[0123] Next, an example of a process executed by the controller 30 for determining whether or not the attachment AT and a slope SF contact each other upon turning of the upper turning body 3 with the current posture of the attachment AT being maintained (hereinafter this process is referred to as a "contact determination process") will be described with reference to FIG. 6 and FIG. 7. FIG. 6 is a flowchart illustrating an example of a flow of the contact determination process. In the illustrated example, the controller 30 repeatedly executes the contact determination process at predetermined control intervals during operation of the shovel 100. FIG. 7 is a top view of the shovel 100 that performs slope shaping (slope finishing). Specifically, FIG. 7 illustrates a state of the shovel 100 after performing the slope shaping (slope finishing) and the discharging of earth and sand following the rightward turning. The slope SF as illustrated in FIG. 7 is a slanting surface before completion of construction having a surface profile (irregularities) different from that of a design surface DS, and the design surface DS is currently buried in the slope SF and is not exposed.

[0124] First, the determination part 30D of the controller 30 determines whether or not a predetermined determination start condition is satisfied (step ST1). The predetermined determination start condition is, for example, "the switch NS is pressed", "the left operation lever 26L is operated", "the left operation lever 26L is operated with the switch NS being pressed", or the like. In the illustrated example, the predetermined determination start condition is "the switch NS is pressed".

[0125] When it is determined that the predetermined determination start condition is not satisfied (NO in step ST1), the determination part 30D ends the current contact determination process. Meanwhile, when it is determined that the predetermined determination start condition is satisfied (YES in step ST1), the determination part 30D determines whether or not the attachment AT and the slope SF contact each other (step ST2).

[0126] In the illustrated example, when the switch NS is pressed, the determination part 30D determines that the predetermined determination start condition is satisfied, and determines whether or not the attachment AT and the slope SF contact each other upon turning with the current posture of the attachment AT being maintained.

[0127] Specifically, the determination part 30D identifies the posture of the attachment AT based on the output of the posture detection device, and obtains coordinates of a plurality of predetermined points in the attachment AT. A point GP as illustrated in FIG. 7 is one of the plurality of predetermined points (one point on the ridge between the back surface 6B and the left side surface 6SL of the bucket 6). Then, the determination part 30D calculates a track TR to be followed by the point GP when the turning is performed with the current posture of the attachment AT being maintained. The track TR corresponds to a part (arc) of a circumference CF of a circle having a center on the turning axis 2X and passing through the point GP.

[0128] In the illustrated example, the determination part 30D calculates the track TR to be followed by the point GP when the leftward turning is performed with the current posture of the attachment AT being maintained, and does not calculate a track to be followed by the point GP when the rightward turning is performed with the current posture of the attachment AT being maintained. Therefore, the track TR is an arc that has a start point at a coordinate GP0 of the current point GP, extends in the leftward turning direction along the circumference CF, and has an end point at a coordinate GP2 of the point GP when the upper turning body 3 is caused to face the slope SF. The determination part 30D can determine that there is a high probability that the leftward turning will be performed rather than the rightward turning in view of, for example, the relative positional relationship between the shovel 100 and the slope SF. However, the track TR may include a track to be followed by the point GP when the rightward turning is performed with the current posture of the attachment AT being maintained.

[0129] Subsequently, the determination part 30D determines whether or not the slope SF and the track TR intersect with each other. The slope SF may be a three-dimensional model of the surface of the design surface DS as an imaginary plane or may be a three-dimensional model of the surface of the existing slope SF generated based on the output of the space recognition device 70. In the illustrated example, the slope SF is a three-dimensional model of the surface of the design surface DS.

[0130] When the determination part 30D determines that the slope SF and the track TR intersect with each other, the determination part 30D determines that the attachment AT and the slope SF contact each other. When the determination part 30D determines that the slope SF and the track TR do not intersect with each other, the determination part 30D determines that the attachment AT and the slope SF do not contact each other.

[0131] In the illustrated example, the determination part 30D determines that the attachment AT and the slope SF contact each other when determining that the slope SF and the track TR intersect with each other. Specifically, the determination part 30D determines that a coordinate GP1 of the point GP is positioned on the design surface DS when the upper turning body 3 is turned leftward about the turning axis 2X by an angle of $\beta 1$. The angle $\beta 1$ is a value of a turning angle β and is an angle between: a dashed line CX0 indicating the position of a front-back axis CX of the current upper turning body 3; and a dashed line CX1 indicating the position of the front-back axis CX of the leftward-turned upper turning body 3, in a top view along the turning axis 2X.

[0132] Thus, in the illustrated example, the determination part 30D determines whether or not the attachment AT and the slope SF contact each other by determining whether or not the track TR extending to the end point (the coordinate GP2) and the three-dimensional model of the surface of the design surface DS intersect with each other. The coordinate GP2 is a coordinate of the point GP when the upper turning body 3 is caused to face the slope SF, i.e., a coordinate of the point GP when the turning angle β becomes an angle βt. The angle βt is a value of the turning angle β and is an angle between: the dashed line CX0 indicating the position of the front-back axis CX of the current upper turning body 3; and the dashed line CX2 indicating the position of the front-back axis CX of the upper turning body 3 that is caused to face the slope SF.

[0133] However, the determination part 30D may be configured to determine whether or not the attachment AT and the slope SF contact each other using the track TR that is shorter. That is, the end point of the track TR may be a coordinate of the point GP when the upper turning body 3 is turned by an angle smaller than the angle βt. For example, if the end point of the track TR is a coordinate of the point GP when the upper turning body 3 is turned by an angle smaller than the angle $\beta 1$, the determination part 30D determines that the slope SF and the track TR do not intersect with each other, and then can determine that the attachment AT and the slope SF do not contact each other. In this case, the determination part 30D can determine that the attachment AT and the slope SF contact each other when the distance between the point GP and the slope SF becomes smaller after start of leftward turning of the upper turning body 3, i.e., at a later timing.

[0134] In the illustrated example, the determination part 30D determines whether or not the attachment AT and the slope SF contact each other using the track TR that extends along the circumference CF. However, the determination part 30D may be configured to determine whether or not the attachment AT and the slope SF contact each other using a guide line GL that extends perpendicularly to the front-back axis CX of the upper turning body 3 in the top view and passes through the point GP. Specifically, the determination part 30D may be configured to determine whether or not the attachment AT and the slope SF contact each other based on whether or not the guide line GL, extending by a predetermined distance from the point GP in parallel to the left-right axis of the upper turning body 3, and the slope SF (e.g., a three-dimensional model of the surface of the design surface DS) intersect with each other. When the guide line GL is used, typically, the determination part 30D can delay the timing of determining that the attachment AT and the slope SF contact each other, compared to when the track TR is used. In FIG. 7, the guide line GL, denoted by a chain line, is generated so as to extend leftward by a predetermined distance from the point GP. However, the guide line GL may be generated so as to extend rightward.

[0135] For ease of understanding, FIG. 7 illustrates an example in which the track TR of the point GP, one of the plurality of predetermined points, is generated. However, in practice, the track TR of each of the plurality of predetermined points is generated, and the determination part 30D determines whether or not the attachment AT and the slope SF contact each other based on whether or not the slope SF and each of the tracks TR intersect with each other. The same applies to the guide line GL.

[0136] When the determination part 30D determines that the attachment AT and the slope SF do not contact each other (NO in step ST2), the determination part 30D ends the current contact determination process. In this case, because the switch NS is pressed, the automatic control part 30C of the controller 30 may automatically turn the upper turning body 3 so as to cause the shovel 100 to face the slope SF, regardless of whether or not the turning operation lever is operated.

[0137] Meanwhile, when the determination part 30D determines that the attachment AT and the slope SF contact each other (YES in step ST2), the controller 30 executes a predetermined function (step ST3).

[0138] The predetermined function includes a function of automatically controlling the turning actuator, a function of informing the operator of the current state, or the like, or any combination thereof.

[0139] The function of automatically controlling the turning actuator is, for example, a function of automatically controlling a turning actuator configured to turn the upper turning body 3 so that the attachment AT and the slope SF do not contact each other during the turning of the upper turning body 3.

[0140] Specifically, in the example as illustrated in FIG. 7, the controller 30 prevents an increase in the pilot pressure applied to the left pilot port of the control valve 173 so as not to turn the upper turning body 3 in the leftward turning direction even if the turning operation lever is operated in the leftward turning direction.

[0141] Alternatively, in the example as illustrated in FIG. 7, the controller 30 reduces the pilot pressure applied to the left pilot port of the control valve 173 so as to decelerate or stop the leftward turning of the upper turning body 3 when the turning operation lever is already operated in the leftward turning direction and the upper turning body 3 is turning leftward.

[0142] When the controller 30 executes the function of automatically controlling the turning actuator, the controller 30 may operate the display device D1, the sound output device D2, or both so as to inform the operator that the function of automatically controlling the turning actuator has been executed. For example, when the controller 30 prohibits the turning of the upper turning body 3, the controller 30 may cause the display device D1 to display a text message saying, "Turning is prohibited because the bucket may hit the slope." In this case, the operator can know the reason why the leftward turning cannot be executed even by operating the turning operation lever, and does not get upset in the situation in which the leftward turning cannot be executed even by operating the turning operation lever. Similarly, when the controller 30 stops the turning of the upper turning body 3, the controller 30 may cause the sound output device D2 to output a voice message saying, "Turning is stopped because the bucket may hit the slope".

[0143] The function of informing the operator of the current situation is, for example, a function of informing the operator that the attachment AT and the slope SF may contact each other if the upper turning body 3 is turned with the current posture of the attachment AT being maintained.

[0144] Specifically, in the example as illustrated in FIG. 7, the controller 30 may cause the display device D1, the sound output device D2, or both to output a message saying, "The bucket and the slope may contact each other by performing the leftward turning".

[0145] Next, a process in which the controller 30 stops the turning by automatic control will be described with reference to FIG. 8 and FIG. 9. FIG. 8 is a perspective view of the shovel 100 in which the turning is stopped by automatic control. FIG. 9 is a top view of the shovel 100 in which the turning is to be stopped by automatic control.

