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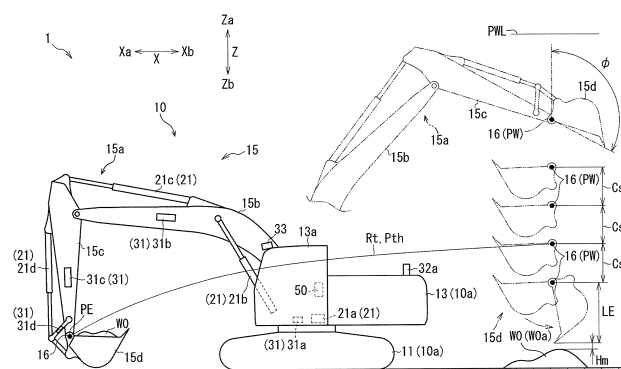
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(54) **AUTOMATED OPERATION SYSTEM FOR WORK MACHINE, WORK MACHINE, AND AUTOMATED OPERATION PROGRAM**

(57) Provided is a system capable of appropriately resetting a work plan when a work position of a tip attachment of a work machine is changed, including an automatic operation part (53), a work position shifting part (63) and a target path correction part (65). The automatic operation part (53) performs a control of making the attachment (15) perform a series of motions including a motion of moving a control target position (16) along a target path (Pth) over a plurality of cycles, through an

automatic operation. The work position shifting part (63) shifts the work position (PW) in at least one of an up-down direction (Z) and a front-rear direction (X) of the attachment (15) in accordance with the advance of the series of motions over the plurality of cycles. The target path correction part (65) corrects a portion of the target path (Pth) between a path end position (PE) and the work position (PW) in accordance with the shift of the work position (PW) by the work position shifting part (63).

FIG.1



Description**Technical Field**

5 **[0001]** The present invention relates to an automatic operation system, a work machine, and an automatic operation program for a work machine.

Background Art

10 **[0002]** Patent Literature 1 discloses a work machine capable of being automatically operated. The work machine includes a tip attachment, which is a bucket in the above literature, and an automatic operation is performed so as to make the attachment repeat a series of motions, which are motions making a circle from excavation to earth removal in the above literature. A work position is shifted at each end of the series of motions, the work position being a position at which the attachment performs work and corresponding to an excavation depth in the literature.

15 **[0003]** In Patent Literature 1, it is described to shift the work position (the excavation depth in the literature) included in the series of motion; however, there is no disclosure about how the target path of the tip attachment from the work position to a position different from the work position, for example, the earth removal position in the literature, is to be set.

Citation List

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Patent Literature

[0004] Patent Literature 1: Japanese Unexamined Patent Publication No. Hei 11-158933

Summary of Invention

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[0005] It is an object of the present invention to provide an automatic operation system for performing an automatic operation of a work machine, the system being capable of appropriately resetting a work plan in accordance with a shift of a work position of a tip attachment of the work machine, a work machine, and a program for the automatic operation.

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[0006] Provided is an automatic operation system that includes a machine body of a work machine, an attachment, and a controller. The attachment is attached to the machine body capably of making a motion. The attachment includes an attachment body and a tip attachment. The tip attachment includes a control target part and is attached to a tip of the attachment body capably of making a work motion. The attachment body is operable to change a position of the control target part. The controller includes a target path setting part, an automatic operation part, a work position shifting part, and a target path correction part. The target path setting part sets a target path, which is a target of a path along which the control target part is to be moved between a work position where the tip attachment makes the work motion and a path end position away from the work position. The automatic operation part automatically controls the motion of the attachment so as to make the attachment perform a series of motions over a plurality of cycles, the series of motions including a motion of moving the control target part along the target path. The work position shifting part shifts the work position in at least one direction of an up-down direction and a front-rear direction of the attachment in accordance with an advance of the series of motions over the plurality of cycles. The target path correction part corrects a portion of the target path between the path end position and the work position in accordance with the shift of the work position.

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[0007] Also provided is a work machine including a machine body, an attachment, and a controller. The attachment is attached to the machine body capably of making a motion. The attachment includes an attachment body and a tip attachment. The tip attachment includes a control target part and is attached to a tip of the attachment body capably of making a work motion. The attachment body is operable to change a position of the control target part. The controller is installed on at least one of the machine body and the attachment. The controller includes a target path setting part, an automatic operation part, a work position shifting part, and a target path correction part. The target path setting part sets a target path, which is a target of a path along which the control target part is to be moved between a work position where the tip attachment makes the work motion and a path end position away from the work position. The automatic operation part automatically controls the motion of the attachment so as to make the attachment perform a series of motions over a plurality of cycles, the series of motions including a motion of moving the control target part along the target path. The work position shifting part shifts the work position in at least one direction of an up-down direction and a front-rear direction of the attachment in accordance with an advance of the series of motions over the plurality of cycles.

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[0008] Also provided is an automatic operation program used for a work machine including a machine body and an attachment. The attachment is attached to the machine body capably of making a motion. The attachment includes an

attachment body and a tip attachment. The tip attachment includes a control target part and is attached to a tip of the attachment body capably of making a work motion. The attachment body is operable to change a position of the control target part. The automatic operation program makes a computer execute a target path setting step, an automatic operation step, a work position shifting step and a target path correction step. The target path setting step is a step of setting a target path, which is a target of a path along which the control target part is to be moved between a work position where the tip attachment makes the work motion and a path end position away from the work position. The automatic operation step is a step of automatically controlling a motion of the attachment so as to make the attachment perform a series of motions over a plurality of cycles, the series of motions including a motion of moving the control target part along the target path. The work position shifting step is a step of shifting the work position in at least one direction of an up-down direction and a front-rear direction of the attachment in accordance with an advance of the series of motions over the plurality of cycles. The target path correction step is a step of correcting a portion of the target path between the path end position and the work position in accordance with the shift of the work position.

[0009] Also provided is a recording medium on which the automatic operation program is recorded. The automatic operation program can be read by the computer.

Brief Description of Drawings

[0010]

FIG. 1 is a side view of a work machine according to an embodiment of the present invention.

FIG. 2 is a block diagram showing an automatic operation system according to the embodiment.

FIG. 3 is a flowchart showing a control action to be executed by the automatic operation system.

FIG. 4 is a diagram showing a target trajectory of a control target part shown in FIG. 1.

FIG. 5 is a table showing a correction example of the target trajectory shown in FIG. 4.

FIG. 6 is a graph showing a plurality of target trajectories according to the correction example.

FIG. 7 is a plan view showing the work machine and the target trajectory.

Detailed Description

[0011] There will be described an embodiment of the present invention with reference to FIGS. 1 to 7.

[0012] FIG. 1 shows a work machine 10 according to the embodiment. The work machine 10 constitutes an automatic operation system 1 shown in FIG. 2. The automatic operation system 1 includes the work machine 10, a posture detector 31, a reference position detector 32, a peripheral-object position detector 33, an input device 35, and a controller 50. Each of the posture detector 31, the reference position detector 32, the peripheral-object position detector 33, the input device 35, and the controller 50 may be disposed either inside the work machine 10 or outside the work machine 10 (for example, at a work site).

[0013] The work machine 10 is a machine for performing work. The work machine 10 illustrated in FIG. 1 is a construction machine for performing construction work, specifically, an excavator. The work machine 10 is capable of being automatically operated. The work machine 10 may be capable of being operated by an operator boarding the work machine 10 or remotely operated at a place away from the work machine 10.

[0014] The work machine 10 includes a machine body 10a, an attachment 15, a driving part 21 shown in FIG. 2, and a driving control part 17.

[0015] The machine body 10a is a main body part of the work machine 10. The machine body 10a includes a lower main body 11 and an upper turning body 13 shown in FIG. 1. The lower main body 11 supports the upper turning body 13. The lower main body 11 illustrated in FIG. 1 is a lower traveling body capable of performing a traveling motion. Specifically, the lower main body 11 includes a traveling body. The traveling body may be either a pair of crawlers illustrated in FIG. 1 or a plurality of wheels. The upper turning body 13 is mounted on the lower main body 11 capably of turning with respect to the lower main body 11. The upper turning body 13 includes an operation chamber 13a, in which an operator can perform operations for moving the work machine 10.

[0016] The upper turning body 13 has an up-down direction Z and a front-rear direction X indicated by respective double-headed arrows in FIG. 1. The up-down direction Z is a direction in which the central axis of the turning of the upper turning body 13 with respect to the lower main body 11 (turning center axis) extends. The up-down direction Z involves an upper side Za of the upper turning body 13 and a lower side Zb opposite thereto, the upper side Za being the opposite side to the lower main body 11 across the upper turning body 13. The up-down direction Z is, for example, a vertical direction. The up-down direction Z is orthogonal to a turning direction Sw shown in FIG. 7, and the upper turning body 13 turns in the turning direction Sw with respect to the lower main body 11. The front-rear direction X is a direction orthogonal to each of the up-down direction Z and the turning direction Sw, thus being equivalent to the turning radius direction. The front-rear direction X is the longitudinal direction of the attachment 15 when viewed along the up-

down direction Z, that is, the direction in which the central axis of the attachment 15 with respect to the width direction thereof extends, being also the front-rear direction of the attachment 15. The front-rear direction X involves a front side Xa of the upper turning body 13 and a rear side Xb opposite thereto, and the front side Xa is a side to which the attachment 15 protrudes from the upper turning body 13.

[0017] The attachment 15, which is capable of performing a motion for performing work, includes an attachment body 15a and a tip attachment 15d attached to the tip of the attachment body 15a.

[0018] The attachment body 15a includes a boom 15b and an arm 15c, being operable to make motions to change the position of the control target part 16 of the tip attachment 15d. The boom 15b is attached to the upper turning body 13 capably of rising and falling with respect to the upper turning body 13, that is, capably of rotational movement in the up-down direction Z. The arm 15c is coupled to the boom 15b capably of rotational movement with respect to the boom 15b.

[0019] The tip attachment 15d is attached to the tip of the attachment body 15a capably of making a specific work motion, specifically, coupled to the arm 15c capably of rotational movement with respect to the arm 15c. The tip attachment 15d shown in FIG. 1 is a bucket, attached to the tip of the attachment body 15a capably of making a capture motion and a release motion. The capture motion is a motion for work of capturing a work object WO, for example, work of scooping earth and sand, and the release motion is a motion for work of releasing the work object WO, for example, an earth removal work. The tip attachment 15d, alternatively, may be either a device for sandwiching a work object WO, such as a grapple or a nibra, or a device for crushing a work object WO, such as a breaker. The tip attachment 15d includes the control target part 16, which can be arbitrarily set in the tip attachment 15d. For example, the control target part 16 may be either a connection part to be connected to the arm 15c of the tip attachment 15d as shown in FIG. 1, namely, a proximal end part, or a distal end part of the tip attachment 15d, which is the end part opposite to the proximal end part. The work object WO is an object of work by the attachment 15 of the work machine 10. Examples of the work object WO include earth and sand, stone, wood, metal, waste, structure such as block, and the like.

