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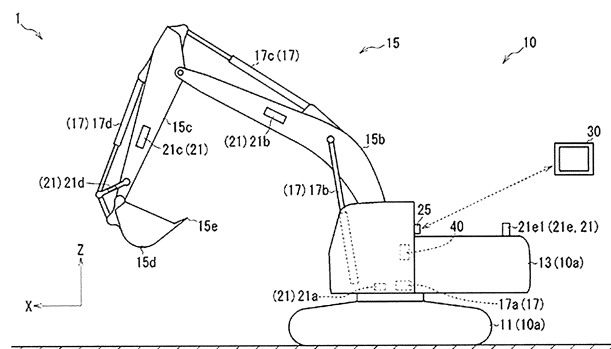
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(54) **TRAJECTORY-GENERATING SYSTEM AND WORK MACHINE COMPRISING SAME**

(57) A trajectory generating system includes a target trajectory setting unit and a target trajectory correcting unit. The target trajectory setting unit sets a reference target trajectory that is a target for a movement of a specific portion of an attachment and includes a reference target path including a plurality of target points and time information that is information about a time for a movement of the specific portion along the plurality of target points. The target trajectory correcting unit specifies a

pre-correction modification point on the reference target trajectory, sets a corrected target path including a post-correction modification point obtained by modifying the pre-correction modification point, and sets the time information in the corrected target path based on at least one of information about a speed of the attachment on the reference target trajectory and information about a preset upper limit of the speed of the attachment.

FIG.1



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Description

Technical Field

[0001] The present invention relates to a trajectory generating system that generates a target trajectory of an attachment of a work machine and a work machine including the same.

Background Art

[0002] For example, Patent Literature 1 discloses a technique that corrects a target point (soil release position) of an attachment of a work machine.

Citation List

Patent Literature

[0003] Patent Literature 1: JP 2000-64359 A

[0004] Patent Literature 1 discloses that a position of one target point among a series of operations of the attachment is corrected. Patent Literature 1, however, does not disclose how a series of operations of the attachment is performed in a case where the target point is corrected. Therefore, the movement of the attachment after the correction of the target point might give a feeling of anxiety to a worker around the work machine.

Summary of Invention

[0005] An object of the present invention is to provide a trajectory generating system that can prevent a movement of an attachment from giving a feeling of anxiety to a worker around a work machine in a case where a target trajectory of the attachment is corrected, and the work machine including the system.

[0006] The present invention provides a trajectory generating system. The trajectory generating system is used in the work machine including a machine body and an attachment. The trajectory generating system includes a target trajectory setting unit and a target trajectory correcting unit. The attachment is mounted on the machine body. The target trajectory setting unit sets a reference target trajectory that is a target for a movement of a specific portion of the attachment, the reference target trajectory including a reference target path including a plurality of target points and time information that is information about a time for the movement of the specific portion along the plurality of target points. The target trajectory correcting unit corrects the reference target trajectory. In a case where a predetermined path correcting condition is satisfied, the target trajectory correcting unit specifies at least one pre-correction modification point among the plurality of target points on the reference target trajectory, and sets a post-correction modification point obtained by modifying a position of the pre-correction modification point, thus setting a corrected target

path including the post-correction modification point. In addition, in a case where a predetermined time correcting condition is satisfied, the target trajectory correcting unit sets the time information in the target path based on at least one of information about a speed of the attachment on the reference target trajectory and information about a preset upper limit of the speed of the attachment.

[0007] The present invention provides the work machine including a machine body, an attachment that is attached to the machine body and performs work, and the trajectory generating system according to any one of the above descriptions.

Brief Description of Drawings

[0008]

FIG. 1 is a side view of a work machine or the like to which a trajectory generating system according to one embodiment of the present invention is applied. FIG. 2 is a block diagram of the trajectory generating system according to one embodiment of the present invention.

FIG. 3 is a diagram illustrating a target trajectory of a specific portion of an attachment illustrated in FIG. 1.

FIG. 4 is a flowchart of target trajectory correction processing executed by the trajectory generating system according to an embodiment of the present invention.

FIG. 5 is a table illustrating information about a pre-correction target trajectory TRa illustrated in FIG. 3. FIG. 6 is a table illustrating information about a post-correction target trajectory TRb illustrated in FIG. 3. FIG. 7 is a table showing information about the pre-correction target trajectory TRa illustrated in FIG. 3, and is a table in a case where a slewing speed at a pre-correction modification point Pa is 0.

Description of Embodiments

[0009] A trajectory generating system 1 according to one embodiment of the present invention will be described with reference to FIGS. 1 to 7. FIG. 1 is a side view of a work machine or the like to which the trajectory generating system according to the present embodiment is applied. FIG. 2 is a block diagram of the trajectory generating system according to the present embodiment. FIG. 3 is a diagram illustrating a target trajectory of a specific portion of an attachment illustrated in FIG. 1.

[0010] The trajectory generating system 1 is a system that generates a target trajectory TR (see FIG. 3) of a specific portion 15e of an attachment 15 of a work machine 10 illustrated in FIG. 1. The trajectory generating system 1 includes an attitude sensor 21, a situation detection unit 23 (see FIG. 2), a communication device 25, a mobile terminal 30, and a controller 40. Note that, in the present embodiment, the work machine 10 includes

the trajectory generating system 1, but the trajectory generating system 1 or a part thereof may be disposed at a place different from the work machine 10.

[0011] The work machine 10 is a machine that performs work, for example, a construction machine such as an excavator that performs construction work. The work machine 10 is configured to be automatically driven by the controller 40. The work machine 10 includes a machine body 10a, the attachment 15, an actuator 17, and a drive control unit 19 (see FIG. 2).

[0012] The machine body 10a is a main portion of the work machine 10. The machine body 10a includes a lower travelling body 11 and an upper slewing body 13. The lower travelling body 11 can travel on a traveling surface such as a ground surface. The lower travelling body 11 includes, for example, a crawler. The upper slewing body 13 is mounted on the lower travelling body 11 so as to be able to slew about a slewing center shaft extending in an up-down direction.

[0013] The attachment 15 is a portion for performing work, and is attached to the machine body 10a (more specifically, the upper slewing body 13). The attachment 15 includes a boom 15b, an arm 15c, and a distal end attachment 15d. The boom 15b is mounted on the upper slewing body 13 so as to be able to be raised and lowered (rotatable in an up-down direction Z). The arm 15c is rotatably mounted on the boom 15b. The distal end attachment 15d is provided at a distal end of the attachment 15 and is rotatably mounted on the arm 15c. The distal end attachment 15d may be a bucket that excavates (scoops), for example, earth, a device (a grapple or the like) that pinches an object, or a device (a breaker or the like) that crushes or excavates an object. A specific portion of the attachment 15 is referred to as a specific portion 15e. The specific portion 15e is a portion that moves along the target trajectory TR (see FIG. 3) generated by the trajectory generating system. In the example illustrated in FIGS. 1 and 3, the specific portion 15e is a distal end of the distal end attachment 15d (more specifically, a bucket). The specific portion 15e may be, for example, a proximal end of the distal end attachment 15d (a connection portion between the distal end attachment 15d and the arm 15c) or the like.