[0146] In FIG. 8 and FIG. 9, a range NR denotes a range in which the slope (up-slope) is not completed, i.e., the ground surface does not coincide with the design surface, and a range CS denotes a range in which the slope (up-slope) is completed, i.e., the ground surface coincides with the design surface.

[0147] FIG. 8 and FIG. 9 illustrate the shovel 100 that performs slope shaping. The slope shaping includes: excavation in which earth and sand on a slanting surface is scraped with the bucket 6; and discharging of earth and sand in which earth and sand gathered in the bucket 6 at the time of excavation is discharged to another place. Specifically, FIG. 9 illustrates a state of the shovel 100 when the discharging of earth and sand is completed, which is represented as a shovel 100A drawn with a dashed line. Further, FIG. 9 illustrates a state of the shovel 100 that is caused to face the slanting surface (slope) in order to perform next excavation, which is represented as a shovel 100C drawn with a chain line.

[0148] Further, in the example as illustrated in FIG. 9, the shovel 100 does not actually reach a state represented as the shovel 100C, because the turning is stopped in a state represented as the shovel 100B drawn with a solid line.

[0149] In FIG. 9, an arrow AR denotes the turning of the upper turning body 3 from the state of the shovel 100 at the completion of the discharging of earth and sand, which is represented by the shovel 100A, to the state of the shovel 100 caused to face the slanting surface (slope), which is represented by the shovel 100C. This turning is implemented by tilting the left operation lever 26L in the leftward turning direction (leftward direction) with the switch NS being pressed. A radius of the turning at this time corresponds to a working radius R1.

[0150] FIG. 9 illustrates the state of the shovel 100 in which the turning is stopped by automatic control, as the shovel 100B drawn with the solid line. The shovel 100 as illustrated in FIG. 8 corresponds to the shovel 100B.

[0151] In FIG. 9, a dashed line L0 denotes the front-back axis of the upper turning body 3 of the shovel 100 (shovel 100A) that completes the discharging of earth and sand, a dashed line L2 denotes the front-back axis of the upper turning body 3 of the shovel 100 (shovel 100B) in which the turning is stopped by automatic control, and a dashed line L4 denotes the front-back axis of the upper turning body 3 of the shovel 100 (shovel 100C) that is caused to face the slanting surface (slope) as a design surface. In FIG. 9, a dashed line L1 denotes the front-back axis of the upper turning body 3 in which the deceleration of the turning is started by automatic control, and a dashed line L3 denotes the front-back axis of the upper turning body 3 in which the predetermined portion of the attachment AT contacts the slanting surface when the turning is continued without applying the automatic control and without stopping the turning. A portion near the end of the arrow AR is illustrated by a dotted line to express that the turning is decelerated. The dashed line L3 (the front-back axis of the upper turning body 3 in which the predetermined portion of the attachment AT contacts the slope) is calculated, for example, based on the coordinate of the predetermined portion of the bucket 6 when the front-back axis of the upper turning body 3 is at the position denoted by the dashed line L1. Therefore, when the height of the bucket 6 (or the posture of the attachment AT) and the radius of the turning change during the turning after the front-back axis of the upper turning body 3 reaches the position denoted by the dashed line L1, the position at which the bucket 6 and the design surface contact each other (the position of a point P3) and the angle between the dashed line L3 and a reference line change. The reference line is, for example, a line corresponding to the front-back axis of the lower traveling body 1 in a top view along the turning axis 2X.

[0152] For example, the controller 30 calculates the track TR to be followed by the predetermined portion of the attachment AT (in this example, a predetermined point of the bucket 6) when the left operation lever 26L (turning operation lever) is operated with the switch NS being pressed. This track TR is calculated based on information on the position of the upper turning body 3 output by the position measurement device 73, information on the posture of the attachment AT output by the posture detection device, and the like.

[0153] When the turning is started or continued, the controller 30 determines whether or not the bucket 6 contacts the design surface, i.e., whether or not the bucket 6 enters the slanting surface beyond the design surface, before the shovel 100 faces the slanting surface (slope). Specifically, the controller 30 determines whether or not the track TR, to be followed by the predetermined point of the bucket 6, and the design surface intersect with each other.

[0154] This determination is based on, for example, data in relation to the design surface stored in the storage device, information on the position of the upper turning body 3 output by the position measurement device 73, and information on the posture of the attachment AT output by the posture detection device. The controller 30 may determine whether or not the bucket 6 contacts the design surface based on information output by the space recognition device 70.

[0155] When the controller 30 determines that the bucket 6 contacts the design surface, the controller 30 stops the turning when a predetermined condition is satisfied. The predetermined condition is, for example, whether or not the distance (hereinafter referred to as a "current distance") between the current position of the predetermined point of the bucket 6 and a contact point (see the point P3) becomes shorter than a predetermined distance. The contact point corresponds to an estimated position of the predetermined point of the bucket 6 when the bucket 6 contacts the design surface before the shovel 100 faces the slanting surface (slope) when the turning is continued. In the example as illustrated in FIG. 9, the current distance is the distance along the track TR. However, the current distance may be, for example, a straight-line distance between the current position of the predetermined point of the bucket 6 and the contact point.

[0156] Even if the controller 30 decelerates or stops the turning, when a turning operation is subsequently performed for turning in a turning direction opposite to the turning direction before the predetermined condition is satisfied, the controller 30 may permit the turning in response to the subsequently performed turning operation. For example, even if the controller 30 determines that the predetermined condition is satisfied, and decelerates or stops the leftward turning by outputting a control command (electric current command) to the solenoid valve 31DL (see FIG. 4D), when the right turning operation is subsequently performed, the controller 30 may turn the upper turning body 3 rightward by outputting a control command (electric current command) to the solenoid valve 31DR (see FIG. 4D) in response to the subsequently performed right turning operation. That is, the controller 30 may be configured so as not to restrict or prohibit the turning for moving the bucket 6 away from the slanting surface (slope). Specifically, when the controller 30 decelerates or stops the leftward turning, for example, the controller 30 outputs a control command (electric current command) to the solenoid valve 31DL regardless of the amount of operation of the turning operation lever in the leftward turning direction, thereby reducing the pilot pressure applied to the left pilot port of the control valve 173. Also, for example, when the controller 30 permits rightward turning, the controller 30 outputs a control command (electric current command) to the solenoid valve 31DR in accordance with the amount of operation of the turning operation lever in the rightward turning direction, thereby increasing or decreasing the pilot pressure applied to the right pilot port of the control valve 173. Conversely, when the controller 30 prohibits rightward turning, the controller 30 does not output a control command (electric current command) to the solenoid valve 31DR regardless of the amount of operation of the turning operation lever in the rightward turning direction, thereby eliminating the pilot pressure applied to the right pilot port of the control valve 173. That is, the controller 30 makes the pilot pressure applied to the right pilot port of the control valve 173 the same as the pilot pressure applied to the left pilot port of the control valve 173, and returns the control valve 173 to the neutral position. Also, the controller 30 may be configured so as not to restrict or prohibit operations other than the turning operation, such as the boom raising operation and the like. Specifically, when the controller 30 permits boom raising, for example, the controller 30 outputs a control command (electric current command) to the solenoid valve 31BL in accordance with the amount of operation of the boom operation lever in the boom raising direction, thereby increasing or decreasing the pilot pressure applied to the right pilot port of the control valve 175L and the pilot pressure applied to the left pilot port of the control valve 175R. Conversely, when the controller 30 prohibits boom raising, the controller 30 does not output a control command (electric current command) to the solenoid valve 31BL regardless of the amount of operation of the boom operation lever in the boom raising direction, thereby eliminating both the pilot pressure applied to the right pilot port of the control valve 175L and the pilot pressure applied to the left pilot port of the control valve 175R. That is, the controller 30 makes the pilot pressure applied to the right pilot port of the control valve 175L the same as the pilot pressure applied to the left pilot port of the control valve 175L, and returns the control valve 175L to the neutral position. Also, the controller 30 makes the pilot pressure applied to the left pilot port of the control valve 175R the same as the pilot pressure applied to the right pilot port of the control valve 175R, and returns the control valve 175R to the neutral position.

[0157] The controller 30 may be configured so as not to stop the turning by automatic control when the switch NS is not pressed even if the predetermined condition is satisfied. This is because the operator can intentionally cause the bucket 6 to contact the slanting surface (slope). That is, the operator can cause the bucket 6 to contact the slanting surface (slope) by performing the turning operation without pressing the switch NS.

[0158] Even if the controller 30 decelerates or stops the turning, when the turning operation lever is returned to the neutral position and then the same turning operation is resumed, the controller 30 may permit the turning in response to the resumed turning operation. For example, even if the controller 30 determines that the predetermined condition is satisfied and decelerates or stops the leftward turning, when the turning operation lever is returned to the neutral position and then the left turning operation is performed again, the controller 30 may permit leftward turning in response to the left turning operation. In this case, even if the operator executes the turning operation while pressing the switch NS, the operator can cause the bucket 6 to contact the slanting surface (slope).

[0159] In the example as illustrated in FIG. 9, the controller 30 calculates the coordinate of the predetermined portion of the bucket 6 at predetermined control intervals during turning. Based on the coordinate of the predetermined portion of the bucket 6 calculated during turning, the controller 30 calculates a distance from the predetermined portion of the bucket 6 to the design surface (the distance along the track TR, not the straight-line distance) at predetermined control intervals. The controller 30 compares the distance from the predetermined portion of the bucket 6 to the design surface at predetermined control intervals with each of predetermined distances X1 and X2. When the current distance becomes below the distance X1, the controller 30 starts to decelerate the turning of the upper turning body 3. Specifically, the controller 30 decelerates the turning of the upper turning body 3 at a predetermined deceleration rate. The predetermined deceleration rate may be unchanged or variable. Then, the controller 30 stops the turning of the upper turning body 3 when the current distance becomes the distance X2 (shorter than the distance X1). A point P1 in FIG. 9 denotes a position of the predetermined portion when the deceleration of the turning is started. A point P2 in FIG. 8 and FIG. 9 denotes a position of the predetermined portion when the turning is stopped. The point P3 in FIG. 8 and FIG. 9 denotes an estimated position of the predetermined portion, i.e., an estimated position of the contact point, when the bucket 6 and the design surface contact each other when the turning is continued without stopping the turning by automatic control. Specifically, the estimated position of the contact point corresponds to a position of the intersection point between the track TR, to be followed by the predetermined point of the bucket 6, and the design surface when the turning is continued.