[0020] The driving part 21 drives a plurality of movable parts of the work machine 10 to make the work machine 10 perform motions. The driving part 21 drives the attachment 15. The driving part 21 includes a plurality of actuators corresponding to the plurality of movable parts, respectively. The plurality of actuators include a turning motor 21a and a plurality of hydraulic cylinders, which include a boom cylinder 21b, an arm cylinder 21c, and a tip attachment cylinder 21d. The turning motor 21a turns the upper turning body 13 with respect to the lower main body 11. The turning motor 21a may be either a hydraulic motor or an electric motor. The boom cylinder 21b is expanded and contracted to raise and lower the boom 15b with respect to the upper turning body 13. The arm cylinder 21c is expanded and contracted to rotationally move the arm 15c with respect to the boom 15b. The tip attachment cylinder 21d is expanded and contracted to rotationally move the tip attachment 15d with respect to the arm 15c. In the case where the tip attachment 15d itself includes a movable part, for example, a part capable of making a motion of holding an object, the driving part 21 may include an actuator (for example, a cylinder or a motor) for moving the movable part of the tip attachment 15d.

[0021] The driving control part 17 controls the motion of the driving part 21, that is, controls the drive of the movable part. Specifically, the driving control part 17 controls respective motions of the turning motor 21a, the boom cylinder 21b, the arm cylinder 21c, and the tip attachment cylinder 21d. In the case where the driving part 21 includes a hydraulic actuator, the driving control part 17 includes a hydraulic circuit for controlling the hydraulic actuator. In the case where the driving part 21 includes an electric actuator, the driving control part 17 includes an electric circuit for controlling the electric actuator.

[0022] The posture detector 31 detects the posture of the work machine 10. Specifically, the posture detector 31 acquires information about the posture of the attachment 15 and the posture of the upper turning body 13 with respect to the lower main body 11, namely, the turning posture.

[0023] In the present embodiment, the posture detector 31 includes a turning sensor 31a, a boom sensor 31b, an arm sensor 31c, and a tip attachment sensor 31d.

[0024] The turning sensor 31a detects the angle of the upper turning body 13 in the turning direction Sw with respect to the lower main body 11 or the work site, namely, a turning angle. The boom sensor 31b detects the posture of the boom 15b. For example, the boom sensor 31b detects the angle of the boom 15b in the rising and falling directions with respect to the horizontal direction or the upper turning body 13, namely, an inclination angle. The arm sensor 31c detects the posture of the arm 15c. The arm sensor 31c detects, for example, the angle of the arm 15c with respect to the horizontal direction or the boom 15b. The tip attachment sensor 31d detects the posture of the tip attachment 15d. The tip attachment sensor 31d detects, for example, the angle of the tip attachment 15d with respect to the horizontal direction or the arm 15c.

[0025] The reference position detector 32 detects the position and orientation of a reference part, which is set in the work machine 10 shown in FIG. 1, with respect to the work site. The reference part can be arbitrarily set, for example, being a specific part of the upper turning body 13 or the lower main body 11. Specifically, the reference part may be either a part to be connected to the upper turning body 13 in the boom 15b, namely, a boom foot, or a part located on the turning central axis of the upper turning body 13. The reference position detector 32 (FIG. 2) may be included in a location positioning system. The location positioning system may be, for example, either a satellite positioning system

such as GNSS (global navigation satellite system) or a system using a total station. The reference position detector 32 according to the present embodiment includes an antenna 32a as shown in FIG. 1, being capable of communicating with the satellite positioning system.

[0026] The peripheral-object position detector 33 acquires information on the position of a peripheral object that is an object present around the work position PW, namely, peripheral-object position information. Examples of the peripheral-object position information include information on the position of the ground surface, information on the position of a work object WOa having been released as described later, and information on the position of an obstacle or the like. The peripheral-object position detector 33 may include an imaging device. Examples of the imaging device include: a device for acquiring two-dimensional information of an imaging object, for example, a position and a shape in an image; a camera for generating two-dimensional information, namely, a monocular camera; a device for acquiring a distance image; a device for generating three-dimensional information of the imaging object, for example, a three-dimensional coordinate or a three-dimensional shape, based on the distance image; a device for generating three-dimensional information using a laser light, for example, a LIDAR (Light Detection and Ranging) or a TOF (Time of Flight) sensor; a device for detecting three-dimensional information using a radio wave, for example, a millimeter wave radar; and a stereo camera. The imaging device may generate three-dimensional information of the imaging object based on the distance image and the two-dimensional image. The peripheral-object position detector 33 may include a plurality of imaging devices.

[0027] The input device 35 is a device that allows an operator to input information to the controller 50 through the input device 35. Specifically, the input device 35 allows an operation to be applied to the input device 35 by an operator, and inputs to the controller 50 an instruction corresponding to the applied operation. If disposed in the work machine 10, the input device 35 may be either a display device or an operation lever provided in the operation chamber 13a. The input device 35 may be a portable terminal, such as a tablet or a smartphone, or a personal computer. The input device 35 may be included in equipment installed outside the work machine 10, for example, a server. The input device 35 conducts communication with the controller 50, which communication may be either wireless communication or wired communication.

[0028] The controller 50 includes a computer that executes input/output, operation (processing), storage of information (such as an operation result), and the like. For example, the controller 50 includes a storage part that stores a program for providing the function of the controller 50, the program including an automatic operation program, and an operation part that executes the program stored in the storage part to achieve the function. The controller 50 may be either installed on the work machine 10, more specifically, at least one of the machine body 10a and the attachment 15, or provided outside the work machine 10, for example, in a server. As shown in FIG. 2, to the controller 50 is input the information acquired by the detectors 31 to 33. To the controller 50 is input an instruction corresponding to the operation by the operator or other information from the input device 35. The controller 50 performs control for automatic operation of the work machine 10. Specifically, the controller 50 inputs, to the driving control part 17, a command for making the driving part 21 drive to make the work machine 10 perform a predetermined motion.

[0029] Specifically, as shown in FIG. 2, the controller 50 includes a target trajectory setting part (target path setting part) 51, an automatic operation part 53, a work end judgment part 55, a work limit position setting part 61, a work position shifting part 63, and a target trajectory correction part (target path correction part) 65, which functions are provided by execution of the automatic operation program as shown in the flowchart of FIG. 3.

[0030] The target trajectory setting part 51 executes a target path setting step (step S10 shown in FIG. 3), specifically, sets a target path Pth shown in FIG. 1 and further a target trajectory Tr. As shown in FIG. 4, the target path Pth is a target of the path of the control target part 16 of the tip attachment 15d. The target path Pth includes a plurality of target points P(i), where "i" is a natural number in a range from 1 to a predetermined maximum number N. Each of the target points P(i) is information about the target position of the control target part 16, specifically, a three-dimensional position coordinate. The target trajectory Rt is information including information on respective positions of the target points P(i) and information about the order of the plurality of target points P(i), namely, a so-called order set. Specifically, the target trajectory Rt is information about the target path Pth added with time information. The "time information" is, for example, a target section time Tst shown in below-described Table 1. The target section time Tst is a target value of the time by which the control target part 16 is to be moved through a section between two target points P(n) and P(n+1) that are adjacent to each other (sequential order), namely, an inter-two-points section. The controller 50 may include, in place of the target trajectory setting part 51, a target path setting part that sets only a target trajectory without the target section time Tst, namely, only the target path Pth.

[0031] The parameter to represent the target trajectory Rt is, for example, one that allows the posture of the work machine 10 in each of the target points (i) to be determined. The coordinate axis of the parameter and the origin thereof (reference position) are arbitrarily set. The origin may be set either in a work site or to an appropriate part of the work machine 10, for example, an appropriate part of the upper turning body 13. For example, the origin may be set to either a part at which the upper turning body 13 and the boom 15b are interconnected, namely, a boom foot pin, or a part on the turning center axis of the upper turning body 13. The below table 1 shows an example of information given to each

of the target points $P(i)$ in the target trajectory R_t , the information including: a target coordinate X_t , which is a target of the coordinate corresponding to the coordinate axis in the front-rear direction X (X-coordinate); a target coordinate Z_t , which is a target of the coordinate corresponding to the coordinate axis in the up-down direction Z (Z-coordinate); a target turning angle θ_t , which is the target of the turning angle of the upper turning body 13; the target section time T_{st} ; and a target tip-attachment angle ϕ_t , which is the target of a tip-attachment angle ϕ . In the example shown in Table 1 and FIG. 1, the tip attachment angle ϕ is an angle of the tip attachment 15d with respect to the up-down direction Z. The tip attachment angle ϕ may be either of an angle of the tip attachment 15d with respect to the front-rear direction X, a rotation angle of the tip attachment 15d with respect to the arm 15c from the position at which the tip attachment 15d is fully opened, and an angle of the tip attachment 15d with respect to the horizontal direction.

TABLE 1

target point $P(i)$	X-coordinate X_t (mm)	Z-coordinate Z_t (mm)	tip-ATT angle ϕ_t (deg)	turning angle θ_t (deg)	target section time T_{st} (sec)
P(1)	7000	-1000	330	0	1
P(2)	6500	-500	330	-20	1
P(3)	6000	0	330	-40	1
P(4)	5500	500	330	-60	1
P(5)	5000	1000	330	-80	1

[0032] The target trajectory correction part 65 corrects the target trajectory R_t shown in FIGS. 4 and 7. In other words, the target trajectory correction part 65 changes the target trajectory R_t from a target trajectory R_{to} before correction to a target trajectory R_{ta} after the correction.

[0033] The plurality of target points $P(i)$ included in the target trajectory R_t include the path end position PE and the work position PW. The path end position PE and the work position PW are respective target points of the positions of the opposite ends of the target trajectory R_t . In other words, one of the opposite ends of the target trajectory R_t is the path end position PE and the other is the work position PW. The work position PW is a position at which the tip attachment 15d is to make the specific work motion. Below will be shown examples of the work performed by the specific work motion.

[0034] [Example A1] In the example shown in FIG. 1, the position where the release is performed, namely, the work position PW, is set to a position directly above the ground. The work position PW may be set directly above a non-illustrated container that accommodates the work object WO, for example, a loading platform of a transport vehicle. In this example, the motion performed by the tip attachment 15d at the path end position PE is not limited. The path end position PE may be, for example, a position where the tip attachment 15d performs a capture motion for work of capturing the work object WO, for example, excavation work. The position where the capture motion is thus performed, namely, the path end position PE, is set to, for example, a place where the work object WO is collected (soil sand or earth pit).

[0035] [Example A2] The work to be performed by the specific work motion of the tip attachment 15d at the work position PW may be work for capturing the work object WO, for example, excavation work. In this case, the tip attachment 15d may make a motion for releasing the work object WO at the path end position PE.

[0036] In either of [Example A1] and [Example A2], the controller 50 controls the driving control part 17 so as to move the tip attachment 15d along the target path P_{th} between the work position PW and the path end position PE. The controller 50 may control the driving control part 17 so as to turn the upper turning body 13 with respect to the lower main body 11 when the tip attachment 15d is moved along the target path P_{th} . There is a lifting turning motion, that is a motion in which the tip attachment 15d is moved from a position at which the tip attachment 15d captures the work object WO (the path end position PE) to a position at which the tip attachment 15d releases the work object WO (the work position PW). There is a return turning motion in which the tip attachment 15d is moved from the release position to the capture position. The capture motion for capturing the work object WO, the lifting turning motion, the release motion for releasing the work object WO, and the return turning motion constitute a series of motions in one cycle, and the controller 50 controls the driving control part 17 to make the series of motions performed repeatedly, that is, to make the series of motions performed over a plurality of cycles.