[0014] The actuator 17 moves the work machine 10. The actuator 17 includes a slewing motor 17a, a boom cylinder 17b, an arm cylinder 17c, and a distal end attachment cylinder 17d. The slewing motor 17a slews the upper slewing body 13 with respect to the lower travelling body 11. The slewing motor 17a may be a hydraulic motor or an electric motor. The boom cylinder 17b raises and lowers the boom 15b with respect to the upper slewing body 13. The boom cylinder 17b is, for example, a hydraulic telescopic cylinder (hydraulic cylinder) (the same applies to the arm cylinder 17c and the distal end attachment cylinder 17d). The arm cylinder 17c rotationally moves the arm 15c with respect to the boom 15b. The distal end attachment cylinder 17d rotationally moves the distal end attachment 15d with respect to the arm 15c.

Note that, in a case where the distal end attachment 15d itself can be driven like, for example, a device that pinches an object, a cylinder or a motor for driving the distal end attachment 15d may be provided.

[0015] The drive control unit 19 (see FIG. 2) controls the operation of the actuator 17. The drive control unit 19 may include a hydraulic circuit or an electric circuit. Note that an operation unit, not illustrated, operated by an operator is disposed in the cab of the work machine 10. Further, in a case where the drive control unit 19 includes a hydraulic circuit, the hydraulic circuit includes a hydraulic pump that discharges hydraulic oil and a control valve interposed between the hydraulic pump and the actuator 17. The control valve opens so as to adjust a supply amount of hydraulic oil to the actuator 17 in accordance with the operation direction and the operation amount of the operation input to the operation unit. Note that in a case where the controller 40 automatically drives the work machine 10, regardless of an operation input to the operation unit, an operation control unit 45 (FIG. 2), described later, forcibly inputs a command signal to the drive control unit 19.

[0016] The attitude sensor 21 detects an attitude of the work machine 10. The attitude sensor 21 may include a sensor (for example, a rotary encoder) that detects an angle, a sensor that detects an inclination with respect to a horizontal plane, or a sensor that detects a stroke of a hydraulic cylinder that drives the attachment 15. Further, the attitude sensor 21 may detect the attitude of the work machine 10 based on at least one of a two-dimensional image and a distance image. In this case, the two-dimensional image or the distance image may be captured by an imaging device 23a (see FIG. 2, described later). The attitude sensor 21 may be mounted on the work machine 10 or may be disposed outside the work machine 10 (for example, at a work site) (the same also applies to the situation detection unit 23, the communication device 25, and the controller 40). For example, the attitude sensor 21 includes a slewing angle sensor 21a, a boom angle sensor 21b, an arm angle sensor 21c, a distal end attachment angle sensor 21d, and a reference position sensor 21e.

[0017] The slewing angle sensor 21a detects a slewing angle of the upper slewing body 13 with respect to the lower travelling body 11. The boom angle sensor 21b detects a rotation angle of the boom 15b with respect to the upper slewing body 13. The arm angle sensor 21c detects a rotation angle of the arm 15c with respect to the boom 15b. The distal end attachment angle sensor 21d detects a rotation angle of the distal end attachment 15d with respect to the arm 15c. The reference position sensor 21e detects the position and orientation of the work machine 10 with respect to the work site. The reference position sensor 21e may perform detection with a positioning system. The positioning system may be a satellite positioning system, such as, a global navigation satellite system (GNSS). In this case, the reference position sensor 21e may include a GNSS antenna 21e1

and the like. The positioning system may use a total station.

[0018] The situation detection unit 23 (see FIG. 2) detects a situation of the work machine 10. The situation detection unit 23 may detect a situation (machine condition, work condition, etc.) of the work machine 10 itself or may detect a situation around the work machine 10. In the present embodiment, the situation detection unit 23 includes the imaging device 23a. The imaging device 23a images an imaging object. The "imaging object" may be the work machine 10 or an object around the work machine 10. The imaging device 23a may detect two-dimensional information about an imaging object (for example, a position and a shape). The imaging device 23a may detect three-dimensional information about an imaging object or may acquire an image (distance image) having distance information (depth information). The imaging device 23a may detect three-dimensional information about an imaging object based on a distance image and a two-dimensional image. The imaging device 23a may include a camera (monocular camera) that detects two-dimensional information. The imaging device 23a may include a device that detects three-dimensional information with laser light, and may include, for example, a light detection and ranging (LIDAR), or, for example, a time of flight (TOF) sensor. The imaging device 23a may include a device (for example, a millimeter wave radar) that detects three-dimensional information using radio waves. The imaging device 23a may include a stereo camera.

[0019] The communication device 25 performs communication. For example, the communication device 25 performs communication between the controller 40 and the mobile terminal 30. In addition, the communication device 25 may perform communication between the controllers 40 disposed outside and inside the work machine 10. Communication by the communication device 25 may include at least one of wireless communication, wired communication, and optical communication.

[0020] The mobile terminal 30 is a device (computer) used by a worker. The mobile terminal 30 may be, for example, a tablet or a smartphone. As illustrated in FIG. 2, the mobile terminal 30 includes an operation unit 31 and a display unit 33.

[0021] The operation unit 31 is operated by a worker. For example, in the operation unit 31, an operation for performing a setting related to an automatic operation of the work machine 10 (see FIG. 1) may be performed. In the operation unit 31, an operation for instructing setting or correction of the target trajectory TR (see FIG. 3, described later) may be performed.

[0022] The display unit 33 performs display. The display unit 33 displays information about the target trajectory TR (see FIG. 3). For example, the display unit 33 performs display related to a post-correction target trajectory TRb (see FIG. 3), described later. Note that the device provided with the display unit 33 (for example, the mobile terminal 30) and the device provided with the op-

eration unit 31 may be integrated or separated.

[0023] The controller 40 is a computer that inputs and outputs signals, performs arithmetic (processing), stores information, and the like. For example, the function of the controller 40 is implemented by causing an arithmetic unit to execute a program stored in a storage unit of the controller 40. For example, the controller 40 acquires information about the attitude of the work machine 10 (see FIG. 1) detected by the attitude sensor 21. For example, the controller 40 causes the drive control unit 19 to automatically operate the work machine 10. The controller 40 sets and corrects the target trajectory TR (see FIG. 3). Note that the controller 40 may be provided separately from the mobile terminal 30 or may be provided in the mobile terminal 30. The controller 40 functions to include functional units of a target trajectory setting unit 41, a target trajectory correcting unit 43, and an operation control unit 45 by the arithmetic unit executing the program stored in the storage unit. These functional units do not have substance and correspond to units of functions executed by the program. That is, it can be said that control executed by these functional units is substantially integrally executed by the controller 40. Note that the functional units may be separately disposed for a plurality of controllers.

[0024] The target trajectory setting unit 41 sets the target trajectory TR illustrated in FIG. 3. As will be described later, the target trajectory TR is corrected as necessary, but the target trajectory setting unit 41 (see FIG. 2) sets a pre-correction target trajectory TRa (reference target trajectory) that is the pre-correction target trajectory TR. The target trajectory TR is a trajectory to be a target for a movement of the specific portion 15e. Specifically, an order set of the plurality of target points P (for example, three-dimensional coordinates) of the specific portion 15e of the attachment 15 is referred to as a "target path". In the example illustrated in FIG. 3, each position and order from the target point P1 to the target point P6 are the target path. The target path to which a time parameter (time information) is added is defined as the target trajectory TR. This "time parameter" is a target movement time of the specific portion 15e between the two (adjacent) target points P in consecutive order (hereinafter, referred to as "a time between two points"). Note that, in another embodiment, the time parameter may be a time at which the specific portion 15e passes through each target point P.