[0160] In the example as illustrated in FIG. 9, the controller 30 is configured such that the distance X1 as a threshold varies as the working radius R1 varies. Specifically, the distance X1 is set such that the larger the working radius R1, the larger the distance X1 becomes. This is because the larger the working radius R1, the larger the moment of inertia of the attachment AT, making it challenging to stop the turning. For the same reason, the controller 30 may be configured such that the distance X2 as a threshold varies as the working radius R1 varies. However, the controller 30 may be configured such that the distance X1 is constant independently of the working radius R1.

[0161] Alternatively, the controller 30 may be configured such that the distance X1 as a threshold varies with change in the posture of the attachment AT. For example, the distance X1 may be set such that the larger the boom angle $\theta 1$, the smaller the distance X1 becomes, and the smaller the arm angle $\theta 2$, the smaller the distance X1 becomes.

[0162] Alternatively, the controller 30 may be configured such that the distance X1 as a threshold varies with change in the turning velocity. For example, the distance X1 may be set such that the larger the turning velocity, the larger the distance X1 becomes.

[0163] When the turning velocity of the upper turning body 3 is equal to or less than a predetermined velocity, the controller 30 may stop the upper turning body 3 without decelerating the upper turning body 3, instead of decelerating the turning of the upper turning body 3 and then stopping the upper turning body 3.

[0164] Also, the predetermined condition may be, for example, whether or not the angle formed between the front-back axis of the current upper turning body 3 and the front-back axis (the dashed line L3) of the upper turning body 3 when the predetermined portion of the attachment AT and the slanting surface contact each other becomes lower than a predetermined angle.

[0165] When the controller 30 determines that the bucket 6 does not contact the design surface, the controller 30 may be configured to stop the turning of the upper turning body 3 by automatic control such that the turning of the upper turning body 3 is stopped when the upper turning body 3 faces the slanting surface (slope). Thereby, when the controller

30 determines that the bucket 6 does not contact the design surface, the operator of the shovel 100 can cause the shovel 100 to face the slanting surface (slope) simply by continuing to tilt the left operation lever 26L in the leftward turning direction in a desired amount of operation without worrying about the contact between the bucket 6 and the design surface. Regardless of the determination result as to whether or not the bucket 6 contacts the design surface, the turning operation of the upper turning body 3 is properly stopped.

[0166] With the above-described configuration, the controller 30 gradually stops the turning rather than suddenly stopping the turning when the predetermined condition is satisfied. Thus, it is possible to suppress the operator of the shovel 100 from feeling some discomfort.

[0167] The controller 30 is also configured to automatically stop the turning independently of the amount of operation of the left operation lever 26L in order to avoid contact between the bucket 6 and the design surface. That is, even when the left operation lever 26L is tilted in the leftward turning direction by the operator of the shovel 100, the controller 30 can automatically stop the left turning operation.

[0168] In the example as illustrated in FIG. 9, the controller 30 automatically stops the turning in order to avoid contact between the bucket 6 and the design surface, but does not automatically stop other movements. For example, when the predetermined condition is satisfied while the operator of the shovel 100 is performing a combined operation including the left turning operation and the arm opening or closing operation, the controller 30 automatically stops the leftward turning but does not automatically stop the movements other than the leftward turning. In the illustrated example, the movements other than the leftward turning are movements for moving the back surface of the bucket 6 along the design surface (attachment movements) and include boom raising, boom lowering, arm closing, arm opening, bucket closing, bucket opening, or any combination thereof.

[0169] As described above, the shovel 100 according to the embodiment of the present disclosure includes: as illustrated in FIG. 1, the lower traveling body 1; the upper turning body 3 turnably mounted on the lower traveling body 1; the attachment AT that is attached to the upper turning body 3; the posture detection device configured to detect the posture of the attachment AT; and the controller 30 as the control device configured to determine, based on the position information of the slope SF and the posture of the attachment AT, whether or not the attachment AT and the slope SF (see FIG. 7) contact each other during turning of the upper turning body 3.

[0170] With this configuration, the operator of the shovel 100 can know in advance that the attachment AT and the slope SF may contact each other upon turning of the upper turning body 3. Therefore, for example, the operator can prevent contact between the attachment AT and the slope SF upon turning of the upper turning body 3. This configuration can reduce, for example, the operator's burden during a series of slope shaping steps including slope shaping, rightward turning, discharging of earth and sand, and leftward turning that are repeatedly executed in this order, and hence can produce the effect of increasing work efficiency. Alternatively, the operator can turn the upper turning body 3 after knowing in advance that there is a high probability that the attachment AT and the slope SF will contact each other upon turning of the upper turning body 3, and can cause the attachment AT to contact the slope SF, if necessary.

[0171] Further, in the shovel 100, when it is determined that the attachment AT and the slope contact each other during turning of the upper turning body 3, the controller 30 may be configured to control the turning actuator configured to turn the upper turning body 3 so that the attachment AT and the slope do not contact each other during turning of the upper turning body 3. The turning actuator is the turning hydraulic motor 2A, the turning motor generator, or the like.

[0172] In this configuration, in order to avoid contact between the attachment AT and the slope during turning of the upper turning body 3, the controller 30 can control the turning actuator so that turning does not start even if the turning operation lever is operated by an operator. Alternatively, in order to avoid contact between the attachment AT and the slope during turning of the upper turning body 3, the controller 30 can control the turning actuator so that turning stops. With this configuration, the shovel 100 can more reliably suppress contact between the attachment AT and the slope during turning of the upper turning body 3.

[0173] Also, in the shovel 100, the controller 30 may be configured to repeatedly determine whether or not the attachment AT and the slope contact each other during turning of the upper turning body 3 while a predetermined operation tool, such as the switch NS or the like, is being operated. For example, even if the turning operation lever is not operated, when the switch NS is pressed, the controller 30 may be configured to determine whether or not the attachment AT and the slope contact each other upon turning of the upper turning body 3 with the current posture of the attachment AT being maintained.

[0174] With this configuration, the operator of the shovel 100 can know in advance that the attachment AT and the slope SF (see FIG. 7) may contact each other upon turning of the upper turning body 3 simply by operating the operation tool. Therefore, for example, the operator can more reliably prevent contact between the attachment AT and the slope SF (see FIG. 7) upon turning of the upper turning body 3.

[0175] In the shovel 100, the controller 30 may be configured to move the predetermined portion of the bucket 6 along the slope in response to the operator's operation of the operation device 26 configured to operate the attachment AT during turning of the upper turning body 3. For example, the controller 30 may be configured to move the bucket 6 along the design surface while causing the back surface 6B of the bucket 6 to contact the slope. The controller 30 may be configured to move the bucket 6 along the design surface with a predetermined gap, i.e., without causing the back surface 6B of the bucket 6 to contact the slope.

[0176] In this configuration, for example, the operator of the shovel 100 can extend or contract the boom cylinder 7, the arm cylinder 8, the bucket cylinder 9, or any combination thereof while turning the upper turning body 3, simply by operating the left operation lever 26L serving as the turning operation lever and the arm operation lever. Therefore, for example, the operator can move the bucket 6 along the design surface DS in leftward and rightward directions or diagonal directions as well as in forward and backward directions (a direction along a line segment connecting the shoulder and the foot of the slope) with the back surface of the bucket 6 coinciding with the design surface DS.

[0177] Further, in the shovel 100, the controller 30 may be configured to stop the turning actuator configured to turn the upper turning body 3 when the upper turning body 3 faces the slope after moving the bucket 6 along the design surface DS.

[0178] In this configuration, for example, the operator of the shovel 100 can move the bucket 6 along the design surface DS with the back surface of the bucket 6 and the design surface DS coinciding with each other, simply by operating the left operation lever 26L serving as the turning operation lever and the arm operation lever. After the upper turning body 3 faces the slope, it is possible to stop the turning and continue the movement of the bucket 6 along the design surface DS in the forward and backward directions (the direction along the line segment connecting the shoulder and the foot of the slope).

[0179] Further, in the shovel 100, when the upper turning body 3 faces the slope after moving the bucket 6 along the design surface DS, the controller 30 may stop the turning actuator configured to turn the upper turning body 3 and stop the attachment actuator configured to move the attachment AT. Specifically, the controller 30 may stop the turning actuator and the attachment actuator, or may stop all of the actuators.

[0180] In this configuration, for example, the operator of the shovel 100 can move the bucket 6 along the design surface DS with the back surface of the bucket 6 coinciding with the design surface DS simply by operating the left operation lever 26L serving as the turning operation lever and the arm operation lever, and then can stop the turning and the attachment movements when the upper turning body 3 faces the slope.

[0181] Also, in the shovel 100, the controller 30 may be configured to inform the operator that the turning actuator has been controlled so that the attachment AT and the slope do not contact each other during turning of the upper turning body 3. In this case, the controller 30 may be configured to output a control command to the display device D1 so as to display a text message, or may be configured to output a control command to the sound output device D2 to output a voice message.

[0182] With this configuration, for example, the shovel 100 can inform the operator of the reason why the turning is not performed as operated using the turning operation lever, and it is possible to suppress the operator, facing the situation in which the turning is not performed as operated using the turning operation lever, from feeling some discomfort.

[0183] As illustrated in FIG. 1, the shovel according to the embodiment of the present disclosure may include: the lower traveling body 1; the upper turning body 3 turnably mounted on the lower traveling body 1; the attachment AT attached to the upper turning body 3; the posture detection device configured to detect the posture of the attachment AT; and the controller 30 as a control device configured to calculate the track TR drawn by the predetermined portion of the attachment AT upon turning of the upper turning body 3, or an approximate straight line thereof. The approximate straight line is, for example, the guide line GL as illustrated in FIG. 7.

[0184] With this configuration, for example, the shovel 100 can determine whether or not an object exists on the track TR drawn by the predetermined portion of the attachment AT before performing the turning operation. The object is, for example, a person, an embankment, a slope, a work machine, or the like. Therefore, the shovel 100 can inform the operator of whether or not the predetermined portion of the attachment AT and the object may contact each other before performing the turning operation.