[0037] The turning of the upper turning body 13 with respect to the lower main body 11 along with the movement of the tip attachment 15d along the target path P_{th} is optional. In other words, the turning of the upper turning body 13 do not have to be included in the "series of motions". For example, the series of motions may be composed of only a motion in which the control target part 16 of the tip attachment 15d is moved only in at least one direction of the front-rear direction X and the up-down direction Z with no movement of the control target part 16 in the turning direction.

[0038] Among the plurality of target points $P(i)$, in the present embodiment, the path end position PE corresponds to

the target point P(1), and the work position PW corresponds to the target point P(N). The number "i" of the target point P(i) may be set so that the control target part 16 passes either through the target point P(1), the target point P(2), ..., the target point P(N) in this order or through the target point P(N), the target point P(N-1), ..., the target point P(1) in this order.

[0039] In advance of the performance of the work by the automatic operation (the work by the tip attachment 15d) of the work machine 10, the initial position of the target trajectory Rt is set (step S10 in FIG. 3). The initial position of the target trajectory Rt may be input to the target trajectory setting part 51 either through teaching or through a method other than the teaching. For example, a numerical value to determine the initial position may be input to the target trajectory setting part 51 through the input device 35.

[0040] For example, the teaching is performed as follows. An operator boards the work machine 10 to operate the work machine 10 or remotely operates the work machine 10 to thereby move the control target part 16 at a speed that is desired to be set for the reference target trajectory Rtb along a path that is desired to be set as the reference target trajectory Rtb. The target trajectory setting part 51 stores the trajectory along which the control target part 16 has been actually moved by the operation of the operator, and sets the stored trajectory to a reference target trajectory Rtb. For example, during the movement of the control target part 16, the position coordinate of the control target part 16 is calculated and stored at each predetermined time (for example, every one second). The position coordinates of the control target part 16 can be calculated based on the posture of the work machine 10 detected by the posture detector 31. The thus stored position coordinates are set to respective position coordinates of the plurality of target points P(i), respectively.

[0041] The automatic operation part 53 of the controller 50 executes the automatic operation of the work machine 10 (automatic operation step; step S20, S21, S22, S23, and S51 in FIG. 3). More specifically, the automatic operation part 53 automatically controls the operation of the work machine 10 so as to make the control target part 16 of the tip attachment 15d moved along the target path Pth (according to the target trajectory Rt) to thereby make the series of motions performed and further so as to make the series of motions repeated over the plurality of cycles. The target of the automatic control by the automatic operation part 53 may be either only the motion of the attachment 15 or both the motion of the attachment 15 and the turning motion of the upper turning body 13 with respect to the lower main body 11. Specifically, the automatic operation part 53 generates a command for the automatic control and inputs the command to the driving control part 17, thereby operating the driving part 21. The automatic operation part 53 generates the command based on the value detected by the posture detector 31.

[0042] Specifically, the automatic operation part 53 according to the present embodiment performs the automatic operation of the work machine 10 so as to make the work machine 10 perform the series of motions constituted by the motion of capturing the work object WO, the lifting turning motion, the motion of releasing the work object WO and the return turning motion over the plurality of cycles. The automatic operation part 53 makes the motion of capturing the work object WO performed with the control target part 16 of the tip attachment 15d located at the path end position PE (step S21 in FIG. 3). After the end of the work at the path end position PE, the automatic operation part 53 operates the attachment 15 to move the control target part 16 from the path end position PE to the work position PW along the target trajectory Rt (step S22). The automatic operation part 53 makes the work motion on the work object WO performed with the control target part 16 located at the work position PW (step S23). After the end of the work at the work position PW, the automatic operation part 53 operates the attachment 15 so as to move the control target part 16 from the work position PW to the path end position PE along the target trajectory Rt. The automatic operation part 53 makes the attachment 15 repeat the series of motions (steps S21, S22, S23, and S51). In the example shown in FIG. 3, a return motion control for returning the tip attachment 15d including the control target part 16 to the path end position PE (step S51) is performed after the shift of the work position PW (steps S40 to S43) as described later; however, the return motion control (step S30) may be performed before the shift of the work position PW (step S40).

[0043] The work end judgment part 55 of the controller 50 judges whether or not a work end condition is satisfied after the end of the motion, which is the release motion in the present embodiment, at the work position PW (work end judgment step; step S30 in FIG. 3). The work end condition is preset as a condition for ending the work by the series of motions over the plurality of cycles. In the present embodiment, the work end condition is a condition for ending the work that is performed by the execution of the series of motions constituted by the motion of capturing the work object WO, the lifting turning motion, the motion of releasing the work object WO, and the return turning motion over the plurality of cycles, i.e., by the repeat of the series of motions. The work end condition can be variously set. The work end condition may either be composed of only a single unit condition or include a plurality of unit conditions. When including the plurality of unit conditions, the work end condition may require that at least one of the plurality of unit conditions be satisfied or that two or more (e.g. all) of the plurality of unit conditions be satisfied.

[0044] The work end condition may include that the number of times by which the series of motions have been performed (the number of cycles) reaches a "preset number of times" that is set in advance. The "preset number of times" is set in the controller 50 in advance of the judgment of the work end condition by the work end judgment part 55. The preset number of times may be set based on information input from the input device 35 to the controller 50 (for

example, a numerical value indicating the number of times of setting). The preset number of times, alternatively, may be automatically calculated by the controller 50. For example, the controller 50 may automatically determine the preset number of times according to a situation around the work machine 10 captured by the imaging device or the like. The preset number of times may be equivalent to an initial value prestored in the controller 50.

[0045] The work end condition, alternatively, may include that the work position PW has reached a "preset position" that is set in advance. Since the work position shifting part 63 shifts the work position PW in accordance with the advance of the series of motions over the plurality of cycles as will be described later, the work end condition is allowed to be set so as to include that the work position PW to be thus shifted has reached the "preset position". The "preset position" is set in the controller 50 (in advance) in advance of the judgment on the work end condition by the work end judgment part 55 of the controller 50. The preset position may be either the same position as the below-described work limit position PWL or a position different from the work limit position PWL. The preset position may include a component in at least one direction of the up-down direction Z and the front-rear direction X. Below will be shown examples of the preset position.

[0046] [Example B1] In the case where the work to be performed at the work position PW is a release of the work object WO, (e.g. earth removal), it is preferable that the preset position is set to such a position that the amount of the work object WO released in the series of motions is appropriate. For example, in the case where the work performed at the work position PW is work of loading the work object WO into a container such as a loading platform, the work limit position is preferably set at such a position as to restrain the work object WO loaded in the container from excess or deficiency.

[0047] [Example B2] In the case where the work performed at the work position PW is capturing the work object WO (for example, excavation), it is preferable that the preset position is set to such a position that the capture of the work object WO can be restrained from excess or deficiency, that is, a position to enable the work to be efficiently performed. Specifically, it is preferable that the preset position is set to such a position that the tip attachment 15d can be restrained from continuing the work motion for the capture work in spite that the work object WO to be captured has been lost. Besides, it is preferable that the preset position is set to such a position that the tip attachment 15d can be restrained from stopping the work motion for the capture work in spite that the work object O to be captured remains still.

[0048] When the work end judgment part 55 judges that the work end condition is satisfied (YES in step S30 shown in FIG. 3), the automatic operation part 53 makes the work by the series of motions over the plurality of cycles ended. When the work end judgment part 55 judges that the work end condition is not satisfied (NO in step S30), the automatic operation part 53 makes the work machine 10 continue the work by the series of motions.

[0049] The work limit position setting part 61 sets the work limit position PWL (work limit position setting step). The work limit position PWL is a position that is the limit of the position to be set as the work position PW, namely, a limit position. When the work position PW is shifted in the up-down direction Z as shown in FIG. 1, the work limit position PWL corresponds to at least one of the upper limit position (the limit on the upper side Za) and the lower limit position (the limit on the lower side Zb) of the work position PW. When the work position PW is shifted in the front-rear direction X as shown in FIG. 7, the work limit position PWL corresponds to at least one of the limit position on the rear side Xb of the work position PW and the limit position on the front side Xa of the work position PW. Based on the work limit position PWL thus set by the work limit position setting part 61, the work position shifting part 63 sets the work position PW within a range in which the work position PW is allowed to be set.

[0050] The work limit position setting part 61 may set the work limit position PWL in various ways. For example, the work limit position PWL may be set based on information on the dimensions, the shapes and the like of the work machine 10, namely, specification information. For example, the work limit position PWL may be set to a position that is the limit of physically reaching for the tip attachment 15d. The work limit position PWL may be set to a position on a boundary between the area the tip attachment 15d can reach and the area the tip attachment 15d cannot reach. The work limit position PWL may be set to a position that is the limit of preventing a specific part of the work machine 10, e.g., the attachment 15, from coming into contact with an obstacle or the like.

[0051] The work limit position setting part 61 may set the work limit position PWL utilizing the teaching that is performed for setting the target trajectory Rt as described above or based on the information having been input to the input device 35, for example, a numerical value. The work limit position setting part 61, alternatively, may be configured to automatically set the work limit position PWL based on the information acquired by an imaging device similar to the imaging device illustrated as the peripheral-object position detector 33. The work limit position PWL, alternatively, may be one that is calculated in advance based on the specification information of the work machine 10 or the like and stored in advance in the work limit position setting part 61.

[0052] The work position shifting part 63 makes the shift of the work position PW, that is, the revision of the work position PW (work position shifting step; step S40 in FIG. 3). The work position shifting part 63 changes the work position PW in accordance with the advance of the series of motions over the plurality of cycles. The work position shifting part 63 may shift the work position PW either for each cycle or for each one or more predetermined number of cycles. The predetermined number may be constant or varied. As shown in FIGS. 1 and 7, the work position shifting part 63 shifts

the work position PW in at least one direction of the up-down direction Z and the front-rear direction X. The work position shifting part 63 may shift the work position PW to both at least one direction of the up-down direction Z and the front-rear direction X and the turning direction Sw.

[0053] In the case where the work performed at the work position PW is the release of the work object WO, the work position shifting part 63 can restrain the tip attachment 15d from coming into contact with a work object WOa having been already released from the tip attachment 15d, namely, a released work object, for example, a stacked work object, by shifting the work position PW in at least one of in the front-rear direction X and to the upper side Za.

[0054] Alternatively, in the case where the work performed at the work position PW is the capture of the work object WO, the work position shifting part 63 enables the tip attachment 15d to efficiently capture the work object WO, for example, the ground, whose shape varies every moment, by shifting the work position PW at least one of in the front-rear direction X and to the lower side Zb. For example, the tip attachment 15d is restrained from making a motion for capturing a work object WO at a position where the work object WO is absent, that is, a position from which the captured work object WO has already been removed.

[0055] For one shift of the work position PW, the work position shifting part 63 shifts the work position PW by a work position shift amount PWSft. Thus, the work position shift amount PWSft is the change amount of the work position PW caused by the one shift of the work position PW by the work position shifting part 63. In other words, the work position shift amount PWSft is the shift amount of the work position PW from the previous work position PWo before the shift by the work position shifting part 63 to the new work position PWa after the shift, namely, the distance therebetween. The work position shift amount PWSft may be set as the change amount from the initial work position PW to the latest work position PW in the target trajectory Rt of the first cycle. The work position shift amount PWSft, alternatively, may be set as the amount of the shift of the work position PW across the previous (most recent) shift.