[0025] The target trajectory setting unit 41 (see FIG. 2) may set the pre-correction target trajectory TRa based on teaching, or may set the pre-correction target trajectory TRa based on a method other than teaching (for example, input of coordinates by the operation unit 31 (see FIG. 2)). The "teaching" is performed as follows. A worker (operator) gets aboard the work machine 10 illustrated in FIG. 1 to operate the work machine 10, or remotely operates the work machine 10. Then, the worker operates the work machine 10 to move the specific portion 15e at such a speed that a time parameter desired

to be set as the target trajectory TR is set along the target path desired to be set as the target trajectory TR illustrated in FIG. 3. The target trajectory setting unit 41 (see FIG. 2) then sets the trajectory along which the specific portion 15e has moved, as the pre-correction target trajectory TRa. The set pre-correction target trajectory TRa is stored in the controller 40.

[0026] The target trajectory correcting unit 43 (see FIG. 2) corrects the pre-correction target trajectory TRa as necessary. The target trajectory correcting unit 43 sets the post-correction target trajectory TRb obtained by changing some of the target points P on the pre-correction target trajectory TRa (details will be described later).

[0027] The operation control unit 45 (see FIG. 2) automatically operates the work machine 10 (see FIG. 1). The operation control unit 45 (see FIG. 2) controls the work machine 10 so that the specific portion 15e of the attachment 15 moves along the target trajectory TR. Specifically, the operation control unit 45 (see FIG. 2) controls the work machine 10 (see FIG. 1) so that the specific portion 15e moves in accordance with the target path (coordinates and order of each target point P) set as the target trajectory TR and the point-to-point time between the target points P. The operation control unit 45 (see FIG. 2) controls the operation (attitude) of the work machine 10 by inputting a command signal to the drive control unit 19 (see FIG. 2).

<Timing of Correcting Target Trajectory TR>

[0028] [Example A1] The target trajectory correcting unit 43 illustrated in FIG. 2 may correct the target trajectory TR illustrated in FIG. 3 based on a determination of the controller 40, that is, automatically. Hereinafter, the controller 40 (including the target trajectory correcting unit 43) will be described with reference to FIG. 2. For example, the target trajectory correcting unit 43 may correct the target trajectory TR illustrated in FIG. 3 based on a detection result of the situation detection unit 23 (FIG. 2), the detection result being input to the controller 40. Specifically, the target trajectory correcting unit 43 may correct the target trajectory TR based on at least one of the situation of the work machine 10 itself and the situation around the work machine 10.

[0029] [Example A1a] For example, the target trajectory correcting unit 43 may correct the target trajectory TR in accordance with progress of the work by the attachment 15. Specifically, the situation detection unit 23 (see FIG. 2) detects a topography around the work machine 10, and the controller 40 determines the progress of the work. The target trajectory correcting unit 43 may set the post-correction target trajectory TRb so that the attachment 15 performs the next work at a position different from the position where the work by the attachment 15 is completed.

[0030] [Example A1b] For example, the target trajectory correcting unit 43 may correct the target trajectory TR depending on a situation of an obstacle around the

work machine 10. Specifically, when the situation detection unit 23 detects an obstacle (for example, a vehicle (a dump car or the like), a topography, or the like) around the work machine 10, the controller 40 sets an entry prohibition area based on the position of the obstacle. In a case where the attachment 15 is expected to enter the entry prohibition area if it moves along the pre-correction target trajectory TRa, the target trajectory correcting unit 43 may set the post-correction target trajectory TRb where the attachment 15 does not enter the entry prohibition area.

[0031] [Example A2] The target trajectory correcting unit 43 may correct the target trajectory TR based on a command (input) different from the determination of the controller 40. For example, the target trajectory correcting unit 43 may set the post-correction target trajectory TRb in accordance with a manual operation (for example, tablet operation or the like) of the operation unit 31 (see FIG. 2) by the worker.

[0032] The above [Example A1] and [Example A2] correspond to examples of a path correcting condition of the present invention. That is, the path correcting condition includes at least one of a condition that an obstacle is present on the target path after the target trajectory setting unit 41 sets the pre-correction target trajectory TRa, a condition that the operator instructs to change the target path, and condition that the work position of the attachment 15 is changed. Note that the path correcting condition may be another condition different from the above conditions.

<Problem in Correcting Target Trajectory TR>

[0033] As described above, at the work site of the work machine 10, there is a case where the target path included in the target trajectory TR set in advance by teaching or the like is corrected as necessary. On the other hand, the target trajectory TR includes the target path and the time parameter as described above. Here, in a case where the target path is changed and the time parameter (point-to-point time) is maintained in order to avoid an obstacle or the like, the moving speed of the attachment 15 changes because the movement time of the attachment 15 is not changed although the distance between the adjacent target points changes. In particular, in a case where the distance between the two target points increases with the change of the target path, the moving speed of the attachment 15 partially increases before and after the correction of the target path in order to move the attachment 15 at the identical movement time. In this case, since the speed of the attachment 15 rapidly increases as compared with the moving operation of the attachment 15 set in advance by teaching, a surrounding worker feels insecure. In the present embodiment, in order to solve such a problem at the work site, the controller 40 also adjusts the time parameter as necessary along with the correction of the target path.

<Flow of Correcting Target Trajectory TR>

[0034] FIG. 4 is a flowchart of target trajectory correction processing executed by the trajectory generating system 1 according to the present embodiment. The target trajectory correction processing in the present embodiment will be described with reference to FIG. 4.

[0035] As described above, the target trajectory setting unit 41 sets the pre-correction target trajectory TR through teaching or the like in advance (step S1). Note that the target trajectory TR at this time corresponds to a reference target trajectory of the present invention. The reference target trajectory includes a reference target path including a plurality of target points and a time parameter (time information) that is information about a time during which the specific portion 15e moves along the plurality of target points.

[0036] Next, the controller 40 determines whether correction of a target trajectory is necessary (step S2). At this time, necessity of the correction is determined based on the above-described path correcting conditions [Example A1], [Example A2], and the like. In a case where the correction is not necessary (NO in step S2), the controller 40 moves the actuator 17 based on the target trajectory TR set in step S1.

[0037] On the other hand, in a case where the correction is necessary (YES in step S2), in other words, in a case where the path correcting condition is satisfied, the target trajectory correcting unit 43 first changes a target path (step S3). In the change of the target path, the target trajectory correcting unit 43 specifies at least one pre-correction modification point among the plurality of target points on the reference target trajectory and sets a post-correction modification point obtained by modifying a position of the pre-correction modification point, thereby setting a new target path including the post-correction modification point. The target path set at this time includes the corrected target path of the present invention.