[0185] The embodiments of the present invention have been described above in detail. However, the present invention is not limited to the above-described embodiments and is not limited to the below-described embodiment. Various modifications, substitutions, or the like are possible in the above- and below-described embodiments without departing from the scope of the present invention. In addition, the features described separately may be combined as long as no technical contradiction arises.

[0186] For example, the shovel 100 may be a remotely operated shovel. In this case, the electric operation lever may be disposed in a remote control room located externally of the shovel 100, and the controller 30 may be a control device located in the remote control room.

REFERENCE SIGNS LIST

[0187]

1	Lower Traveling Body

1C	Crawler
1CL	Left Crawler
1CR	Right Crawler
2	Turning Mechanism
2A	Turning Hydraulic Motor
2M	Traveling Hydraulic Motor
2ML	Left Traveling Hydraulic Motor
2MR	Right Traveling Hydraulic Motor
2X	Turning Axis
3	Upper Turning Body
4	Boom
5	Arm
6	Bucket
6B	Back Surface
6S	Side Surface
6SL	Left Side Surface
6SR	Right Side Surface
7	Boom Cylinder
8	Arm Cylinder
9	Bucket Cylinder
10	Cab
11	Engine
13	Regulator
14	Main Pump
15	Pilot Pump
17	Control Valve Unit
18	Restrictor
19	Control Pressure Sensor
26	Operation Device
26D	Traveling Lever
26DL	Left Traveling Lever
26DR	Right Traveling Lever
26L	Left Operation Lever
26R	Right Operation Lever
28	Discharge Pressure Sensor
29,29DL,29DR,29LA,29LB,29RA,29RB	Operation Sensor
29A	Operation Sensor
30	Controller
30A	Position Calculation Part
30B	Track Generation Part
30C	Automatic Control Part
30D	Determination Part
31,31AL-31DL,31AR-31DR	Solenoid Valve
40	Center Bypass Conduit
42	Parallel Conduit
70	Space Recognition Device
70F	Front Sensor
70B	Back Sensor
70L	Left Sensor
70R	Right Sensor
71	Direction Detection Device
72	Information Input Device
73	Position Measurement Device
100	Shovel
171-176	Control Valve
AT	Attachment
CF	Circumference
CS	Range

CX	Front-Back Axis
CX0-CX2	Dashed Line
D1	Display Device
D2	Sound Output Device
DS	Design Surface
GL	Guide Line
GP	Point
GP0-GP2	Coordinate
NR	Range
NS	Switch
P1-P3	Point
S1	Boom Angle Sensor
S2	Arm Angle Sensor
S3	Bucket Angle Sensor
S4	Machine Tilt Sensor
S5	Turning Angular Velocity Sensor
SF	Slope
TR	Track

Claims

1. A shovel, comprising:

a lower traveling body;
an upper turning body that is turnably mounted on the lower traveling body;
an attachment that is attached to the upper turning body;
a posture detection device configured to detect a posture of the attachment; and
a control device configured to determine, based on position information of a slope and a posture of the attachment, whether or not the attachment and the slope contact each other during turning of the upper turning body.

2. The shovel according to claim 1, wherein
upon determining that the attachment and the slope contact each other during the turning of the upper turning body, the control device is configured to control a turning actuator such that the attachment and the slope do not contact each other during the turning of the upper turning body, the turning actuator being configured to turn the upper turning body.

3. The shovel according to claim 1, wherein
the control device is configured to determine whether or not the attachment and the slope contact each other during the turning of the upper turning body while a predetermined operation tool is being operated.

4. The shovel according to claim 1, wherein
during the turning of the upper turning body, the control device is configured to move a predetermined portion of a bucket along the slope in response to an operation by an operator on an operation device configured to operate the attachment, the bucket being included in the attachment.

5. The shovel according to claim 4, wherein
upon the upper turning body facing the slope, the control device is configured to stop a turning actuator configured to turn the upper turning body.

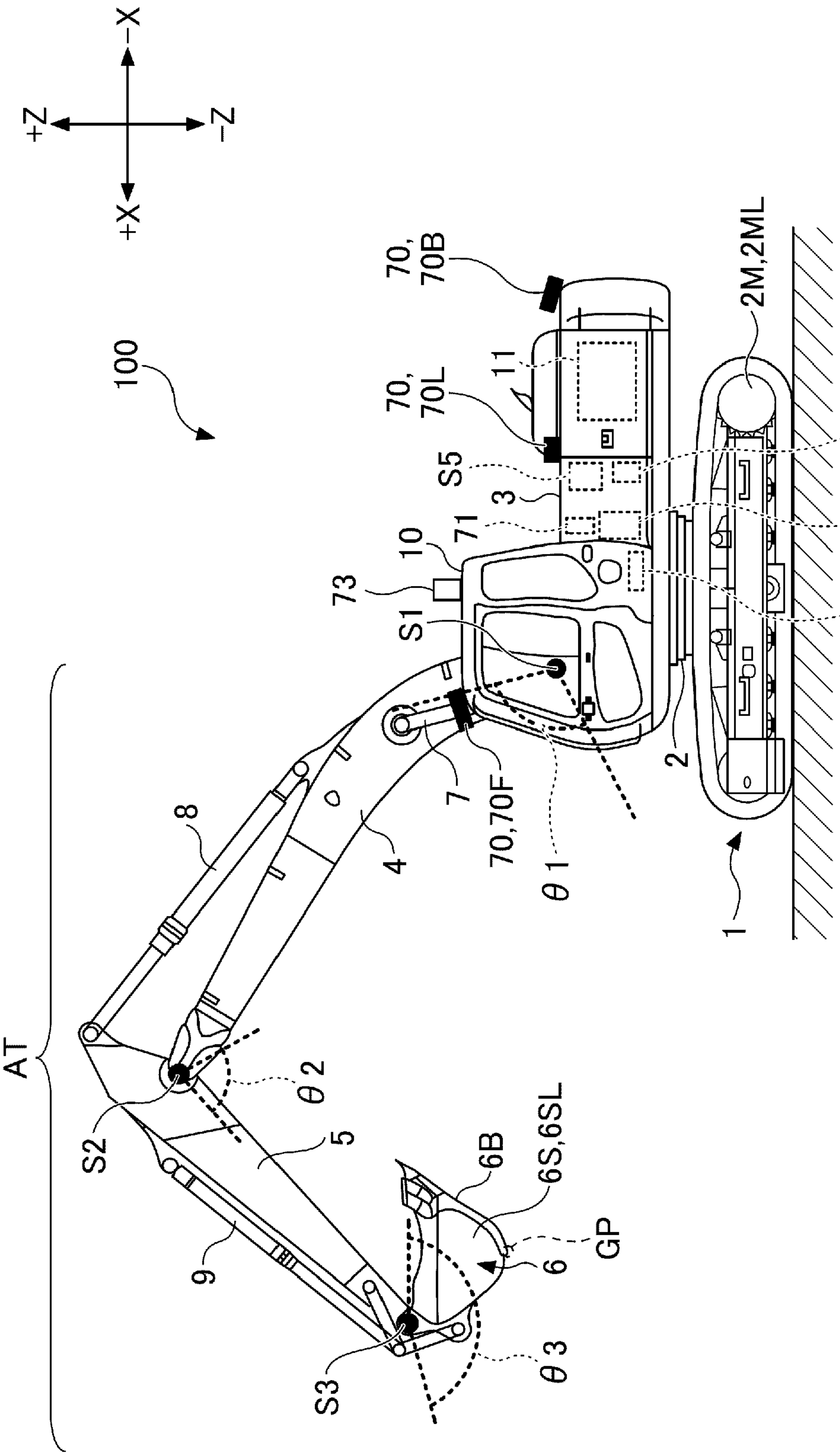
6. The shovel according to claim 5, wherein
upon the upper turning body facing the slope, the control device is configured to stop an attachment actuator configured to move the attachment.

7. The shovel according to claim 2, wherein
the control device is configured to inform an operator that the turning actuator is controlled such that the attachment and the slope do not contact each other during the turning of the upper turning body.

8. A shovel, comprising:

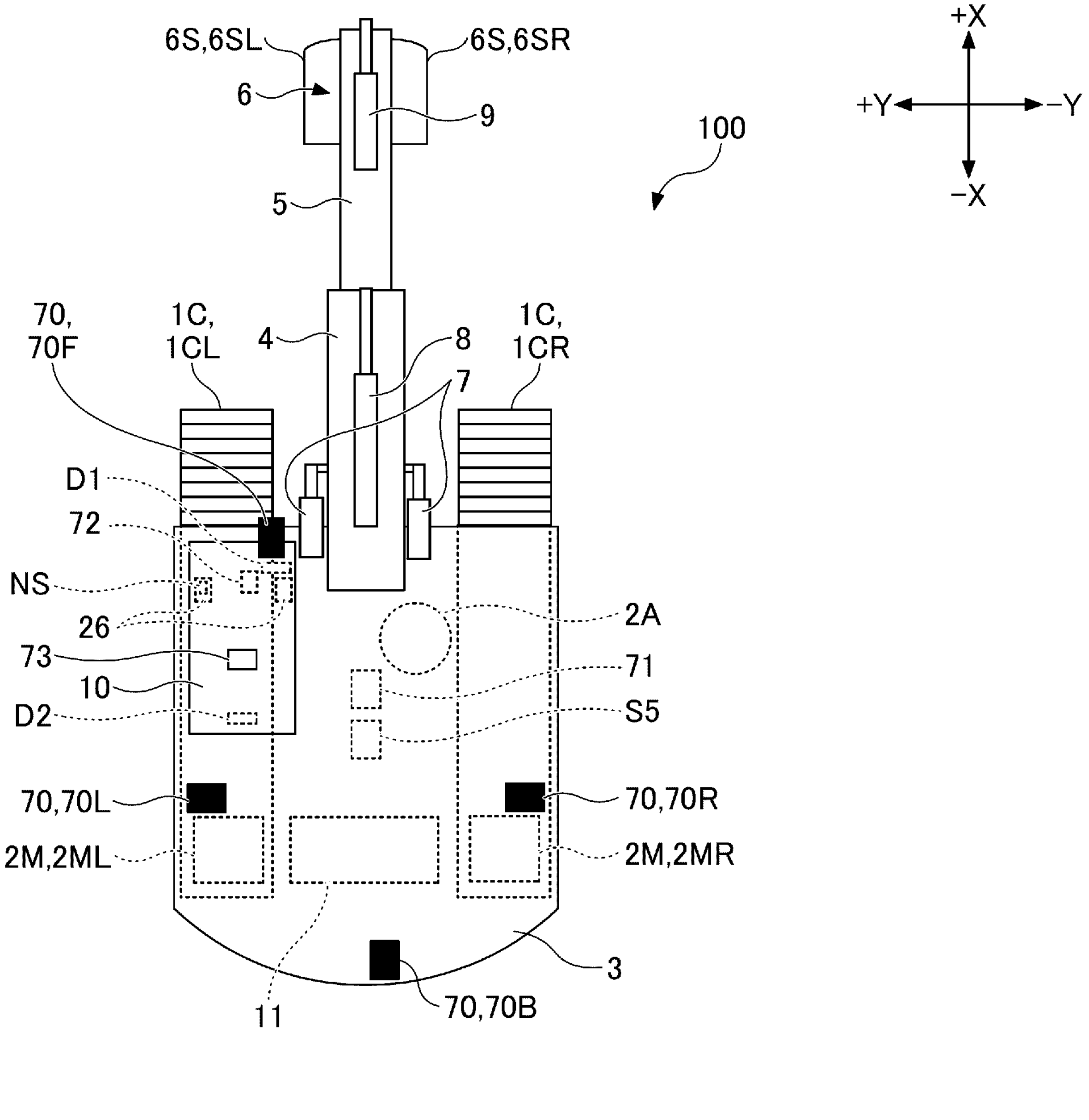
a lower traveling body;
an upper turning body that is turnably mounted on the lower traveling body;
an attachment that is attached to the upper turning body;
a posture detection device configured to detect a posture of the attachment; and
a control device configured to calculate a track drawn by a predetermined portion of the attachment upon turning of the upper turning body, or an approximate straight line of the track.