[0056] For example, in the case where the work position shifting part 63 shifts the work position PW in the up-down direction Z, the height position of the path end position PE corresponding to the target point P(1) is Z(1); the height position at the previous work position PWo (target point Po(N)) is Zo(N); the height position of the shifted work position PWa (target point Pa(N)) is Za(N), wherein Z(i) is the position in the up-down direction Z, namely, the "height position", of each of the target points P(i); Zo(i) is the height position of each of the target points P(i) before the correction; and Za(i) is the height position of each of the target points P(i) after the correction. Regarding the work position shift amount PWSft in the up-down direction Z, namely, the up-down direction shift amount Zsft (N) of the target point P(N), $Zsft(N) = Za(N) - Zo(N)$.

[0057] The manner of the shift of the work position PW by the work position shifting part 63 is not limited. Below will be shown examples of the shift.

[0058] [Example D1] In accordance with the advance of the series of motions, the work position shifting part 63 may shift the work position PW by a constant shift amount Csf stored in the controller 50. According to this example, the work position PW can be shifted by the setting of a simple parameter, that is, the setting of the shift amount Csf.

[0059] [Example D2] The work position shifting part 63 may set the work position PW based on the information acquired by the peripheral-object position detector 33, for example, information on the position of an object present around the work position PW, which is, for example, the work position PW immediately after the performance of the previous work.

[0060] For example, in the case where the work to be performed at the work position is the release of a work object WO, it is preferable that the work position shifting part 63 sets (shifts) the work position PW so as to prevent the tip attachment 15d from coming into contact with an obstacle. The "obstacle" is, for example, the ground, a loading platform, or a released work object WOa.

[0061] For example, in the case where the work position shifting part 63 shifts the work position PW to the upper side Za with the control target part 16 set at the proximal end of the tip attachment 15d, the work position shifting part, for example, sets the work position PW to the position on the upper side Za of the top (the end on the upper side Za) of the released work object WOa by the sum of an effective length LE of the tip attachment 15d and a margin height Hm. The effective length LE is, for example, the length of the tip attachment 15d in the up-down direction Z in the posture with the maximum length of the tip attachment 15d in the up-down direction Z. Such setting of the work position PW restrains the tip attachment 15d from coming into contact with the released work object WOa. The margin height Hm is set, for example, to be greater than the height of the work object WO that is expected to be stacked on the released work object WOa after the work object WO is released from the tip attachment 15d.

[0062] In the case where the work position PW is shifted in the front-rear direction X as shown in FIG. 7, it is preferable that the work position PW is set so as to restrain the tip attachment 15d from coming into contact with a work object similar to the released work object WOa shown in FIG. 1, similarly to the shift in the up-down direction Z.

[0063] For example, in the case where the work to be performed at the work position PW shown in FIG. 1 is the capture of the work object WO, it is preferable that the work position shifting part 63 preferably sets the work position PW at such a position as to allow the tip attachment 15d to capture the work object WO. This enables the work machine 10 to efficiently capture the work object WO.

[0064] [Example D3] Example D1 and Example D2 may be combined with each other. For example, the work position

shifting part 63 may set the work position PW in the series of motions in the first cycle, namely, the initial work position, based on the position information acquired by the peripheral-object position detector 33 and thereafter shift the work position PW by the shift amount Csf in the series of motions of the second and subsequent cycles.

[0065] The work position shifting part 63 does not set the work position PW on the outer side of the work limit position PWL, that is, on the outer side of the area in which the work position PW is allowed to be set. The work position PW is thus limited to the position on the inner side of the work limit position PWL.

[0066] Specifically, when the work position PW calculated by the work position shifting part 63 is on the outer side of the work limit position PWL, that is, when the work position PW has made reached the work limit position PWL by the shift of the work position PW (YES in step S41 in FIG. 3), the work position shifting part 63 sets the work position PW to the work limit position PWL (step S42). Specifically, the work position shifting part 63 revises the work position PW to be shifted from the position provided by the calculation to the work limit position PWL. The automatic operation part 53 may end the series of motions over the plurality of cycles after the performance of the motion for work by the tip attachment 15d at the work position PW that is thus revised to the work limit position PWL (YES in step S30). Alternatively, when the work position PW has reached the work limit position PWL, the series of motions of the plurality of cycles may be ended without the revision of the work position PW to the work limit position PWL (YES in step S30).

[0067] When the work position PW calculated by the work position shifting part 63 is the work limit position PWL or a position on the inner side of the work limit position PWL (NO in step S41 in FIG. 3), the work position shifting part 63 determines the calculated work position PW (step S40) as the actual work position PW as it is (step S43).

[0068] The target trajectory correction part (target path correction part) 65 of the controller 50 makes correction of the target path Pth, that is, correction of the target trajectory Rt in the present embodiment, in accordance with the shift of the work position PW (target trajectory correction step; step S60 in FIG. 3). The target trajectory correction part 65 corrects the portion of the target trajectory Rt between the path end position PE and the work position PW. Out of the information included in the target trajectory Rt, the target trajectory correction part 65 may make either both the correction of the target path Pth and the correction of the target moving speed of the control target part 16 (i.e., the correction of the target section time Tst) or only the correction of the target path Pth between the target path Pth and the target moving speed.

[0069] The target trajectory correction part 65 corrects the target trajectory Rt shown in FIG. 4 based on the work position shift amount PWSft. For example, the target trajectory correction part 65 may correct each of the target points P(i) so as to increase the change amount Psft(i) of the target points P(i) across the correction with an increase in the work position shift amount PWSft.

[0070] For example, in the case where the work position shifting part 63 shifts the work position PW in the up-down direction Z, the target trajectory correction part 65 corrects the position of each of the target points P(i) in the up-down direction Z, namely, the height position, based on the work position shift amount PWSft. More specifically, the target trajectory correction part 65 corrects the target trajectory Rt so as to increase an up-down direction shift amount Zsft(i) with an increase in the work position shift amount PWSft (Zsft(N)) in the up-down direction Z. The up-down direction shift amount Zsft(i) is the shift amount Psft(i) in the up-down direction Z of each of the target points P(i), being the difference between the previous height position Zo(i) and the new height position Za(i) in the up-down direction. For example, the target trajectory correction part 65 may correct the target trajectory Rt so as to increase the up-down direction shift amount Zsft(i) with an approach of the control target part 16 to the work position PW from the path end position PE. This enables the target trajectory correction part 65 to set the corrected target trajectory Rta so as to render the target path Pth from the path end position PE to the new work position PWA smooth.

[0071] More specifically, the target trajectory correction part 65 may calculate a change ratio, for example, a change ratio RTZ shown in FIG. 5, based on the work position shift amount PWSft or the like, and correct the target trajectory Rt based on the change ratio.

[0072] The change ratio RTZ shown in FIG. 5, which is used when the work position PW is shifted in the up-down direction Z, can be represented as in the following Formula 1 by use of a relative height Zdiff.

(Formula 1)

$$RTZ = (Zdiff + Zsft(N)) / Zdiff$$

[0073] The relative height Zdiff is the height of the previous work position PWO relative to the height position of the path end position PE, wherein $Zdiff = Zo(N) - Zo(1)$. In this example, where the height position $Zo(1)$ of the path end position PE is not changed regardless of the correction of the target trajectory Rt, the reference sign Z(1) is given to the height position of the path end position PE in FIG. 4. Besides, in FIG. 4, indicated is the up-down direction shift amount $Zsft(N) (= Za(N) - Zo(N))$, which is the work position shift amount PWSft in the up-down direction Z.

[0074] The target trajectory correction part 65 calculates the height position $Za(i)$ of the corrected target point P(i) based on the following Formula 2.

(Formula 2)

$$Za(i) = Z(1) + (Zo(i) - Z(1)) \times RTZ$$

[0075] FIG. 5 shows a specific example of the height position $Za(i)$ of the target point $P(i)$ in respective corrected target trajectories $Rta1$, $Rta2$, $Rta3$ and $Rta4$ according to the correction examples 1, 2, 3, and 4, namely, the Z-coordinate, each of the height positions $Z(i)$, i.e., Z-coordinates, is calculated based on the change ratio $Zrto$. In these examples, initially set is the Z-coordinate $Z(i)$ of each of the target points $P(i)$ in the target trajectory Rto before correction. Next is determined, for each of the correction examples 1 to 4, the up-down direction shift amount $Zsft$ (N) corresponding to the work position shift amount $Pwsft$ in the up-down direction Z. Next is calculated the change ratio RTZ for each of the correction examples 1 to 4 based on the Z-coordinates of each of the path end position PE ($P(1)$) and the work position PW ($P(N)$) of the target trajectory Rto before correction, the up-down direction shift amount $Zsft$ (N) of the work position PW , and the above Formula 1. Based on the coordinates of the target points $P(i)$ of the target trajectory Rto before correction, the change ratio RTZ and the above Formula 2, then, the Z-coordinates of the plurality of target points $P(i)$ in each of the correction examples 1 to 4 are determined.

[0076] FIG. 6 is a graph showing the result that is obtained as described above, namely, the target trajectory Rto before correction and the target trajectories $Rta1$ to $Rta4$ after the correction according to the correction examples 1 to 4, respectively. FIG. 6 teaches that the correction with the change ratio RTZ being a positive value as in the correction examples 1 to 3 makes the target path Pth (the shape of the graph) of each of the corrected target trajectories ($Rta1$ to $Rta3$) have a shape corresponding to (for example, similar to) the target path Pth of the target trajectory Rto before correction. Besides, FIG. 6 teaches that the correction with the change ratio RTZ being a negative value as in the correction example 4 renders the increase/decrease tendency reverse to that of the target path Pth of the target trajectory Rto before correction, that is, makes the shape of the target path Pth of the target trajectory ($Rta4$) after the correction be a shape corresponding to (for example, similar to) a shape obtained by inverting the target path Pth before correction in the up-down direction Z. For example, if the target path Pth of the target trajectory Rto before correction is smooth curved, each target path Pth of the corrected target trajectory $Rta1$ to $Rta4$ can also be smooth curved.

[0077] Preferably, the target trajectory correction part 65 makes correction of the target moving speed of the control target part 16 (for example, correction of the target section time Tst) so as to minimize the change amount of the speed of the control target part 16 that is moved along the target trajectory Rt shown in FIG. 4 due to the correction.

[0078] For example, the target trajectory correction part 65 may correct the target moving speed of the control target part 16 based on the target moving speed of the attachment 15 before and after the correction of the target trajectory Rt . For example, the target trajectory correction part 65 corrects the target moving speed of the control target part 16 so as to render an after-correction moving speed Va equal to or less than a before-correction moving speed Vo . The before-correction moving speed Vo is the target of the speed at which the control target part 16 is to be moved through a second predetermined portion selected from the target trajectory Rto before the correction, and the after-correction moving speed Va is the target of the speed at which the control target part 16 is to be moved through a portion corresponding to the second predetermined section in the corrected target trajectory Rta . The first predetermined portion is, for example, the section between two consecutive target points $P(n)$ and $P(n+1)$ among the plurality of target points $P(i)$, namely, an inter-two-points section. For example, the target trajectory correction part 65 preferably corrects the target moving speed of the control target part 16 so as to render the after-correction moving speed Va equal to or less than the before-correction moving speed Vo over the entire target trajectory Rt (i.e., all sections).