[0038] Next, the target trajectory correcting unit 43 determines, based on the time parameter included in the reference target trajectory, the newly set corrected target path as to whether a feeling of anxiety is likely to be given to the surrounding worker, in other words, whether a pre-determined time correcting condition is satisfied in a case where the specific portion 15e (attachment 15) moves. Specifically, the target trajectory correcting unit 43 determines whether the point-to-point speed is higher after the correction of the target path than before the correction of the target path (step S4). In the present embodiment, since the time parameter is the time (movement time) between two adjacent points in the plurality of target points, the determination processing in step S4 is equivalent to determining whether the distance between the two adjacent points increases before and after the correction. In a case where the set movement times are the same, when the point-to-point distance increases, the movement speed increases as a result. Thus, the surrounding workers are likely to feel insecure.

[0039] Therefore, in a case where the point-to-point speed is higher after the correction of the target path than before the correction of the target path (the speed of the attachment on the reference target trajectory) (YES in step S4), the target trajectory correcting unit 43 corrects the point-to-point time (time parameter) (step S5). As a result, the setting of the post-correction target trajectory TR is completed (step S6). Note that, in step S4, in a case where the point-to-point speed after the correction of the target path is equal to or less than the point-to-point speed before the correction of the target path (NO in step S4), the target trajectory correcting unit 43 completes the setting of the post-correction target trajectory TR based only on the correction of the target path without correcting the point-to-point time (step S6).

[0040] Note that the flowchart of FIG. 4 may be performed before the work is started by the attachment 15 or may be performed during the work. As an example, the determination as to the necessity of the correction in step S2 may be executed during the movement of the attachment 15. That is, in a case where an obstacle is confirmed ahead during the movement of the attachment 15, the target path may be changed at that time (step S3), and the target trajectory TR may be corrected based on steps S4 to S6.

[0041] Note that, in step S4, a case where the point-to-point speed after the correction of the target path is equal to or less than the point-to-point speed before the correction of the target path (NO in step S4) is equivalent to that the distance between two adjacent points decreases before and after the correction. In this case, since the speed of the attachment 15 is partially reduced, a feeling of anxiety is not given to the surrounding workers. However, the point-to-point time may be corrected in accordance with the point-to-point speed before correction from the viewpoint of a cycle time such as productivity.

<Setting of Target Path of Post-Correction Target Trajectory TRb>

[0042] Next, a method for correcting the target trajectory TR will be specifically described in detail. The target trajectory correcting unit 43 corrects the target trajectory TR as follows. The target trajectory correcting unit 43 sets the pre-correction modification point Pa. The pre-correction modification point Pa is a part of the plurality of target points P on the pre-correction target trajectory TRa. Only one pre-correction modification point Pa may be set, or a plurality of pre-correction modification points Pa may be set. The pre-correction modification point Pa may be a first point (target point P1 in FIG. 3), middle points (target points P2 to P5 in FIG. 3), or a last point (target point P6 in FIG. 3) on the pre-correction target trajectory TRa. The target trajectory correcting unit 43 sets the post-correction modification point Pb obtained by modifying the position of the pre-correction modification point Pa. The target trajectory correcting unit 43 sets the post-correction target trajectory TRb (target path) that

is the target trajectory TR including the post-correction modification point Pb.

<Setting of Point-to-Point Time of Post-Correction Target Trajectory TRb>

[0043] The target trajectory correcting unit 43 sets the point-to-point time (time parameter) of the post-correction target trajectory TRb so as to prevent a feeling of anxiety from being given to a worker who views the attachment 15 that moves along the post-correction target trajectory TRb. Specifically, the target trajectory correcting unit 43 may set the point-to-point time at the post-correction modification point Pb based on the information about the speed of the attachment 15 on the pre-correction target trajectory TRa. The target trajectory correcting unit 43 may set the point-to-point time at the post-correction modification point Pb based on information about an upper limit of the speed of the attachment 15 at the post-correction modification point Pb.

[0044] The "speed of the attachment 15" (hereinafter, also referred to as "ATT speed") may include the slewing speed of the upper slewing body 13 (of the attachment 15) with respect to the lower travelling body 11. The ATT speed may include a rotation (raising and lowering) speed of the boom 15b (the speed of the boom 15b) with respect to the upper slewing body 13 illustrated in FIG. 1. The ATT speed may include a rotation speed of the arm 15c (the speed of the arm 15c) with respect to the boom 15b. The ATT speed may include a rotation speed of the distal end attachment 15d (the speed of the distal end attachment 15d) with respect to the arm 15c. The ATT speed may include a speed of the specific portion 15e with respect to the ground surface.

[0045] The "information about the speed of the attachment 15" may be information about the speed of the attachment 15 itself or may be the operation speed of the actuator 17 that operates the attachment 15 (the same applies to the "information about the upper limit of the speed of the attachment 15"). The "information about the speed of the attachment 15 itself" is, for example, the rotation speed of the boom 15b with respect to the upper slewing body 13. The "operation speed of the actuator 17 that operates the attachment 15" may be, for example, the expansion and contraction speed of the hydraulic cylinder (for example, the boom cylinder 17b or the like) or the rotation speed of the slewing motor 17a.

[0046] The "point-to-point time at the post-correction modification point Pb" may be a point-to-point time between the target point P (P5 in FIG. 3) immediately before the post-correction modification point Pb and the post-correction modification point Pb (the same applies to a point-to-point time at a reference target point to be described later). The "point-to-point time at the post-correction modification point Pb" may be a point-to-point time between the target point P (not illustrated) immediately after the post-correction modification point Pb and the post-correction modification point Pb (the same applies

to a point-to-point time at a reference target point to be described later).

[0047] Hereinafter, the information at the pre-correction modification point Pa illustrated in FIG. 3 is also simply referred to as "pre-correction" information. For example, the point-to-point time at the pre-correction modification point Pa is also referred to as "a post-correction point-to-point time". For example, the ATT speed at the pre-correction modification point Pa is also referred to as "a pre-correction ATT speed". Similarly to the information at the pre-correction modification point Pa, the information at the post-correction modification point Pb is simply referred to as "post-correction" information.

[0048] For example, the target trajectory correcting unit 43 may set the point-to-point time as in [Example B1] and [Example B2], described below.

[0049] [Example B1] The target trajectory correcting unit 43 sets the point-to-point time at the post-correction modification point Pb based on the information about the pre-correction ATT speed (the speed of the attachment 15 on the pre-correction target trajectory TRa) (in consideration of the pre-correction ATT speed). In this case, the target trajectory correcting unit 43 preferably sets the post-correction target trajectory TRb so that a worker around the work machine 10 feels the speeds identical to each other before and after the correction when the specific portion 15e moves along the target trajectory TR.

<Relationship of Post-Correction ATT Speed $\leq$ Pre-Correction ATT Speed>

[0050] For example, the target trajectory correcting unit 43 sets the point-to-point time at the post-correction modification point Pb so that the ATT speed at the post-correction modification point Pb becomes equal to or less than the ATT speed at the pre-correction modification point Pa. The "ATT speed at the post-correction modification point Pb" may be an ATT speed (specifically, the average value or average speed of the magnitudes of the ATT speeds) between the target point P (in FIG. 3, P5 that is also referred to as an adjacent target point) immediately before the post-correction modification point Pb and the post-correction modification point Pb. The "ATT speed at the post-correction modification point Pb" may be an ATT speed (specifically, the average value of the magnitudes of the ATT speeds) between the target point P (not illustrated) immediately after the post-correction modification point Pb and the post-correction modification point Pb. Similarly to the "ATT speed at the post-correction modification point Pb", the "ATT speed at the pre-correction modification point Pa" is the ATT speed between at least the target point P immediately before or after the pre-correction modification point Pa and the pre-correction modification point Pa. The target trajectory correcting unit 43 sets the corrected point-to-point time based on at least one type of the ATT speed among a plurality of types of ATT speeds.