FIG.1



+Z
−Z
+X
−X
100
70,
70B
70,
70L
11
2M,2ML
S5
S4
3
71
2A
10
73
30
S1
2
7
70,70F
θ1
1
4
8
AT
θ2
S2
5
6B
6S,6SL
GP
6
9
θ3
S3

FIG.2



6S,6SL
6S,6SR
6
9
5
100
+X
+Y
-Y
-X
70,
70F
1C,
1CL
4
8
7
1C,
1CR
D1
72
NS
26
73
10
D2
2A
71
S5
70,70L
70,70R
2M,2ML
2M,2MR
3
11
70,70B

FIG.3

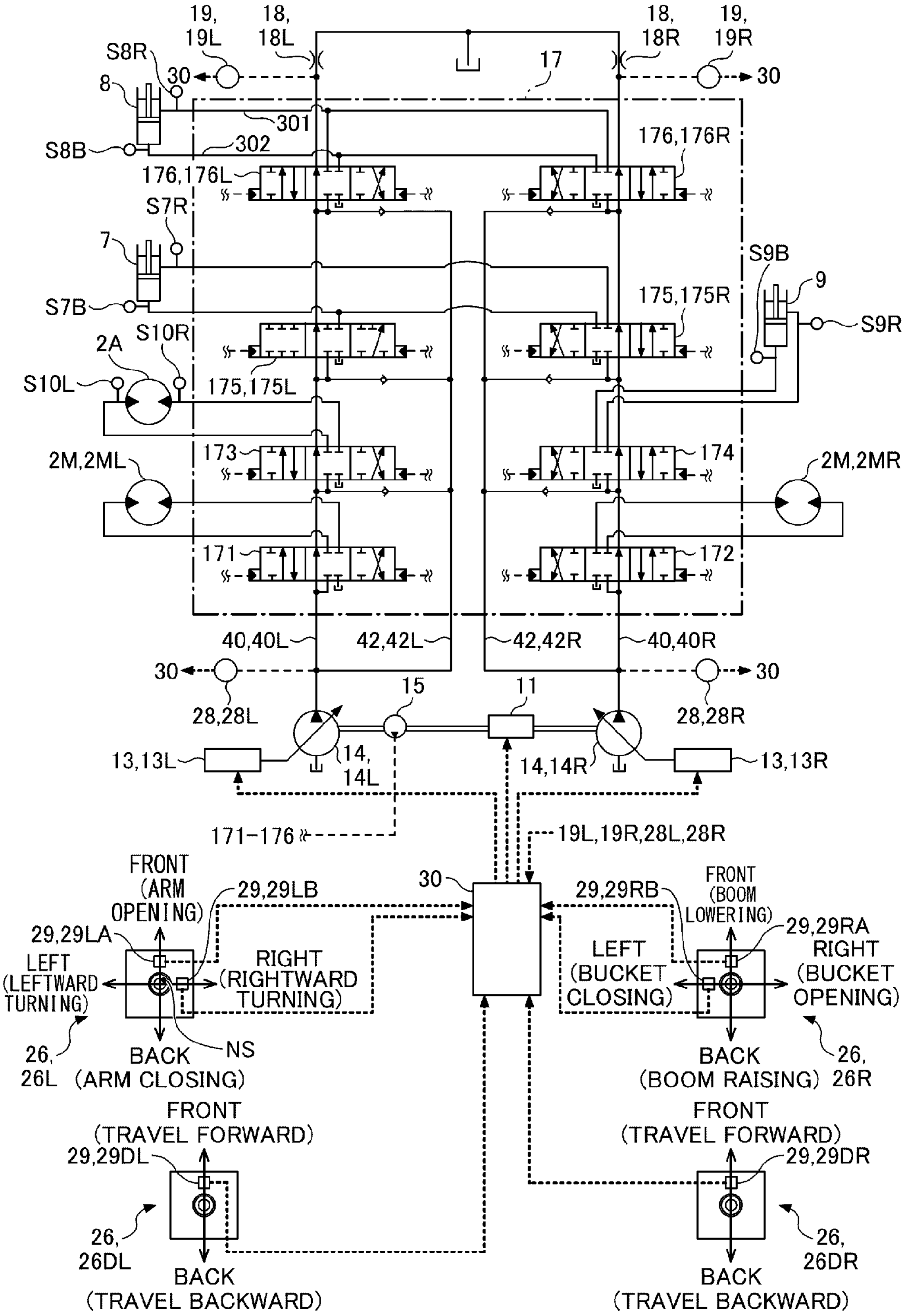

19,
19L
18,
18L
18,
18R
19,
19R
S8R
30
30
30
8
17
301
S8B
302
176,176R
176,176L
S7R
7
S9B
9
S7B
175,175R
S9R
2A
S10R
S10L
175,175L
173
174
2M,2ML
2M,2MR
171
172
40,40L
42,42L
42,42R
40,40R
30
30
28,28L
28,28R
15
11
13,13L
14,
14L
14,14R
13,13R
171-176
19L,19R,28L,28R
FRONT
(ARM
OPENING)
29,29LB
30
29,29RB
FRONT
(BOOM
LOWERING)
29,29RA
29,29LA
LEFT
(LEFTWARD
TURNING)
RIGHT
(RIGHTWARD
TURNING)
LEFT
(BUCKET
CLOSING)
RIGHT
(BUCKET
OPENING)
26,
26L
BACK
(ARM CLOSING)
NS
BACK
(BOOM RAISING)
26,
26R
FRONT
(TRAVEL FORWARD)
FRONT
(TRAVEL FORWARD)
29,29DL
29,29DR
26,
26DL
BACK
(TRAVEL BACKWARD)
26,
26DR
BACK
(TRAVEL BACKWARD)