[0079] More specifically, the target trajectory correction part 65 may correct the target moving speed of the control target part 16, for example, based on the speed of the drive, namely, the driving speed, by the driving part 21 before and after the correction of the target trajectory Rt . For example, the target trajectory correction part 65 corrects the target moving speed of the control target part 16 so as to render an after-correction driving speed VDa equal to or less than a before-correction driving speed VDo . The before-correction driving speed VDo is the driving speed of each of the actuators when the control target part 16 is moved through a second predetermined portion selected from the target trajectory Rto before the correction (for example, an inter-two-points section between two consecutive target points), and the after-correction driving speed VDa is the driving speed of each of the actuators in the driving part 21 when the control target part 16 is moved through a portion corresponding to the second predetermined portion in the target trajectory Rta after the correction. For example, the target trajectory correction part 65 preferably corrects the target moving speed of the control target part 16 so as to render the after-correction driving speed VDa equal to or less than the before-correction driving speed VDo over the entire target trajectory Rt (all the inter-two-points sections).

[0080] For example, the target trajectory correction part 65 corrects the target speed of the control target part 16 so as to render the expansion/contraction speed of the boom cylinder 21b after the correction equal to or less than the speed before correction as to the second predetermined portion of the target trajectory Rto before correction. The same applies to the actuators other than the boom cylinder 21b. The "driving speed of each of the actuators" is, for example, the driving speed (expansion/contraction speed) of each of the boom cylinder 21b, the arm cylinder 21c, and the tip

attachment cylinder 21d. The "driving speed of each of the actuators" may include the driving speed (rotational speed) of the turning motor 21a.

[0081] There will be described further specific examples of the correction by the target trajectory correction part 65 so as to render the after-correction driving speed V_{Da} equal to or less than the before-correction driving speed V_{Do} . These specific examples are based on the premise that respective values of the target movement distances (target expansion/contraction amounts) of the actuators in the section between two consecutive target points (inter-two-point section) in the target trajectory R_{to} before correction shown in FIG. 4 are as follows.

The target moving distance of the boom cylinder 21b: 80mm

The target moving distance of the arm cylinder 21c: 60mm

The target moving distance of the tip attachment cylinder 21d: 40mm

[0082] On the above premise, when the target movement time of the control target part 16 between the two points, namely, the target section time T_{st} , is one second, respective target moving speeds of the actuators in the inter-two-points sections have the following values.

The target moving speed of the boom cylinder 21b: 80mm/s

The target moving speed of the arm cylinder 21c: 60mm/s

The target moving speed of the tip attachment cylinder 21d: 40mm/s

[0083] If the cylinder movement distances (cylinder expansion/contraction amount) in the inter-two-points section in the corrected target trajectory R_{ta} are as follows:

The moving distance of boom cylinder 21b: 120mm

The moving distance of the arm cylinder 21c: 80mm

The movement distance of the tip attachment cylinder 21d: 40mm,

respective required section times T_{sr} , which are respective times required for moving the respective movement distances of the plurality of actuators in order to render the after-correction driving speed V_{Da} equal to the before-correction driving speed V_{Do} , are as follows.

The moving distance of the boom cylinder 21b: 120mm, and the target moving speed: 80mm/s → The required section time T_{sr} : 1.5s

The moving distance of the arm cylinder 21c: 80 mm, and the target moving speed: 60 mm/s → The required section time T_{sr} : 1.33s

The moving distance of the tip attachment cylinder 21d: 40mm, and the target moving speed 40mm/s → The required section time t_{sr} : 1s

[0084] The target trajectory correction part 65 selects the longest time among the required section times T_{sn} which are obtained for the actuators as described above, which time is 1.5s of the boom cylinder 21b in the above example, as the target section time T_{st} in the corrected target trajectory R_{ta} . This renders the driving speed of each actuator in the second predetermined portion (inter-two-point section) after correction, namely, the after-correction driving speed V_{Da} , equal to or less than the driving speed in the second predetermined portion (inter-two-point section) before correction, namely, the before-correction driving speed V_{Do} . More specifically, the after-correction driving speed V_{Da} in the two-point section for each of the boom cylinder 21b, the arm cylinder 21c, and the tip attachment cylinder 21d is rendered equal to or less than the before-correction driving speed V_{Do} in the two-point section.

[0085] The target trajectory correction part 65 may correct the target moving speed of the control target part 16 in accordance with the change amount of the target trajectories R_t across the correction. For example, the target trajectory correction part 65 may correct (determine) the after-correction moving speed V_a in a portion corresponding to a third predetermined portion that is selected from the target trajectory R_{to} before the correction based on the before-correction moving speed V_o in the third predetermined portion and the change amount of the target trajectories R_t across the correction. For example, the target trajectory correction part 65 may correct (determine) the after-correction moving speed V_a in the third predetermined portion based on the before-correction moving speed V_o between the specific two points of the target trajectory R_t and the change amount $Psft(i)$ of any target point $P(i)$ between the specific two points. The "target point $P(i)$ between the specific two points" may be, for example, the target point $P(n+1)$ that is closer one to the work position PW between the two target points $P(n)$ and $P(n+1)$ which are "specific two points".

[0086] The target trajectory correction part 65 may make such a correction as to render the after-correction moving speed V_a in the predetermined portion greater than the before-correction moving speed V_o in the predetermined portion

by an amount that is increased with an increase in the change amount of the target trajectories R_t across the correction (e.g., $Psft(i)$).

[0087] In the case of the shift of the work position PW in the up-down direction Z, the target trajectory correction part 65 may make correction of setting the time obtained by adding a unit correction time Δt_{st} (sec) to a before-correction target section time $T_{sto}(i)$ for 1mm (the unit can be variously changed) of the change amount across the correction at the target point P(i) to an after-correction target section time $T_{sta}(i)$. The before-correction target section time $T_{sto}(i)$ and the after-correction target section time $T_{sta}(i)$ are respective target movement times in a predetermined section in the target trajectory R_{to} before correction and the target trajectory R_{ta} after correction, that is, a predetermined portion that is a section between two consecutive target points P(i-1), P(n). Specifically, the target trajectory correction part 65 can calculate the corrected target section time $T_{sta}(i)$, for example, by use of the following Formula 3.

(Formula 3)

$$T_{sta}(i) = T_{sto}(i) + |(Z_a(i) - Z_o(i))| \times \Delta T_{st}$$

[0088] The unit correction time Δt_{st} can be variously set. For example, the unit correction time Δt_{st} may be set either so as to cause or promote the after-correction moving speed V_a to be equal to or less than the before-correction moving speed V_o or so as to cause or promote the after-correction driving speed V_{Da} to be equal to or less than the before-correction driving speed V_{Do} . The unit correction time Δt_{st} may be set to a negative value in order to render the length of the predetermined portion after the correction, namely, an inter-two-point distance, smaller than that before correction. In short, the target trajectory correction part 65 may make correction to reduce the target section time T_{st} .

[0089] The above embodiments may be variously modified. For example, the number of components (including modification examples) of the above embodiment may be changed, and some of the components may be omitted. For example, the connection of components shown in FIG. 2 may be varied. For example, the inclusion relationship of the components may be variously changed. For example, the components described as components included in a certain generic component may be included in not the generic component but other component. For example, those described as a plurality of members and portions different from each other may be modified to one member or a portion. For example, a component described as a single member or a single part may be divided into a plurality of members or parts different from each other. For example, various parameters (such as the set values, ranges, etc. of the margin height H_m and the like) may be either set in advance in the controller 50 or directly set by the manual operation of a worker. Various parameters may be calculated by the controller 50 based on either information set by the manual operation of the worker or information detected by the sensor such as an imaging device). For example, various parameters may be either of non-changed, manually changed and automatically changed the controller 50 in accordance with some conditions. For example, the order of the steps of the flowchart shown in FIG. 3 may be changed, and a part of the steps may be omitted. For example, each component may have only a part of the feature thereof as to action function, arrangement, shape, actuation, or the like.

[0090] As has been described, there are provided an automatic operation system for performing an automatic operation of a work machine, the system being capable of appropriately resetting a work plan in accordance with a shift of a work position of a tip attachment of the work machine, a work machine, and a program for the automatic operation.

[0091] Provided is an automatic operation system that includes a machine body of a work machine, an attachment, and a controller. The attachment is attached to the machine body capably of making a motion. The attachment includes an attachment body and a tip attachment. The tip attachment includes a control target part and is attached to a tip of the attachment body capably of making a work motion. The attachment body is operable to change a position of the control target part. The controller includes a target path setting part, an automatic operation part, a work position shifting part, and a target path correction part. The target path setting part sets a target path, which is a target of a path along which the control target part is to be moved between a work position where the tip attachment makes the work motion and a path end position away from the work position. The automatic operation part automatically controls the motion of the attachment so as to make the attachment perform a series of motions over a plurality of cycles, the series of motions including a motion of moving the control target part along the target path. The work position shifting part shifts the work position in at least one direction of an up-down direction and a front-rear direction of the attachment in accordance with an advance of the series of motions over the plurality of cycles. The target path correction part corrects a portion of the target path between the path end position and the work position in accordance with the shift of the work position.

[0092] The target trajectory correction part, which corrects the target path based on the shift of the work position, can appropriately reset (correct) a work plan in accordance with the shift of the work position. The target trajectory correction part, for example, can eliminate or reduce the time and effort for an operator to manually reset a target path upon the shift of the work position.

[0093] Specifically, it is preferable that the target path includes a plurality of target points, each of which is information on a target position of the control target part, and the target path correction part is configured to correct each of the

target points so as to increase a change amount of the target points across the correction with an increase in the work position change amount. The thus configured target path correction part can make appropriate correction of the target path with high accuracy.

[0094] It is preferable that the target path correction part is configured to correct a target moving speed of the control target part so as to render an after-correction moving speed equal to or less than a before-correction moving speed. The before-correction moving speed is a target of a speed at which the control target part is to be moved through a first predetermined portion selected from the target path before correction, and the before-correction moving speed is a target of a speed at which the control target part is to be moved through a portion corresponding to the first predetermined portion in the corrected target path. The correction prevents the after-correction moving speed from being larger than the before-correction moving speed, thereby restraining the movement of the attachment from giving anxiety to an operator.

[0095] It is preferable that the automatic operation system further includes a plurality of actuators for driving the attachment wherein the target path correction part is configured to correct a target moving speed of the control target part in the target path so as to render an after-correction driving speed equal to or less than a before-correction driving speed. The before-correction driving speed is the driving speed of each of the actuators when the control target part is moved through a second predetermined portion selected from the target path before the correction, and the after-correction driving speed is the driving speed of each of the actuators when the control target part is moved through a portion corresponding to the second predetermined portion in the target path after the correction. The correction prevents the after-correction driving speed from being larger than the before-correction driving speed, thereby preventing the movement of the attachment from giving anxiety to the operator.

[0096] It is preferable that the target path correction part is configured to correct a target moving speed of the control target part in a portion corresponding to a three predetermined portion in the corrected target path based on the target moving speed of the control target part in the third predetermined portion selected from the target path before correction and a change amount of the target path across the correction. The correction allows the target moving speed after the correction of the control target part to be appropriately set according to the change amount of the target path across the correction, thereby reducing discomfort to be given to the operator.

[0097] It is preferable that the target path correction part is configured to render a before-correction moving speed greater than an after-correction moving speed by a change amount that is increased with an increase in the change amount of the target path across the correction. The before-correction moving speed is a target of the speed at which the control target part is to be moved through a third predetermined portion selected from the target path before the correction, and the after-correction moving speed is a target of the speed at which the control target part is to be moved through a portion corresponding to the third predetermined portion in the target path after the correction. The correction allows the target moving speed of the control target part to be appropriately set in accordance with the change amount of the target path across the correction, thereby enabling a sense of incongruity given to an operator to be more reliably reduced.