[0051] For example, the target trajectory correcting

unit 43 sets the corrected point-to-point time so that a certain type of post-correction ATT speed (for example, the slewing speed) is equal to or less than the same type of pre-correction ATT speed (for example, the slewing speed). For example, the target trajectory correcting unit 43 sets the corrected point-to-point time so that a certain type of post-correction ATT speed (for example, the slewing speed) is equal to the same type of pre-correction ATT speed (for example, the slewing speed).

<Comparison between Pre-ATT Speed and Post-Correction ATT Speed Assuming that Point-To-Point Time is not Changed>

[0052] For example, the target trajectory correcting unit 43 sets the point-to-point time as follows. For the sake of explanation the target trajectory correcting unit 43 is assumed not to change the post-correction point-to-point time from the pre-correction point-to-point time. In this assumption, the plurality of types of ATT speeds may include an ATT speed (for example, a slewing speed) that is higher after correction than before correction. In this case, the target trajectory correcting unit 43 sets the corrected point-to-point time so that the post-correction ATT speed (slewing speed) becomes equal to or less than the pre-correction ATT speed (slewing speed).

[0053] Assuming that the point-to-point time is not changed before and after correction, a plurality of types of ATT speeds that are higher after correction than before correction may present. In this case, the target trajectory correcting unit 43 sets the corrected point-to-point time so that the post-correction ATT speed becomes equal to or less than the pre-correction ATT speed among all types of ATT speeds higher after correction than before correction. Here, it is assumed that the directions of the ATT speed is equal to each other before and after correction. Specifically, for example, in a case where a direction of the slewing speed before correction is rightward (right slewing), a direction of the slewing speed after correction is also rightward (right slewing).

[0054] For example, assuming that the point-to-point time is not changed before and after correction, the target trajectory correcting unit 43 calculates a ratio (speed change ratio) of a certain type of post-correction ATT speed to the same type of pre-correction ATT speed for each of the plurality of types of ATT speeds. The target trajectory correcting unit 43 specifies the type of the ATT speed having the greatest speed change ratio among the plurality of types of ATT speeds. The target trajectory correcting unit 43 then sets the point-to-point time so that the post-correction ATT speed becomes equal to or less than the pre-correction ATT speed for the type of the ATT speed having the greatest speed change ratio.

[0055] Note that in a case where a central target point among the three consecutive target points is set as the pre-correction modification point Pa and the position thereof is modified, the distance between the post-cor-

rection modification point Pb and the first target point may be long, whereas the distance between the post-correction modification point Pb and the third target point may be short. Also in such a case, the time parameter may be changed based on these distances (attachment speeds) between two points.

<Specific Example of Information about Pre-Correction Target Trajectory TRa>

[0056] FIG. 5 illustrates a specific example of information about the pre-correction target trajectory TRa. Note that each numerical value shown in the drawing is merely an example, and can be variously set. The same applies to the numerical values shown in FIGS. 6 and 7. For example, the attachment 15 may repeat a series of operations including catching (for example, excavation), lifting and slewing, releasing (for example, discharging soil), and returning and slewing of a work object (for example, soil). In this case, the pre-correction target trajectory TRa (see FIG. 3) is set for each operation including catching, lifting and slewing, releasing, and the returning and slewing. The example illustrated in FIG. 5 is an example of the pre-correction target trajectory TRa for the returning and slewing in the series of works of the attachment 15 (see FIG. 3).

[0057] Here, as illustrated in FIG. 1, a direction where a rotation shaft of slewing of the upper slewing body 13 with respect to the lower travelling body 11 extends is defined as an up-down direction Z. In the up-down direction Z, a direction from the lower travelling body 11 toward the upper slewing body 13 is defined as a positive direction. As illustrated in FIG. 3, a direction where the attachment 15 protrudes with respect to the upper slewing body 13 is defined as a front-rear direction X. In the front-rear direction X, a direction where the attachment 15 protrudes with respect to the upper slewing body 13 is a positive direction. A direction where the upper slewing body 13 slews with respect to the lower travelling body 11 is a slewing direction Sw (FIG. 3), and "Sw" in FIG. 5 indicates an angle (slewing angle) of the specific portion 15e in the same direction. Reference signs "X" and "Z" in FIG. 5 respectively indicate the positions (coordinates) of the specific portion 15e in the respective directions. Reference sign "Xi" in FIG. 5 indicates an angle of the distal end attachment 15d illustrated in FIG. 1 with respect to the horizontal plane (or a bottom surface of the lower travelling body 11). The value of the "point-to-point time" in FIG. 5 is a movement time of the specific portion 15e (see FIG. 3) between a certain target point P and a target point P immediately before the certain target point P. For example, the point-to-point time "1" of the target point P6 in the drawing is a movement time of the specific portion 15e (attachment 15) from the target point P5 to the target point P6. Note that in a case where the target point P does not exist immediately before the target point P1, the information about the point-to-point time "1" set at the target point P1 may be ignored. For example, in a

case where the target point (not illustrated) immediately before the target point P1 is set, the point-to-point time "1" set at the target point P1 is a movement time of the specific portion 15e from the target point immediately before the target point P1 to the target point P1.

[0058] The controller 40 calculates the slewing speed between the target points P based on the change amount of a slewing angle Sw between the target points P and the point-to-point time. In addition, the controller 40 calculates at least one of the rotation angle of each portion (for example, the boom 15b) of the attachment 15 illustrated in FIG. 1 and the stroke of the hydraulic cylinder (the boom cylinder 17b or the like) based on the change amount of the coordinates between the target points P. The controller 40 then calculates at least one of the rotation speed of each portion of the attachment 15 and the expansion and contraction speed of the hydraulic cylinder between the target points P (see FIG. 5) based on at least the information about the rotation angle or the information about the stroke and the point-to-point time. For example, the controller 40 calculates each type of ATT speed at the pre-correction target point P6 (pre-correction modification point Pa) as follows.

<Various Types of Speeds (Point-to-Point Time: 1) at Pre-Correction Target Point P6>

[0059]

- Expansion and contraction speed of boom cylinder 17b (speed of boom 15b): -10 mm/sec
- Expansion and contraction speed of arm cylinder 17c (speed of arm 15c): 20 mm/sec
- Expansion and contraction speed of distal end attachment cylinder 17d (speed of distal end attachment 15d): 30 mm/sec
- Slewing speed: 10 deg/sec

<Specific Example of Information about Post-Correction Target Trajectory TRb>

[0060] FIG. 6 illustrates a specific example of the information about the post-correction target trajectory TRb. This example is an example of a case where the slewing angle Sw at a time when the slewing of the upper slewing body 13 illustrated in FIG. 3 stops is corrected from the information of FIG. 5. Specifically, in the post-correction target trajectory TRb in FIG. 6, the slewing angle Sw at the target point P6 is corrected with respect to the pre-correction target trajectory TRa (see FIG. 5). Furthermore, the slewing angle Sw at the target point P6 is 0 on the pre-correction target trajectory TRa illustrated in FIG. 5 and -10 on the post-correction target trajectory TRb illustrated in FIG. 6. That is, the target point P6 is changed to a position far from the target point P5 before and after correction.