FIG.4A

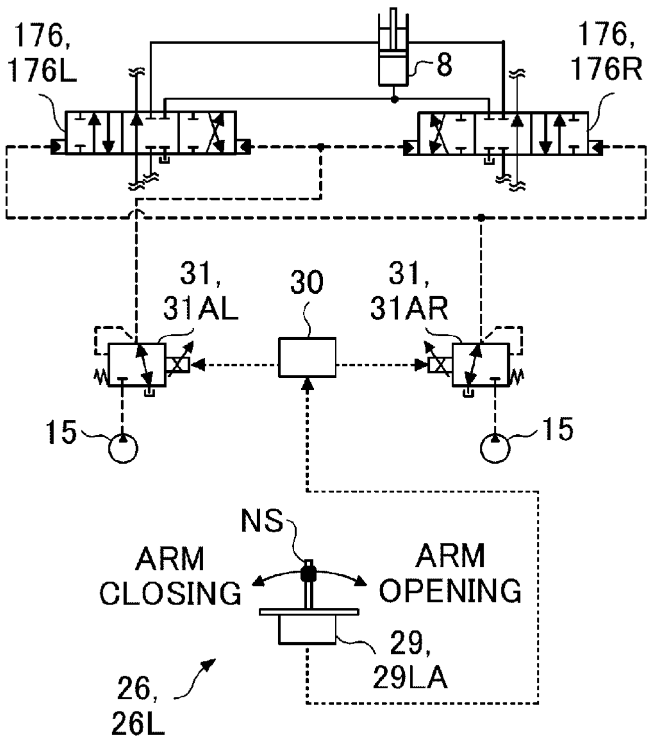

176,
176L
8
176,
176R
31,
31AL
30
31,
31AR
15
15
NS
ARM
CLOSING
ARM
OPENING
29,
29LA
26,
26L

FIG.4B

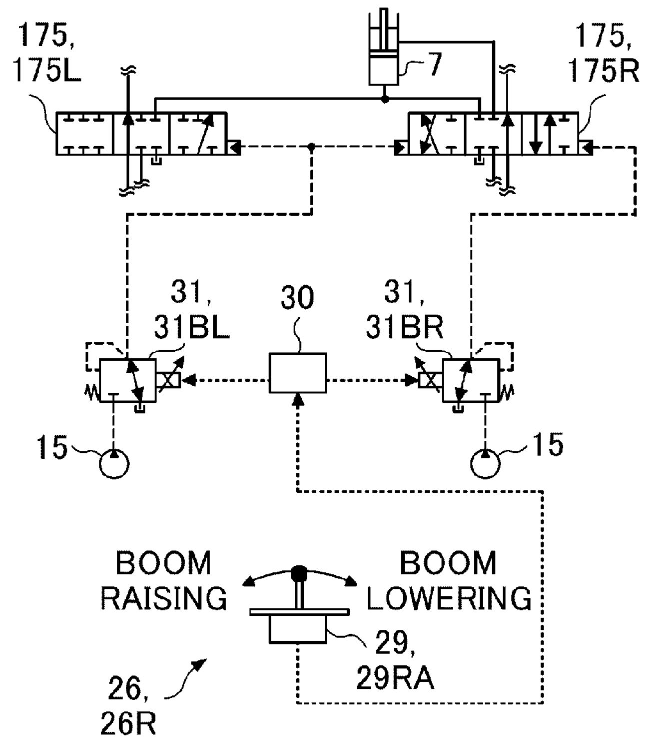

175,
175L
7
175,
175R
31,
31BL
30
31,
31BR
15
15
BOOM
RAISING
BOOM
LOWERING
29,
29RA
26,
26R

FIG.4C

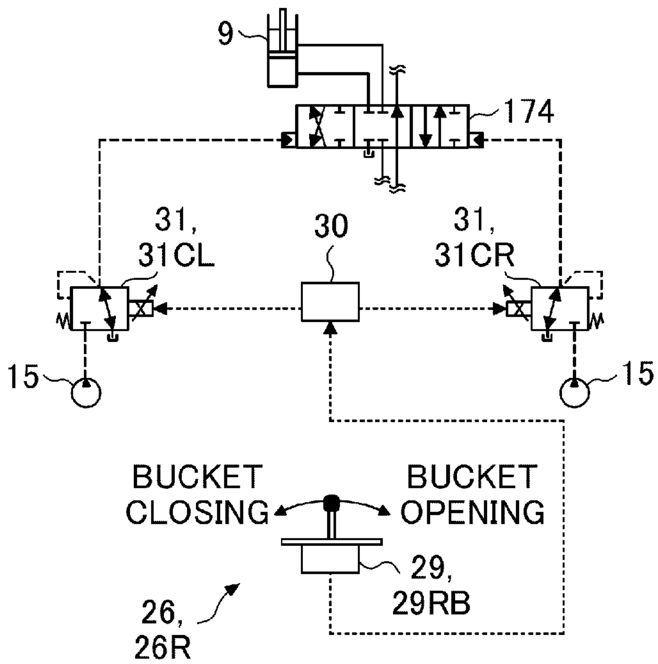

9
174
31,
31CL
30
31,
31CR
15
15
BUCKET
CLOSING
BUCKET
OPENING
29,
29RB
26,
26R

FIG.4D

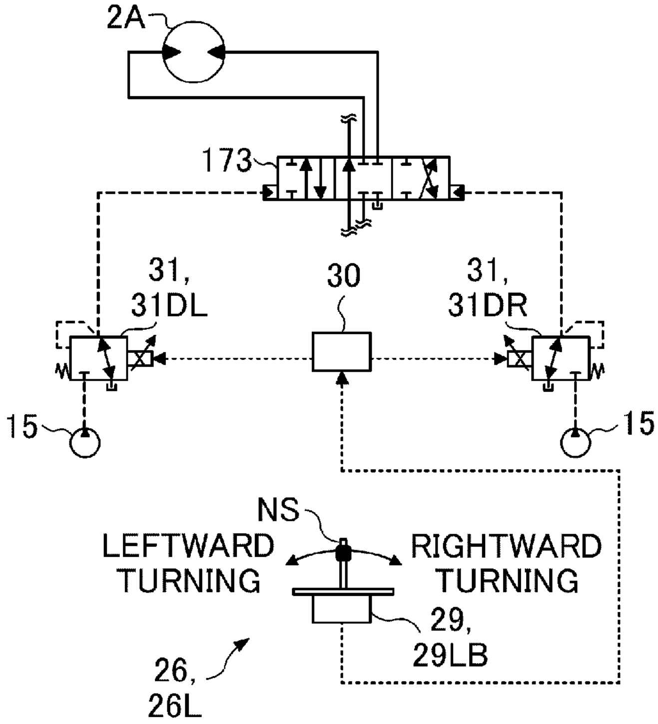

2A
173
31,
31DL
30
31,
31DR
15
15
NS
LEFTWARD
TURNING
RIGHTWARD
TURNING
29,
29LB
26,
26L

FIG.4E

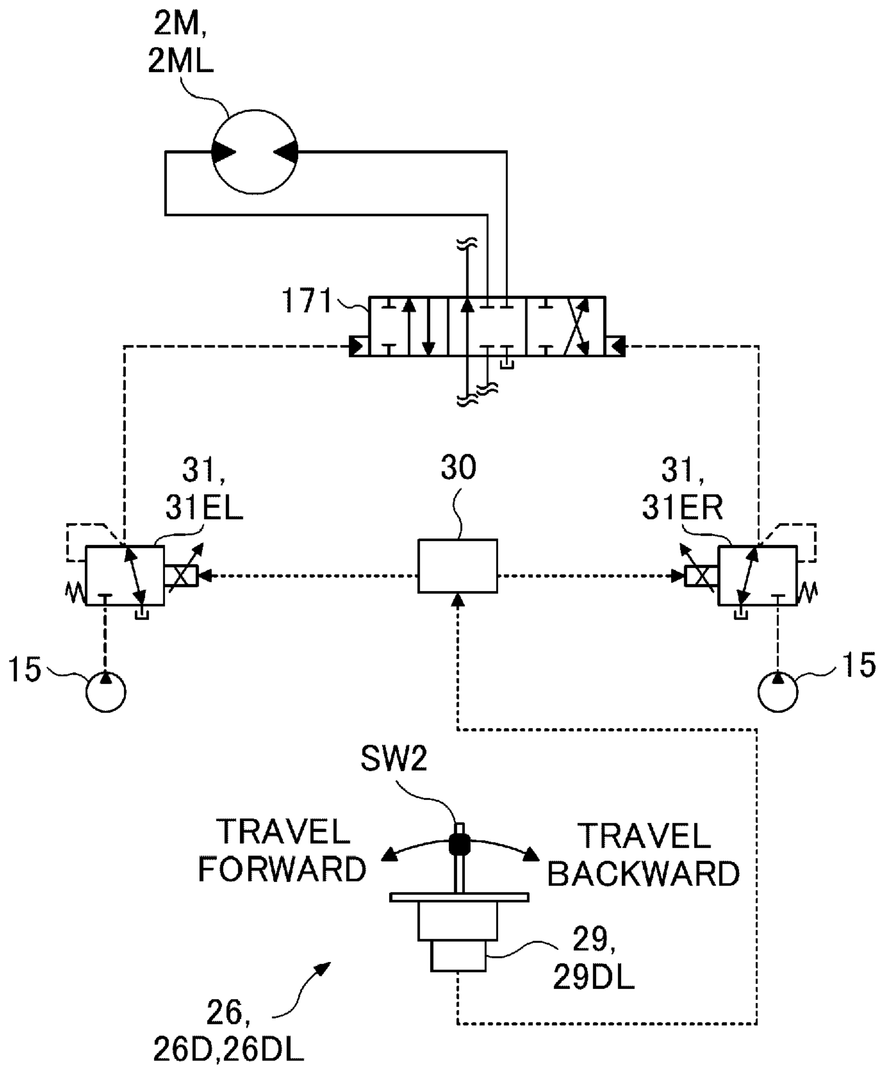
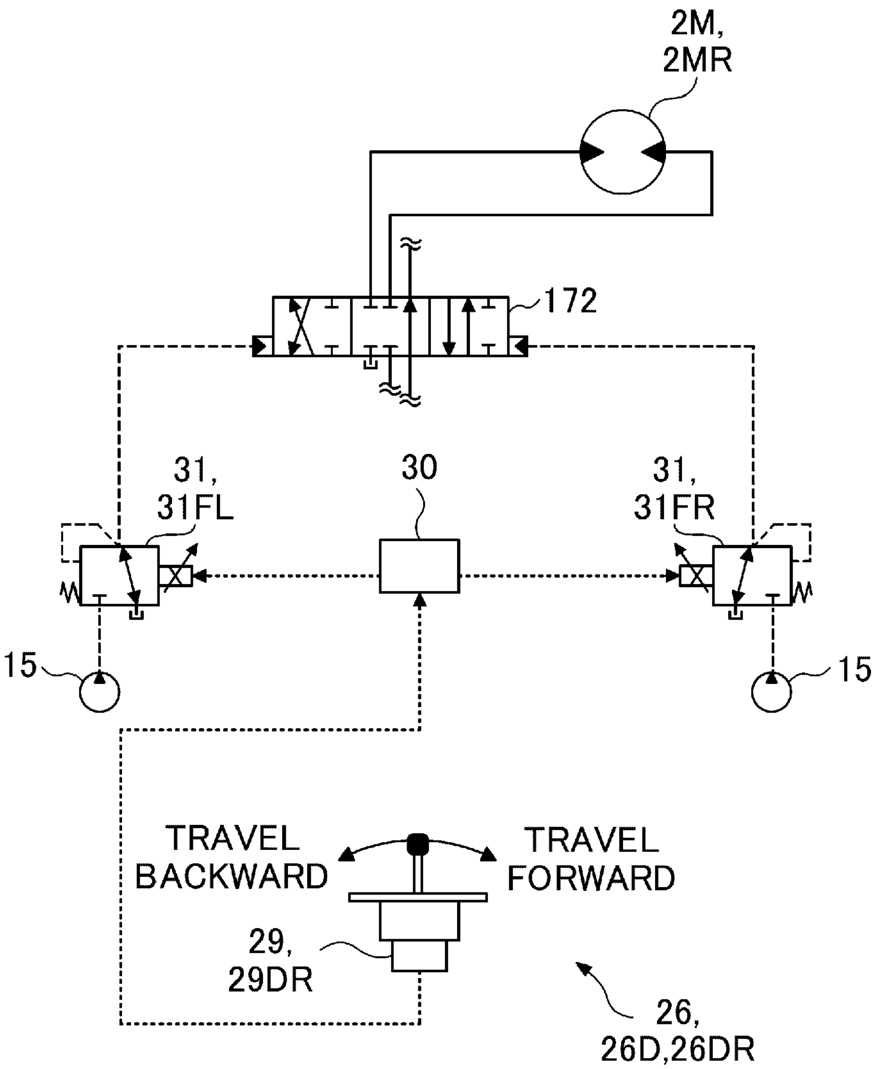