[0098] It is preferable that the work position shifting part is configured to shift the work position by a preset shift amount in accordance with an advance of the series of operations over the plurality of cycles. This allows the controller to shift the work position with a simple configuration only for storing the shift amount.

[0099] It is preferable that the automatic operation system further includes a peripheral-object position detector that acquires peripheral-object position information that is information about the position of a peripheral object present around the work position, wherein the work position shifting part is configured to shift the work position based on the peripheral-object position information acquired by the peripheral-object position detector. This enables an appropriate work position for allowing the tip attachment to efficiently perform work to be set.

[0100] It is preferable that the controller further includes a work limit position setting part, which sets a work limit position that is a limit of a work position setting allowable range within which the work position is allowed to be set, wherein the work position shifting part is configured to shift the work position within the work position setting allowable range based on the work limit position set by the work limit position setting part.

[0101] The work limit position setting part can confine the work position to be shifted by the work position shifting part within the work position setting allowable range.

[0102] It is preferable that the controller further includes a work end judgment part, and the work end judgment part judges whether or not a work end condition that is set for ending the work by the series of operations over the plurality of cycles is satisfied. The work end condition may include either that the number of the plurality of cycles, which is the number of times the series of operations have been performed, reaches a preset number of times, or that the work position shifted by the work position shifting part has reached a preset position that is set in advance. Any of these conditions allows the work to be ended at a preferred timing.

[0103] Also provided is a work machine including a machine body, an attachment, and a controller. The attachment is attached to the machine body capably of making a motion. The attachment includes an attachment body and a tip attachment. The tip attachment includes a control target part and is attached to a tip of the attachment body capably of

making a work motion. The attachment body is operable to change a position of the control target part. The controller is installed on at least one of the machine body and the attachment. The controller includes a target path setting part, an automatic operation part, a work position shifting part, and a target path correction part. The target path setting part sets a target path, which is a target of a path along which the control target part is to be moved between a work position where the tip attachment makes the work motion and a path end position away from the work position. The automatic operation part automatically controls the motion of the attachment so as to make the attachment perform a series of motions over a plurality of cycles, the series of motions including a motion of moving the control target part along the target path. The work position shifting part shifts the work position in at least one direction of an up-down direction and a front-rear direction of the attachment in accordance with an advance of the series of motions over the plurality of cycles. The target path correction part corrects a portion of the target path between the path end position and the work position in accordance with the shift of the work position.

[0104] Also provided is an automatic operation program used for a work machine including a machine body and an attachment. The attachment is attached to the machine body capably of making a motion. The attachment includes an attachment body and a tip attachment. The tip attachment includes a control target part and is attached to a tip of the attachment body capably of making a work motion. The attachment body is operable to change a position of the control target part. The automatic operation program makes a computer execute a target path setting step, an automatic operation step, a work position shifting step and a target path correction step. The target path setting step is a step of setting a target path, which is a target of a path along which the control target part is to be moved between a work position where the tip attachment makes the work motion and a path end position away from the work position. The automatic operation step is a step of automatically controlling a motion of the attachment so as to make the attachment perform a series of motions over a plurality of cycles, the series of motions including a motion of moving the control target part along the target path. The work position shifting step is a step of shifting the work position in at least one direction of an up-down direction and a front-rear direction of the attachment in accordance with an advance of the series of motions over the plurality of cycles. The target path correction step is a step of correcting a portion of the target path between the path end position and the work position in accordance with the shift of the work position.

[0105] Also provided is a recording medium on which the automatic operation program is recorded. The automatic operation program can be read by the computer.

Claims

1. An automatic operation system for performing automatic operation of a work machine, comprising:

a machine body of the work machine;

an attachment attached to the machine body capably of making a motion and including an attachment body and a tip attachment, the tip attachment including a control target part and attached to a tip of the attachment body capably of making a work motion, the attachment body being operable to change a position of the control target part; and

a controller including:

a target path setting part that sets a target path, which is a target of a path along which the control target part is to be moved between a work position where the tip attachment makes the work motion and a path end position away from the work position;

an automatic operation part that automatically controls the motion of the attachment so as to make the attachment perform a series of motions over a plurality of cycles, the series of motions including a motion of moving the control target part along the target path;

a work position shifting part that shifts the work position in at least one direction of an up-down direction and a front-rear direction of the attachment in accordance with an advance of the series of motions over the plurality of cycles; and

a target path correction part that corrects a portion of the target path between the path end position and the work position in accordance with a shift of the work position by the work position shifting part.

2. The automatic operation system according to claim 1, wherein the target path includes a plurality of target points, each of which is information on a target position of the control target part, and the target path correction part corrects each of the target points so as to increase a change amount of each of the target points across correction with an increase in a work position change amount that is a change amount of the work position.

3. The automatic operation system according to claim 1 or 2, wherein the target path correction part is configured to

correct a target moving speed of the control target part so as to render an after-correction moving speed equal to or less than a before-correction moving speed, the before-correction moving speed being a target of a speed at which the control target part is to be moved through a first predetermined portion selected from the target path before correction, the after-correction moving speed being a target of a speed at which the control target part is to be moved through a portion corresponding to the first predetermined portion in the target path after the correction.

4. The automatic operation system according to claim 1 or 2, further comprising a plurality of actuators for driving the attachment, wherein the target path correction part is configured to correct a target moving speed of the control target part in the target path so as to render a plurality of after-correction driving speeds equal to or less than a plurality of before-correction driving speeds, respectively, the plurality of before-correction driving speeds being respective driving speeds of the actuators when the control target part is moved through a second predetermined portion selected from the target path before correction, the plurality of after-correction driving speeds being respective driving speeds of the actuators when the control target part is moved through a portion corresponding to the second predetermined portion in the target path after the correction.

5. The automatic operation system according to claim 1 or 2, wherein the target path correction part is configured to correct an after-correction moving speed that is a target of a speed at which the control target part is to be moved in a third predetermined portion in the target path after correction based on a before-correction moving speed that is a target of a speed at which the control target part is to be moved in the third predetermined portion selected from the target path before the correction and a change amount of the target path across the correction.

6. The automatic operation system according to claim 5, wherein the target path correction part renders the after-correction moving speed greater than the before-correction moving speed by a change amount that is increased with an increase in a change amount of the target path across the correction.

7. The automatic operation system according to any one of claims 1 to 6, wherein the work position shifting part is configured to shift the work position by a preset shift amount in accordance with the advance of the series of operations over the plurality of cycles.

8. The automatic operation system according to any one of claims 1 to 6, further comprising a peripheral-object position detector that acquires peripheral-object position information that is information about a position of a peripheral object present around the work position, wherein the work position shifting part is configured to shift the work position based on the peripheral-object position information acquired by the peripheral-object position detector.

9. The automatic operation system according to any one of claims 1 to 8, wherein the controller further includes a work limit position setting part that sets a work limit position that is a limit of a work position setting allowable range that is a range within which the work position is allowed to be set, and the work position shifting part is configured to shift the work position within the work position setting allowable range based on the work limit position set by the work limit position setting part.

10. The automatic operation system according to any one of claims 1 to 9, wherein the controller further includes a work end judgment part that judges whether or not a work end condition that is set for ending the work by the series of motions over the plurality of cycles is satisfied, the work end condition including that the number of times the series of operations have been performed reaches a preset number of times.

11. The automatic operation system according to any one of claims 1 to 9, wherein the controller further includes a work end judgment part that judges whether or not a work end condition that is set for ending the work by the series of motions over the plurality of cycles is satisfied, the work end condition including that the work position shifted by the work position shifting part has reached a preset position that is set in advance.

12. A work machine comprising:

a machine body;

an attachment attached to the machine body capably of making a motion for performing work and including an attachment body and a tip attachment, the tip attachment including a control target part and attached to a tip of the attachment body capably of making a work motion, the attachment body being operable to change a position of the control target part; and

a controller installed on at least one of the machine body and the attachment, the controller including:

a target path setting part that sets a target path, which is a target of a path along which the control target part is to be moved between a work position where the tip attachment makes the work motion and a path end position away from the work position;

an automatic operation part that automatically controls the motion of the attachment so as to make the attachment perform a series of motions over a plurality of cycles, the series of motions including a motion of moving the control target part along the target path;

a work position shifting part that shifts the work position in at least one direction of an up-down direction and a front-rear direction of the attachment in accordance with an advance of the series of motions over the plurality of cycles; and

a target path correction part that corrects a portion of the target path between the path end position and the work position in accordance with a shift of the work position by the work position shifting part.

- 13.** An automatic operation program for performing automatic operation of a work machine including a machine body and an attachment attached to the machine body capably of making a motion for performing work, the attachment including an attachment body and a tip attachment, which includes a control target part and is attached to a tip of the attachment body capably of making a work motion for performing work of releasing the work target, the attachment body being operable to change a position of the control target part, the automatic operation program making a computer execute:

a target path setting step of setting a target path, which is a target of a path along which the control target part is to be moved between a work position at which the tip attachment makes the work motion and a path end position away from the work position;

an automatic operation step of automatically controlling a motion of the attachment so as to make the attachment perform a series of motions over a plurality of cycles, the series of motions including a motion of moving the control target part along the target path;

a work position shifting step of shifting the work position in at least one direction of an up-down direction and a front-rear direction of the attachment in accordance with an advance of the series of motions over the plurality of cycles; and

a target path correction step of correcting a portion of the target path between the path end position and the work position in accordance with a shift of the work position.

- 14.** A recording medium on which the automatic operation program according to claim 13 is recorded, wherein the automatic operation program can be read by the computer.