[0061] The controller 40 calculates each type of speeds at the post-correction target point P6 as follows

assuming that the point-to-point time at the post-correction target point P6 is 1 second which is identical to the point-to-point time at the pre-correction target point P6.

- 5 <Each Type of Speeds (Assuming that Point-to-Point Time: 1) at Post-Correction Target Point P6>

[0062]

- 10 • Expansion and contraction speed of boom cylinder 17b (speed of boom 15b): -15 mm/sec
- Expansion and contraction speed of arm cylinder 17c (speed of arm 15c): 20 mm/sec
- 15 • Expansion and contraction speed of distal end attachment cylinder 17d (speed of distal end attachment 15d): 30 mm/sec
- Slewing speed: 20 deg/sec

[0063] In this example, the magnitude of the expansion and contraction speed of the boom cylinder 17b illustrated in FIG. 1 is greater after correction (-15 mm/sec) than before correction (-10 mm/sec). The magnitude of the slewing speed is greater after correction (20 deg/sec) than before correction (10 deg/sec). In this example, the speed change ratio of the expansion and contraction speed of the boom cylinder 17b is 1.5 times, and the speed change ratio of the slewing speed is 2 times. Therefore, the target trajectory correcting unit 43 specifies the type of ATT speed having the greatest speed change ratio as the slewing speed. Therefore, the target trajectory correcting unit 43 sets the point-to-point time at the post-correction target point P6 to 2 (or 2 or more) so that the magnitude of the post-correction slewing speed becomes the pre-correction slewing speed (or becomes equal to or less than the pre-correction slewing speed). As a result, each type of speeds at the post-correction target point P6 is as follows. Note that the controller 40 may or may not calculate the next speed.

- 40 <Each type of Speeds (Point-to-Point Time: 2) at Post-Correction Target Point P6>

[0064]

- 45 • Expansion and contraction speed of boom cylinder 17b (speed of boom 15b): -7.5 mm/sec
- Expansion and contraction speed of arm cylinder 17c (speed of arm 15c): 10 mm/sec
- 50 • Expansion and contraction speed of distal end attachment cylinder 17d (speed of distal end attachment 15d): 15 mm/sec
- Slewing speed: 10 deg/sec

[0065] In this example, since the point-to-point time at the target point P6 is set to 2, the magnitude of the post-correction slewing speed becomes 10 which is identical to the pre-correction slewing speed (see FIG. 6). Further, the post-correction speed of each of the boom 15b, the

arm 15c, and the distal end attachment 15d is equal to or less than the pre-correction speed. As a result, the speed feeling of the entire attachment 15 felt by a worker around the attachment 15 can be made to be an identical degree before and after correction.

[0066] On the pre-correction target trajectory TRa of the example illustrated in FIG. 5, a slewing angle difference from the target point P5 to the target point P6 is 10 degrees, and the slewing speed is 10 deg/sec. On the post-correction target trajectory TRb illustrated in FIG. 6, the slewing angle difference from the target point P5 to the target point P6 is 20 degrees. In this example, in order to set the post-correction slewing speed from the target point P5 to the target point P6 to 10 deg/sec identical to the pre-correction slewing speed, the post-correction point-to-point time is set to 2. Similarly, in a case where the slewing angle Sw at the target point P6 of the post-correction modification point Pb is -20, the slewing angle difference from the target point P5 to the target point P6 is 30 degrees, and the point-to-point time is set to 3. In a case where the slewing angle Sw at the target point P6 is -30, the slewing angle difference from the target point P5 to the target point P6 is 40 degrees, and the point-to-point time is set to 4.

<Case where Speed is 0 or the Like>

[0067] FIG. 7 illustrates another specific example of information about the pre-correction target trajectory TRa. FIG. 7 is an example where the attachment 15 (specific portion 15e) stands still at the target point P6. In the example of FIG. 5, the target trajectory correcting unit 43 sets the post-correction point-to-point time so that the post-correction ATT speed becomes equal to or less than the pre-correction ATT speed. In this setting method, in a case where the pre-correction ATT speed is 0 as illustrated in FIG. 7 (see the slewing speed at the target point P6 in FIG. 7), the post-correction ATT speed can be only 0, and the point-to-point time cannot be set (the point-to-point time becomes infinite). In addition, even in a case where the pre-correction ATT speed is a minute value (approximately 0), the post-correction ATT speed becomes minute, and the point-to-point time becomes approximately infinite.

[0068] Therefore, in a case where the pre-correction ATT speed is equal to or less than a predetermined minute threshold (referred to also as a threshold or a first minute threshold), the target trajectory correcting unit 43 sets the post-correction point-to-point time as follows. In this case, the target trajectory correcting unit 43 determines a reference target point (for example, the target point P5) closest to the pre-correction modification point Pa (for example, the target point P6) among the target points P where the ATT speed is greater than the minute threshold. The target trajectory correcting unit 43 then sets the point-to-point time at the post-correction modification point Pb so that the post-correction ATT speed becomes equal to or less than the ATT speed at the ref-

erence target point (for example, the target point P5). The "minute threshold" is set in the target trajectory correcting unit 43 in advance (before the processing for setting the point-to-point time). The minute threshold may be 0. In a case where the post-correction modification point Pb is a point (a point that is neither the start point nor the end point) between the start point and the end point of the pre-correction target trajectory TRa, two reference target points may be present.

[0069] In the above example, the controller 40 calculates the ratio (speed change ratio) of the post-correction ATT speed to the pre-correction ATT speed for each of the plurality of types of ATT speeds. In this calculation method, the speed change ratio cannot be calculated at the ATT speed of such a type that the pre-correction speed is zero. Further, as for a pre-correction ATT speed that has a minute value, the speed change ratio has an extremely great value.

[0070] Therefore, in a case where a pre-correction ATT speed having a value equal to or less than a second minute threshold, the target trajectory correcting unit 43 calculates the speed change ratio as follows. In this case, the target trajectory correcting unit 43 determines a second reference target point (for example, the target point P5) closest to the pre-correction modification point Pa (for example, the target point P6) among the target points P where the speed is greater than the second minute threshold. The target trajectory correcting unit 43 then calculates a ratio of the ATT speed at the post-correction modification point Pb to the pre-correction ATT speed at the second reference target point (for example, the target point P5) as the speed change ratio. Note that the "minute threshold" and the "second minute threshold" may be equal to or different from each other.

[0071] [Example B2] The target trajectory correcting unit 43 may set the point-to-point time at the post-correction modification point Pb based on the information about an upper limit ("upper limit speed Vm" of the speed of the attachment 15 at the post-correction modification point Pb illustrated in FIG. 3. Specifically, the target trajectory correcting unit 43 sets the point-to-point time at the post-correction modification point Pb so that the ATT speed at the post-correction modification point Pb becomes equal to or less than the upper limit speed Vm. The upper limit speed Vm is set in the target trajectory correcting unit 43 in advance (before the setting of the point-to-point time). The upper limit speed Vm is set in a region of a predetermined position (for example, a region of a pin-point position). For example, the upper limit speed Vm may be set in a region near an obstacle, or may be set for each site where the work machine 10 performs work. The upper limit speed Vm may not be set outside the "region of the predetermined position".