2M,
2ML
171
31,
31EL
30
31,
31ER
15
15
SW2
TRAVEL
FORWARD
TRAVEL
BACKWARD
29,
29DL
26,
26D,26DL

FIG.4F


2M,
2MR
172
31,
31FL
30
31,
31FR
15
15
TRAVEL
BACKWARD
TRAVEL
FORWARD
29,
29DR
26,
26D,26DR

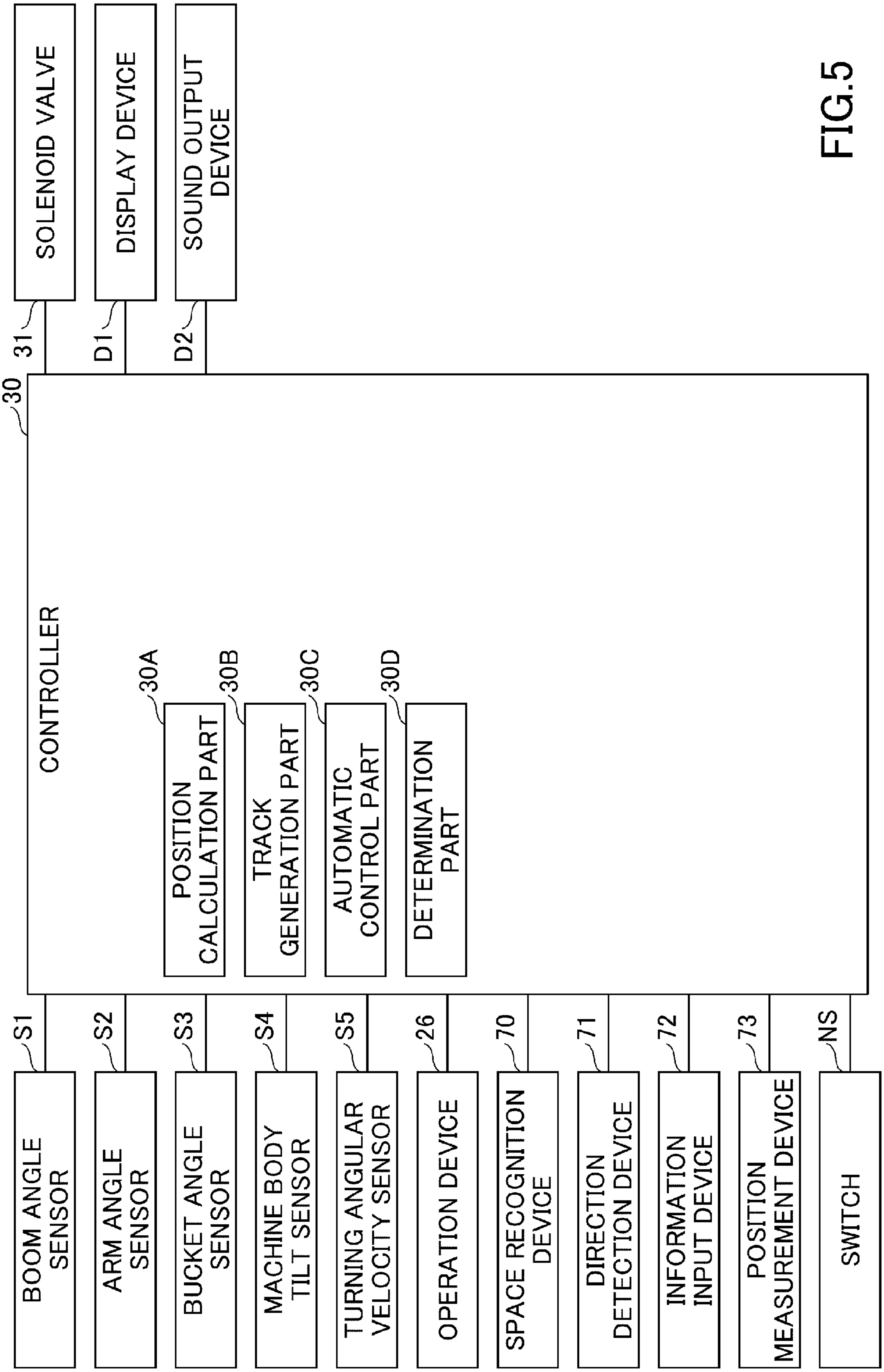

SOLENOID VALVE
DISPLAY DEVICE
SOUND OUTPUT DEVICE
31
D1
D2
30
CONTROLLER
30A
POSITION CALCULATION PART
30B
TRACK GENERATION PART
30C
AUTOMATIC CONTROL PART
30D
DETERMINATION PART
S1
BOOM ANGLE SENSOR
S2
ARM ANGLE SENSOR
S3
BUCKET ANGLE SENSOR
S4
MACHINE BODY TILT SENSOR
S5
TURNING ANGULAR VELOCITY SENSOR
26
OPERATION DEVICE
70
SPACE RECOGNITION DEVICE
71
DIRECTION DETECTION DEVICE
72
INFORMATION INPUT DEVICE
73
POSITION MEASUREMENT DEVICE
NS
SWITCH

FIG.5

FIG.6

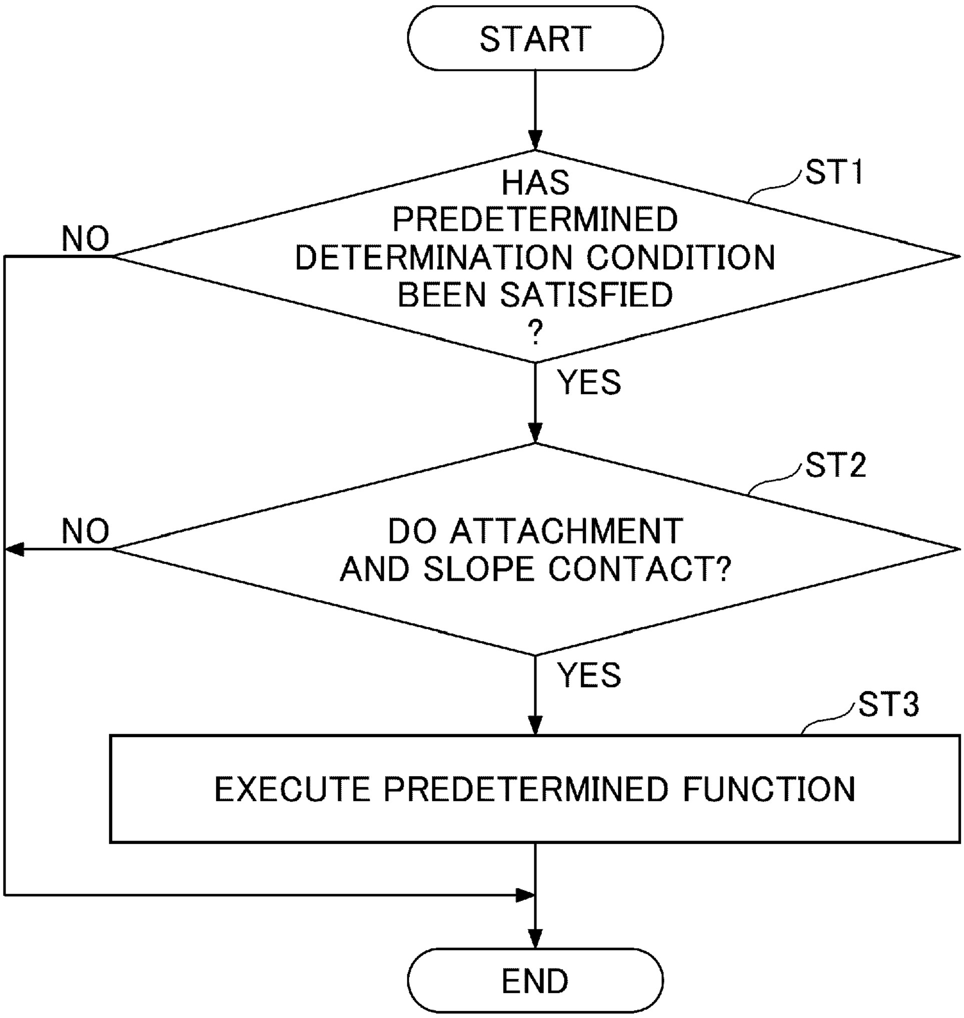

START
HAS PREDETERMINED DETERMINATION CONDITION BEEN SATISFIED ?
ST1
NO
YES
DO ATTACHMENT AND SLOPE CONTACT?
ST2
NO
YES
EXECUTE PREDETERMINED FUNCTION
ST3
END