FIG. 1

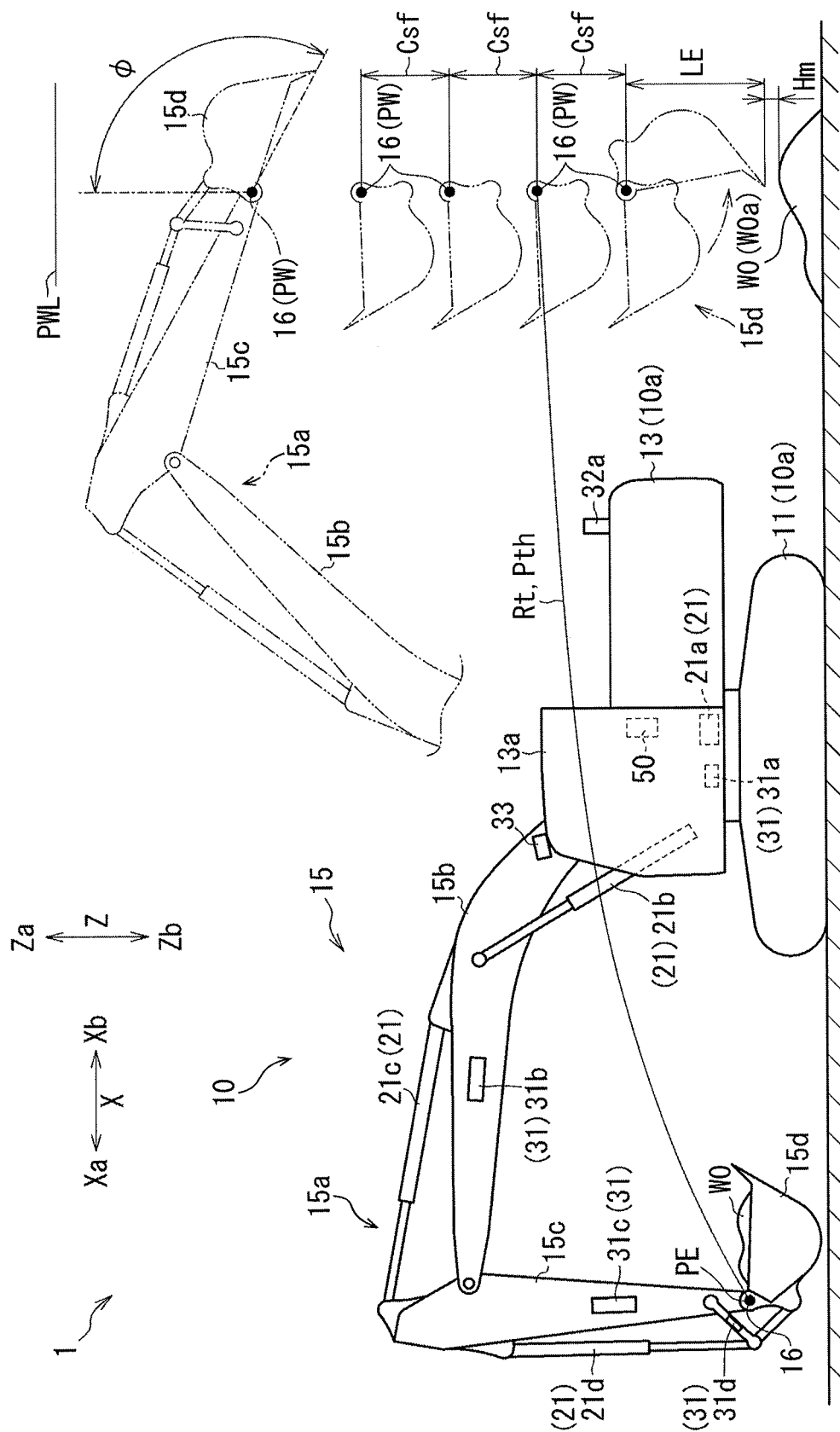


FIG.2

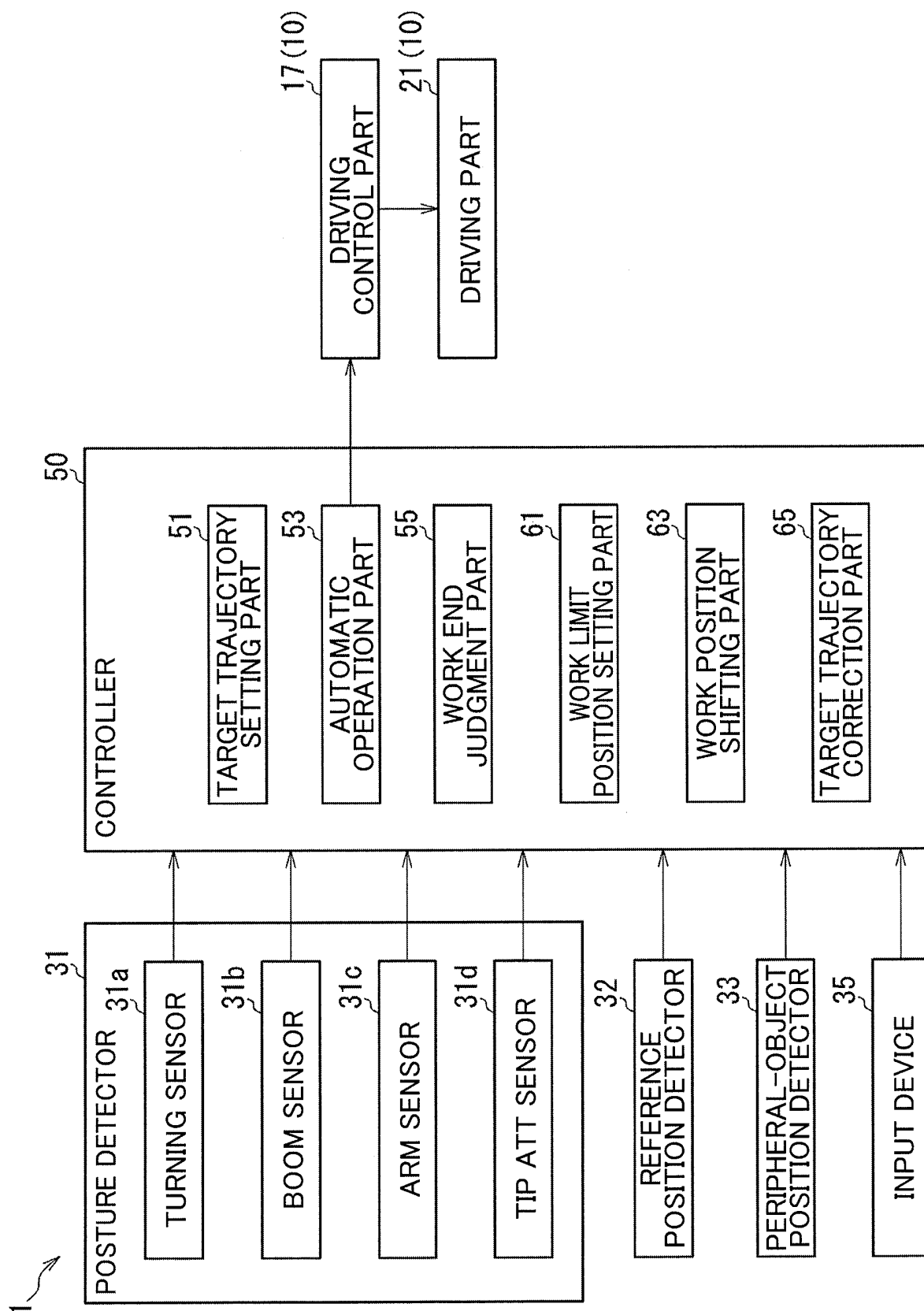


FIG.3

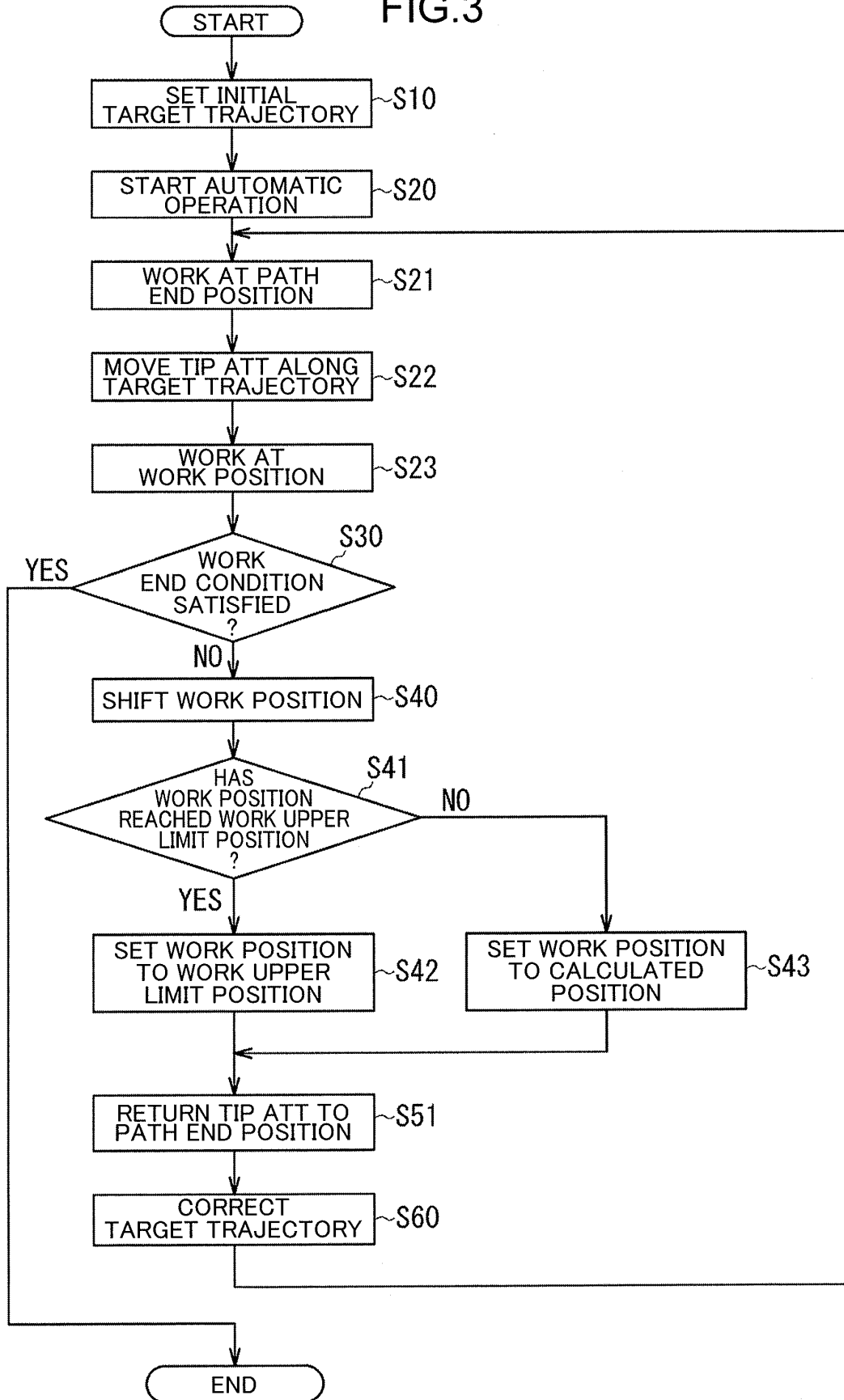


FIG.4

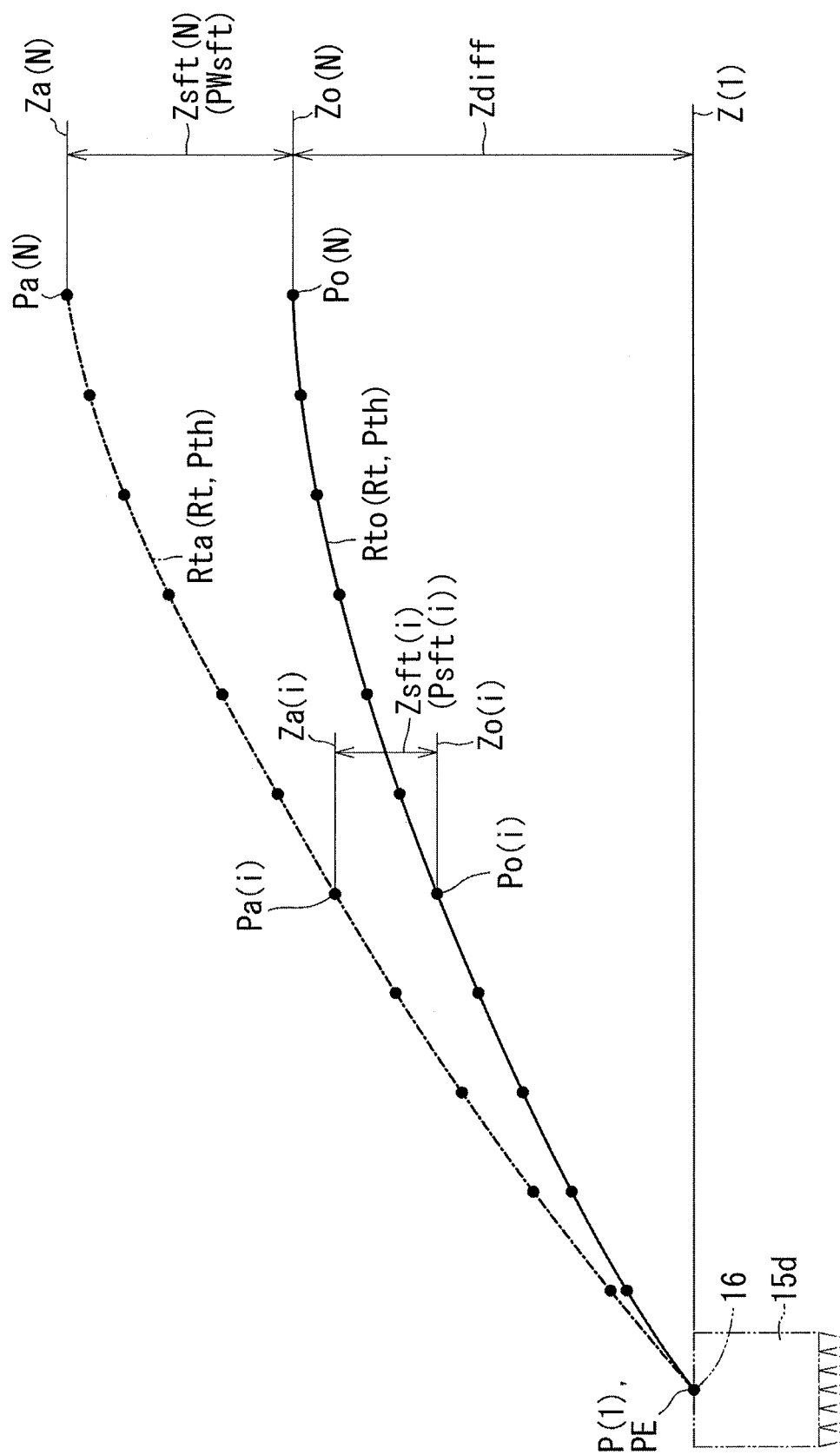
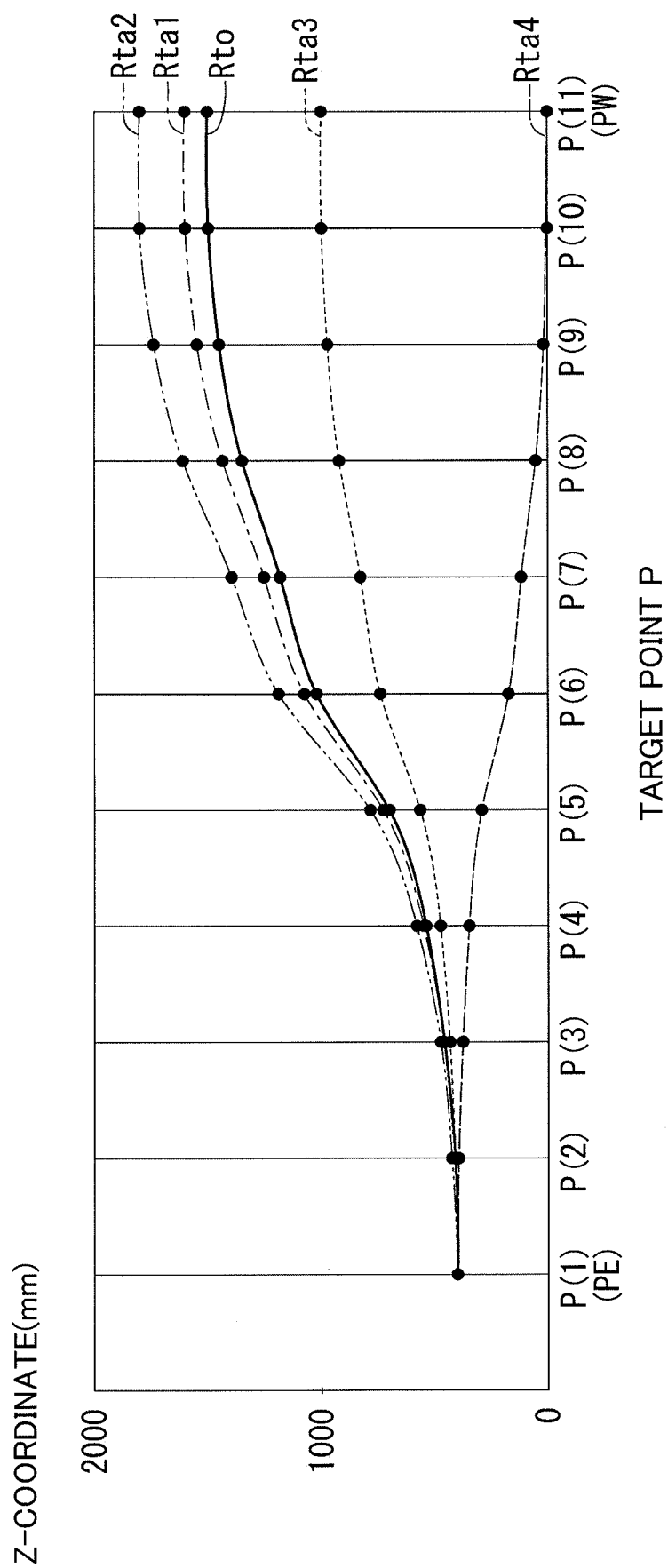


FIG.5

TARGET POINT P(i)	Z-COORDINATE (mm)				
	TARGET TRAJECTORY BEFORE CORRECTION Rto	TARGET TRAJECTORY ACCORDING TO CORRECTION EXAMPLE 1 Rta1	TARGET TRAJECTORY ACCORDING TO CORRECTION EXAMPLE 2 Rta2	TARGET TRAJECTORY ACCORDING TO CORRECTION EXAMPLE 3 Rta3	TARGET TRAJECTORY ACCORDING TO CORRECTION EXAMPLE 4 Rta4
P(1)	400	400	400	400	400
P(2)	420	422	425	411	393
P(3)	460	465	476	433	378
P(4)	540	553	578	476	349
P(5)	700	727	782	564	291
P(6)	1020	1076	1189	738	175
P(7)	1180	1251	1393	825	116
P(8)	1350	1436	1609	918	55
P(9)	1450	1545	1736	973	18
P(10)	1500	1600	1800	1000	0
P(11)	1500	1600	1800	1000	0

	TARGET TRAJECTORY BEFORE CORRECTION Rto	TARGET TRAJECTORY ACCORDING TO CORRECTION EXAMPLE 1 Rta1	TARGET TRAJECTORY ACCORDING TO CORRECTION EXAMPLE 2 Rta2	TARGET TRAJECTORY ACCORDING TO CORRECTION EXAMPLE 3 Rta3	TARGET TRAJECTORY ACCORDING TO CORRECTION EXAMPLE 4 Rta4
Zsft(N)		100	300	-500	-1500
RTZ		1.09	1.27	0.55	-0.36

FIG.6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/002286

A. CLASSIFICATION OF SUBJECT MATTER <i>E02F 3/43</i> (2006.01)i; <i>E02F 9/22</i> (2006.01)i FI: E02F3/43 A; E02F9/22 E According to International Patent Classification (IPC) or to both national classification and IPC																											
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) E02F9/20-E02F9/22, E02F3/42-E02F3/43, E02F3/84-E02F3/85 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Published examined utility model applications of Japan 1922-1996 Published unexamined utility model applications of Japan 1971-2023 Registered utility model specifications of Japan 1996-2023 Published registered utility model applications of Japan 1994-2023 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)																											
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>JP 2021-059945 A (SUMITOMO HEAVY INDUSTRIES) 15 April 2021 (2021-04-15) paragraphs [0078]-[0245], fig. 1-11</td> <td>1-9, 11-14</td> </tr> <tr> <td>Y</td> <td>paragraphs [0078]-[0245], fig. 1-11</td> <td>8-10</td> </tr> <tr> <td>X</td> <td>JP 2018-016975 A (KOMATSU MFG CO LTD) 01 February 2018 (2018-02-01) paragraphs [0015]-[0110], fig. 1-16</td> <td>1-14</td> </tr> <tr> <td>X</td> <td>WO 2019/181872 A1 (SUMITOMO HEAVY INDUSTRIES) 26 September 2019 (2019-09-26) paragraphs [0089]-[0208], fig. 6-15</td> <td>1-7, 11-14</td> </tr> <tr> <td>Y</td> <td>paragraphs [0089]-[0208], fig. 6-15</td> <td>8-10</td> </tr> <tr> <td>Y</td> <td>JP 