[0072] The target trajectory correcting unit 43 may set the point-to-point time at the post-correction modification point Pb by combining [Example B1] and [Example B2] described above. For example, when the post-correction target trajectory TRb is in the "region of the predeter-

mined position", the target trajectory correcting unit 43 may set the post-correction point-to-point time so that the post-correction ATT speed becomes equal to or less than smaller one of the pre-correction ATT speed and the upper limit speed V_m .

<Regarding Displaying>

[0073] The display unit 33 (see FIG. 2) displays information about the post-correction target trajectory TRb set by the target trajectory correcting unit 43. For example, the display unit 33 may display a figure representing the post-correction target trajectory TRb (for example, a figure illustrated in FIG. 3). The display unit 33 (see FIG. 2) may display a moving image showing how the attachment 15 including the specific portion 15e moves along the post-correction target trajectory TRb. The display unit 33 may display numerical values such as the coordinates of the post-correction target trajectory TRb and the point-to-point time as illustrated in FIGS. 6 and 7.

[0074] Effects of the trajectory generating system 1 illustrated in FIG. 1 are as follows. The trajectory generating system 1 is applied to the work machine 10 having the machine body 10a and the attachment 15, and includes the target trajectory setting unit 41 (FIG. 2) and the target trajectory correcting unit 43 (FIG. 2). The attachment 15 is mounted on the machine body 10a and performs work. The target trajectory setting unit 41 sets the pre-correction target trajectory TRa (see FIG. 3) that is a target trajectory of the specific portion 15e of the attachment 15. The target trajectory correcting unit 43 (see FIG. 2) corrects the pre-correction target trajectory TRa illustrated in FIG. 3. The pre-correction target trajectory TRa includes the information about the target path of the specific portion 15e and the information about the point-to-point time that is the movement time of the specific portion 15e between the target points P on the target path. The target trajectory correcting unit 43 sets the post-correction modification point Pb obtained by modifying the position of the pre-correction modification point Pa. The pre-correction modification point Pa is a part of the plurality of target points P on the pre-correction target trajectory TRa. The target trajectory correcting unit 43 sets the post-correction target trajectory TRb including the post-correction modification point Pb.

[0075] The target trajectory correcting unit 43 sets the point-to-point time at the post-correction modification point Pb based on at least one of the information about the speed of the attachment 15 on the pre-correction target trajectory TRa and the information about the upper limit of the speed of the attachment 15 at the post-correction modification point Pb.

[0076] In the above configuration, in a case where the point-to-point time at the post-correction modification point Pb is set based on the information about the speed of the attachment 15 on the pre-correction target trajectory TRa, the following effects can be obtained. In this case, the post-correction target trajectory TRb can be set

so that the movement of the specific portion 15e moving along the post-correction target trajectory TRb is close to the movement of the specific portion 15e moving along the pre-correction target trajectory TRa. Therefore, the post-correction target trajectory TRb can be set so that the speeds of the attachment 15 felt by a worker around the work machine 10 are equivalent to each other before and after the correction of the target trajectory TR. As a result, the trajectory generating system 1 (see FIG. 1) can prevent the movement of the attachment 15 from giving a feeling of anxiety to a worker around the work machine 10 in a case where the target trajectory TR of the attachment 15 is corrected.

[0077] In the above configuration, in a case where the post-correction point-to-point time is set based on the information about the upper limit of the speed of the attachment 15 at the post-correction modification point Pb, the following effects can be obtained. In this case, the post-correction target trajectory TRb can be set so that the speed of the attachment 15 at the position of the post-correction modification point Pb is equal to or less than the upper limit of the speed (upper limit speed V_m). As a result, the trajectory generating system 1 (see FIG. 1) can prevent the movement of the attachment 15 from giving a feeling of anxiety to a worker around the work machine 10 in a case where the target trajectory TR of the attachment 15 is corrected.

[0078] The target trajectory correcting unit 43 (see FIG. 2) sets the point-to-point time at the post-correction modification point Pb based on the information about the speed of the attachment 15 on the pre-correction target trajectory TRa.

[0079] The above configuration can provide the same effects as those described above.

[0080] The target trajectory correcting unit 43 (see FIG. 2) sets the point-to-point time at the post-correction modification point Pb so that the speed of the attachment 15 at the post-correction modification point Pb is equal to or less than the speed of the attachment 15 at the pre-correction modification point Pa.

[0081] With the above configuration, the speed of the attachment 15 moving along the post-correction target trajectory TRb does not become higher than the speed of the attachment 15 moving along the pre-correction target trajectory TRa. As a result, it is possible to more reliably prevent the movement of the attachment 15 from giving a feeling of anxiety to a worker around the work machine 10.

[0082] The target trajectory correcting unit 43 (see FIG. 2) determines the reference target point (P5) (see FIG. 7) in a case where the speed of the attachment 15 at the pre-correction modification point Pa (P6) is equal to or less than a predetermined threshold (minute threshold). The reference target point (P5) is the target point P that is the closest to the pre-correction modification point Pa among the target points P at which the speed of the attachment 15 is higher than the minute threshold. The target trajectory correcting unit 43 sets the point-to-point

time at the post-correction modification point Pb so that the speed of the attachment 15 at the post-correction modification point Pb is equal to or less than the speed of the attachment 15 at the reference target point (P5).

[0083] With the above configuration, even in a case where the speed of the attachment 15 at the pre-correction modification point Pa is equal to or less than the predetermined minute threshold, the point-to-point time can be appropriately set based on the speed of the attachment 15 on the pre-correction target trajectory TRa.

[0084] The target trajectory correcting unit 43 (see FIG. 2) sets the point-to-point time at the post-correction modification point Pb so that the speed of the attachment 15 at the post-correction modification point Pb is equal to or less than the upper limit of the speed (upper limit speed Vm) of the attachment 15 at the position of the post-correction modification point Pb.

[0085] With the above configuration, the trajectory generating system 1 can reliably prevent the movement of the attachment 15 from giving a feeling of anxiety to a worker around the work machine 10 in a case where the target trajectory TR of the attachment 15 is corrected.

[0086] As illustrated in FIG. 2, the trajectory generating system 1 includes the display unit 33 that displays the information about the post-correction target trajectory TRb (see FIG. 3) set by the target trajectory correcting unit 43.

[0087] With the above configuration, even if the specific portion 15e is not actually moved along the post-correction target trajectory TRb illustrated in FIG. 3 (in advance), a worker who views the display of the display unit 33 (see FIG. 2) can be notified of the information about the post-correction target trajectory TRb.