FIG.7

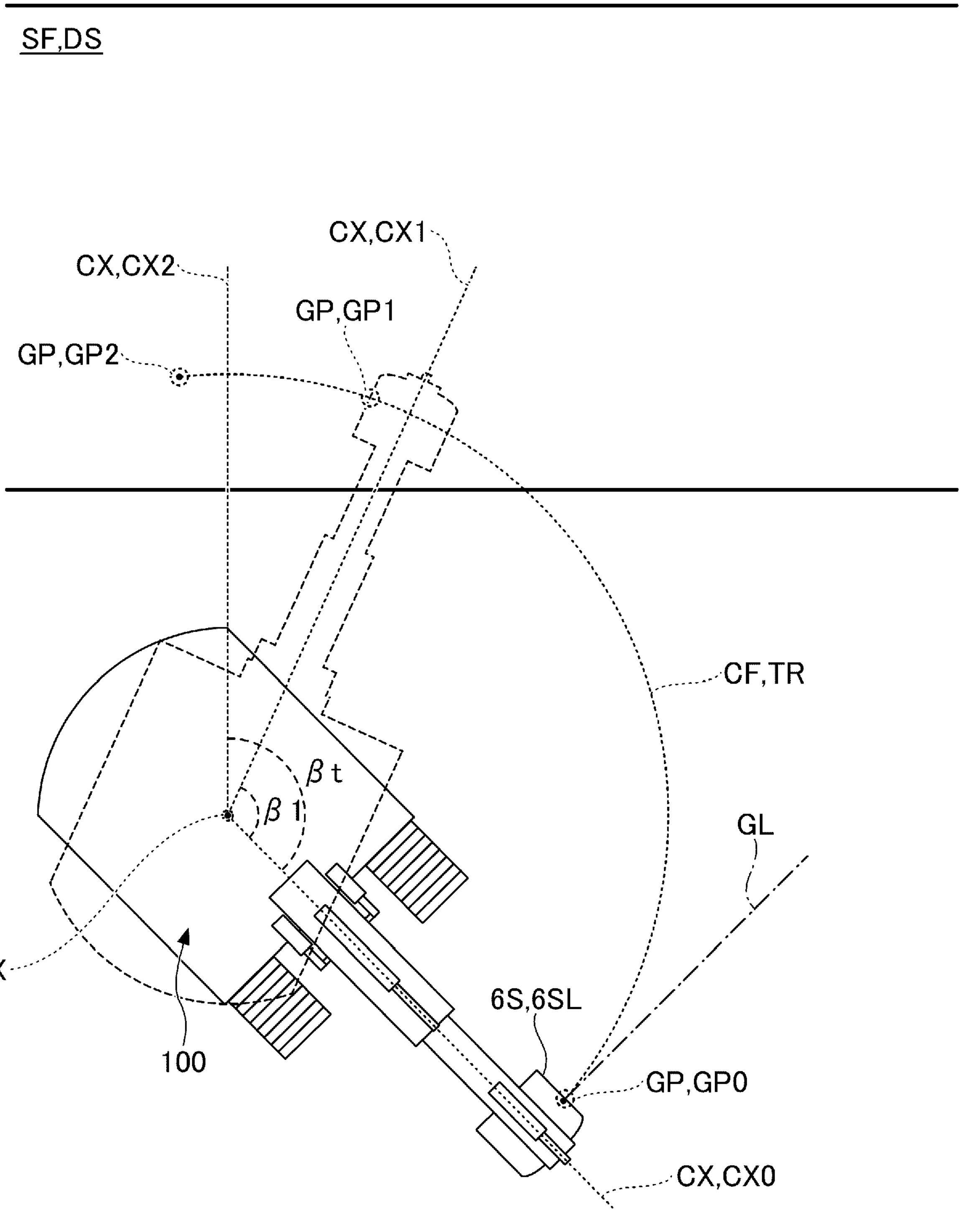

SF,DS
CX,CX1
CX,CX2
GP,GP1
GP,GP2
CF,TR
β t
β 1
GL
2X
6S,6SL
100
GP,GP0
CX,CX0

FIG.8

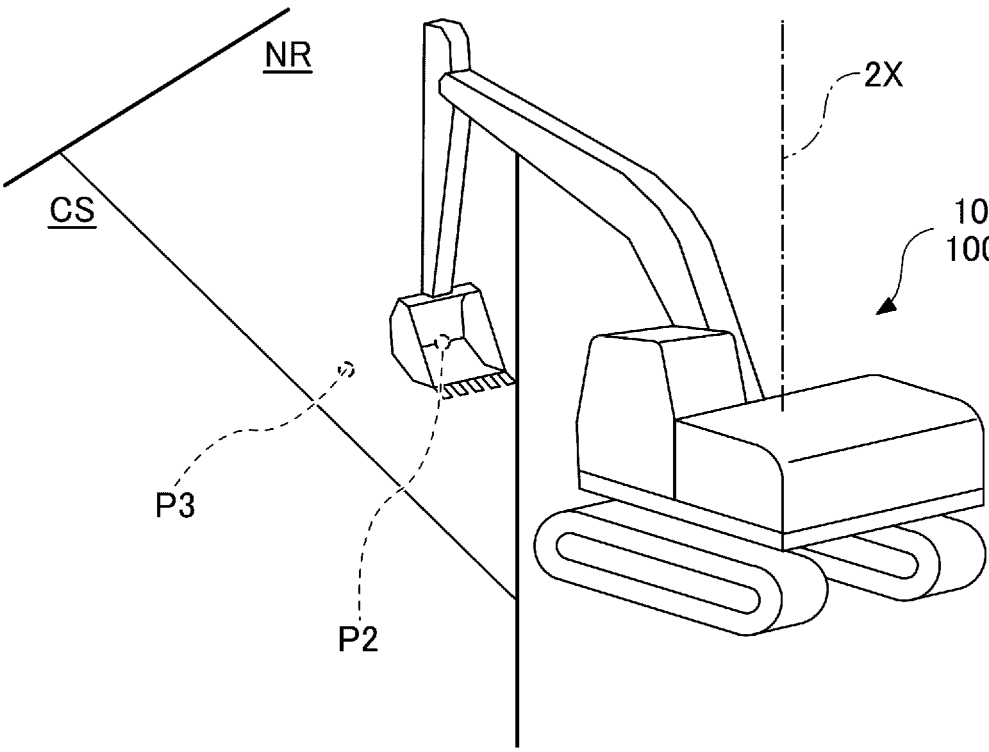
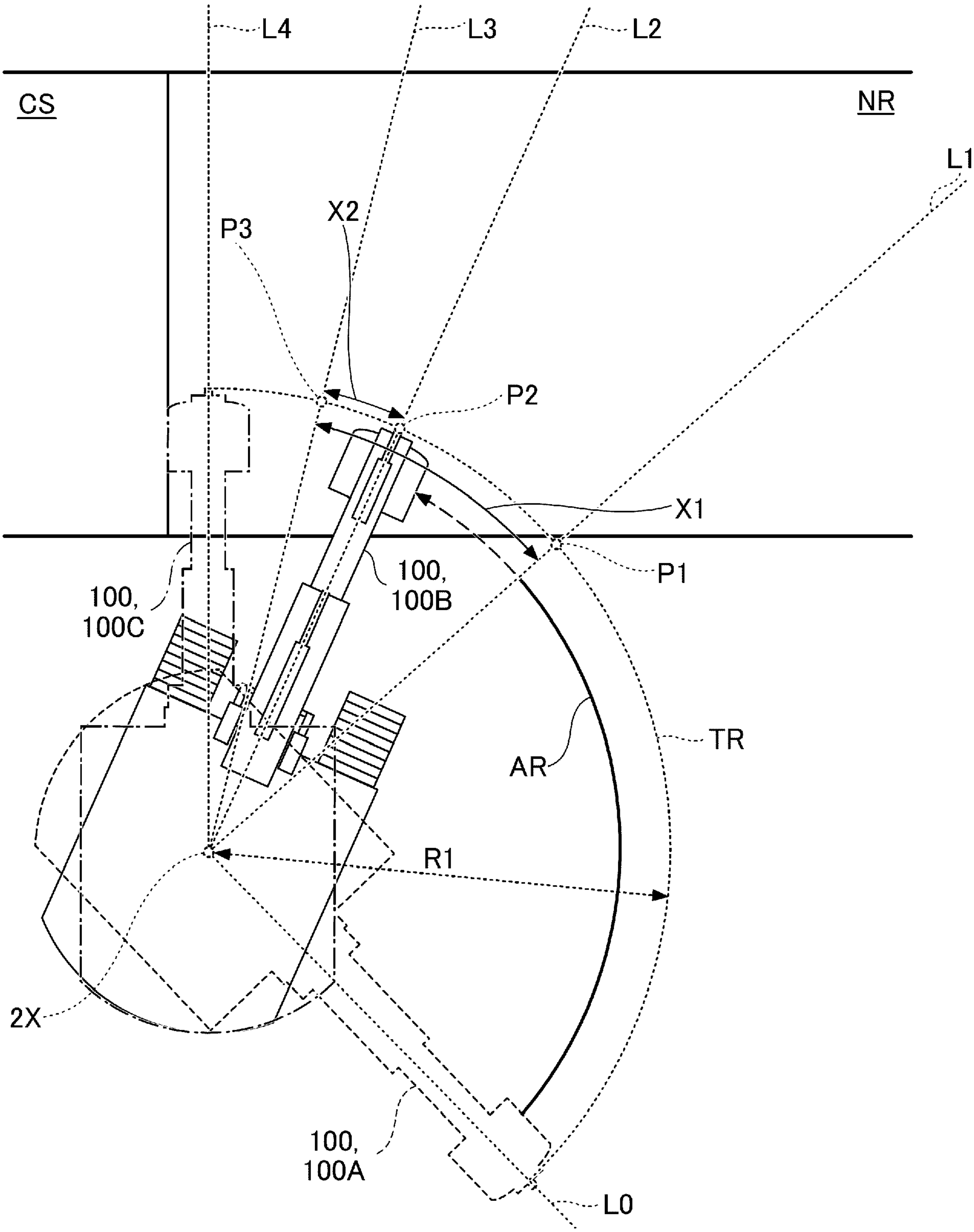


FIG.9


L4
L3
L2
CS
NR
L1
P3
X2
P2
X1
P1
100,
100B
100,
100C
TR
AR
R1
2X
100,
100A
L0

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EUROPEAN SEARCH REPORT

Application Number
EP 24 17 0136

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	WO 2022/202674 A1 (SUMITOMO CONSTRUCTION MACHINERY CO LTD [JP]) 29 September 2022 (2022-09-29) * figures 1,6,7 * & EP 4 317 594 A1 (SUMITOMO CONSTRUCTION MACHINERY CO LTD [JP]) 7 February 2024 (2024-02-07) * paragraphs [0006], [0009] - [0015], [0104] - [0115], [0124], [0135], [0136] *	1-8	INV. E02F3/43 E02F9/20 E02F9/26

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A	* paragraphs [0004], [0006], [0076], [0077], [0078]; figures 1,2A,2B *	3-6	

X	EP 3 767 044 B1 (KOBELCO CONSTR MACH CO LTD [JP]) 7 September 2022 (2022-09-07)	8	
A	* paragraphs [0008], [0009], [0030] *	1-7	

TECHNICAL FIELDS SEARCHED (IPC)
E02F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 September 2024	Luta, Dragos

2

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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19-09-2024

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