2021-188364 A (KOMATSU MFG CO LTD) 13 December 2021 (2021-12-13) paragraph [0055]</td> <td>10</td> </tr> <tr> <td>A</td> <td>JP 2016-089559 A (HITACHI CONSTRUCTION MACHINERY) 23 May 2016 (2016-05-23)</td> <td>1-14</td> </tr> <tr> <td>A</td> <td>JP 2020-033825 A (KOMATSU MFG CO LTD) 05 March 2020 (2020-03-05)</td> <td>1-14</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	JP 2021-059945 A (SUMITOMO HEAVY INDUSTRIES) 15 April 2021 (2021-04-15) paragraphs [0078]-[0245], fig. 1-11	1-9, 11-14	Y	paragraphs [0078]-[0245], fig. 1-11	8-10	X	JP 2018-016975 A (KOMATSU MFG CO LTD) 01 February 2018 (2018-02-01) paragraphs [0015]-[0110], fig. 1-16	1-14	X	WO 2019/181872 A1 (SUMITOMO HEAVY INDUSTRIES) 26 September 2019 (2019-09-26) paragraphs [0089]-[0208], fig. 6-15	1-7, 11-14	Y	paragraphs [0089]-[0208], fig. 6-15	8-10	Y	JP 2021-188364 A (KOMATSU MFG CO LTD) 13 December 2021 (2021-12-13) paragraph [0055]	10	A	JP 2016-089559 A (HITACHI CONSTRUCTION MACHINERY) 23 May 2016 (2016-05-23)	1-14	A	JP 2020-033825 A (KOMATSU MFG CO LTD) 05 March 2020 (2020-03-05)	1-14
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex. <table border="0"> <tr> <td>* Special categories of cited documents:</td> <td>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>"A" document defining the general state of the art which is not considered to be of particular relevance</td> <td>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>"E" earlier application or patent but published on or after the international filing date</td> <td>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>"&" document member of the same patent family</td> </tr> <tr> <td>"O" document referring to an oral disclosure, use, exhibition or other means</td> <td></td> </tr> <tr> <td>"P" document published prior to the international filing date but later than the priority date claimed</td> <td></td> </tr> </table>	* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family	"O" document referring to an oral disclosure, use, exhibition or other means		"P" document published prior to the international filing date but later than the priority date claimed																
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Date of the actual completion of the international search 02 March 2023	Date of mailing of the international search report 14 March 2023																										
Name and mailing address of the ISA/JP Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan	Authorized officer Telephone No.																										

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/002286

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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