<Modifications>

[0088] The above embodiment may be variously modified. For example, the connection mode of the components illustrated in FIG. 2 or the like may be changed. For example, values such as the thresholds (for example, the minute threshold and the second minute threshold) may be constant, may be changed by manual operation, or may be automatically changed in accordance with a certain condition. For example, the number of the components in the above embodiment may be changed, and some of the components do not have to be provided. For example, the components may be fixed or connected directly or indirectly. For example, a plurality of components and parts different from each other may be described as one component and part. For example, what has been described as one component and part may be divided and provided as a plurality of different components and parts. For example, the components each may have only some of features (function, arrangement, shape, operation, and the like).

[0089] The present invention provides a trajectory generating system that is used in a work machine including a machine body and an attachment that is attached to

the machine body and performs work. The trajectory generating system includes a target trajectory setting unit and a target trajectory correcting unit. The target trajectory setting unit sets a reference target trajectory that is a target for a movement of a specific portion of the attachment and includes a reference target path including a plurality of target points and time information that is information regarding time for a movement of the specific portion along the plurality of target points. The target trajectory correcting unit corrects the reference target trajectory. In addition, in a case where a predetermined path correcting condition is satisfied, the target trajectory correcting unit specifies at least one pre-correction modification point among the plurality of target points on the reference target trajectory and sets a post-correction modification point obtained by modifying a position of the pre-correction modification point, thus setting a corrected target path including the post-correction modification point, and in a case where a predetermined time correcting condition is satisfied, the target trajectory correcting unit sets the time information in the corrected target path based on at least one of information about a speed of the attachment on the reference target trajectory and information about a preset upper limit of the speed of the attachment.

[0090] In the above configuration, the target trajectory correcting unit may set the time information in the corrected target path based on information about the speed of the attachment on the reference target trajectory.

[0091] In the above configuration, the target trajectory correcting unit may set the time information in the corrected target path so that a speed of the attachment at the post-correction modification point is equal to or less than a speed of the attachment at the pre-correction modification point on the reference target trajectory.

[0092] In the above configuration, the target trajectory correcting unit may set the time information in the corrected target path so that an average speed of the attachment in a region between an adjacent target point adjacent to the post-correction modification point among the plurality of target points and the post-correction modification point is equal to or less than an average speed of the attachment in a region between the pre-correction modification point and the adjacent target point on the reference target trajectory.

[0093] In the above configuration, in a case where the speed of the attachment at the pre-correction modification point is equal to or less than a predetermined threshold on the reference target trajectory, the target trajectory correcting unit may specify, among the plurality of target points, a certain reference target point that is the target point at which the speed of the attachment is higher than the threshold, the target point being the closest to the pre-correction modification point, and may set the time information in the corrected target path so that a speed of the attachment at the post-correction modification point is equal to or less than the speed of the attachment at the reference target point on the reference target tra-

jectory.

[0094] In the above configuration, the target trajectory correcting unit may set the time information in the corrected target path so that a speed of the attachment at the post-correction modification point is equal to or less than a preset upper limit of the speed of the attachment.

[0095] In the above configuration, the time information may be a movement time of the attachment between two target points adjacent to each other among the plurality of target points.

[0096] The above configuration may further include a display unit that displays information about the reference target trajectory corrected by the target trajectory correcting unit.

[0097] In the above configuration, the path correcting condition includes at least one of a such condition that an obstacle is present in the reference target path after the target trajectory setting unit sets the reference target trajectory, a condition that an operator instructs to change the reference target path, and a condition that the work position of the attachment is modified.

[0098] In the above configuration, the time correcting condition may include a condition that assuming that the attachment moves to the plurality of target points included in the corrected target path, based on the time information about the reference target trajectory, the speed of the attachment at the post-correction modification point is higher than the speed of the attachment at the pre-correction modification point on the reference target trajectory.

[0099] The present invention provides a work machine including a machine body, an attachment that is attached to the machine body and performs work, and any one trajectory generating system among the above-described systems.

Claims

1. trajectory generating system that is used in a work machine including a machine body and an attachment that is attached to the machine body and performs work, the trajectory generating system comprising:

a target trajectory setting unit that sets a reference target trajectory that is a target for movement of a specific portion of the attachment, the reference target trajectory including a reference target path including a plurality of target points and time information that is information about a time for movement of the specific portion along the plurality of target points; and
a target trajectory correcting unit that corrects the reference target trajectory,
wherein in a case where a predetermined path correcting condition is satisfied, the target trajectory correcting unit specifies at least one pre-

correction modification point among the plurality of target points on the reference target trajectory and sets a post-correction modification point obtained by modifying a position of the pre-correction modification point, thus setting a corrected target path including the post-correction modification point, and

in a case where a predetermined time correcting condition is satisfied, the target trajectory correcting unit sets the time information in the corrected target path based on at least one of information about a speed of the attachment on the reference target trajectory and information about a preset upper limit of the speed of the attachment.

2. The trajectory generating system according to claim 1, wherein the target trajectory correcting unit sets the time information in the corrected target path based on the information about the speed of the attachment on the reference target trajectory.
3. The trajectory generating system according to claim 2, wherein the target trajectory correcting unit sets the time information in the corrected target path so that a speed of the attachment at the post-correction modification point is equal to or less than a speed of the attachment at the pre-correction modification point on the reference target trajectory.
4. The trajectory generating system according to claim 2, wherein the target trajectory correcting unit sets the time information in the corrected target path so that an average speed of the attachment in a region between an adjacent target point adjacent to the post-correction modification point among the plurality of target points and the post-correction modification point is equal to or less than an average speed of the attachment in a region between the pre-correction modification point and the adjacent target point on the reference target trajectory.
5. The trajectory generating system according to claim 2, wherein

in a case where the speed of the attachment at the pre-correction modification point is equal to or less than a predetermined threshold on the reference target trajectory, the target trajectory correcting unit

specifies, among the plurality of target points, a certain reference target point that is the target point at which the speed of the attachment is higher than the threshold, the target point being closest to the pre-correction modification point, and

sets the time information in the corrected target path so that a speed of the attachment at the

post-correction modification point is equal to or less than a speed of the attachment at the reference target point on the reference target trajectory.

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6. The trajectory generating system according to claim 1, wherein the target trajectory correcting unit sets the time information in the corrected target path so that a speed of the attachment at the post-correction modification point is equal to or less than the preset upper limit of the speed of the attachment. 10
7. The trajectory generating system according to any one of claims 1 to 6, wherein the time information includes a movement time of the attachment between two target points adjacent to each other among the plurality of target points. 15
8. The trajectory generating system according to any one of claims 1 to 7, further comprising a display unit that displays information about the reference target trajectory corrected by the target trajectory correcting unit. 20
9. The trajectory generating system according to any one of claims 1 to 8, wherein the path correcting condition includes at least one of a condition that an obstacle is present in the reference target path after the target trajectory setting unit sets the reference target trajectory, a condition that an operator instructs to change the reference target path, and a condition that a work position of the attachment is modified. 25 30
10. The trajectory generating system according to any one of claims 1 to 9, wherein the time correcting condition includes a condition that assuming that the attachment moves to the plurality of target points included in the corrected target path, based on the time information on the reference target trajectory, the speed of the attachment at the post-correction modification point is higher than the speed of the attachment at the pre-correction modification point on the reference target trajectory. 35 40 45
11. A work machine comprising:
 - a machine body;
 - an attachment that is attached to the machine body and performs work; and 50
 - the trajectory generating system according to any one of claims 1 to 10.

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FIG. 1

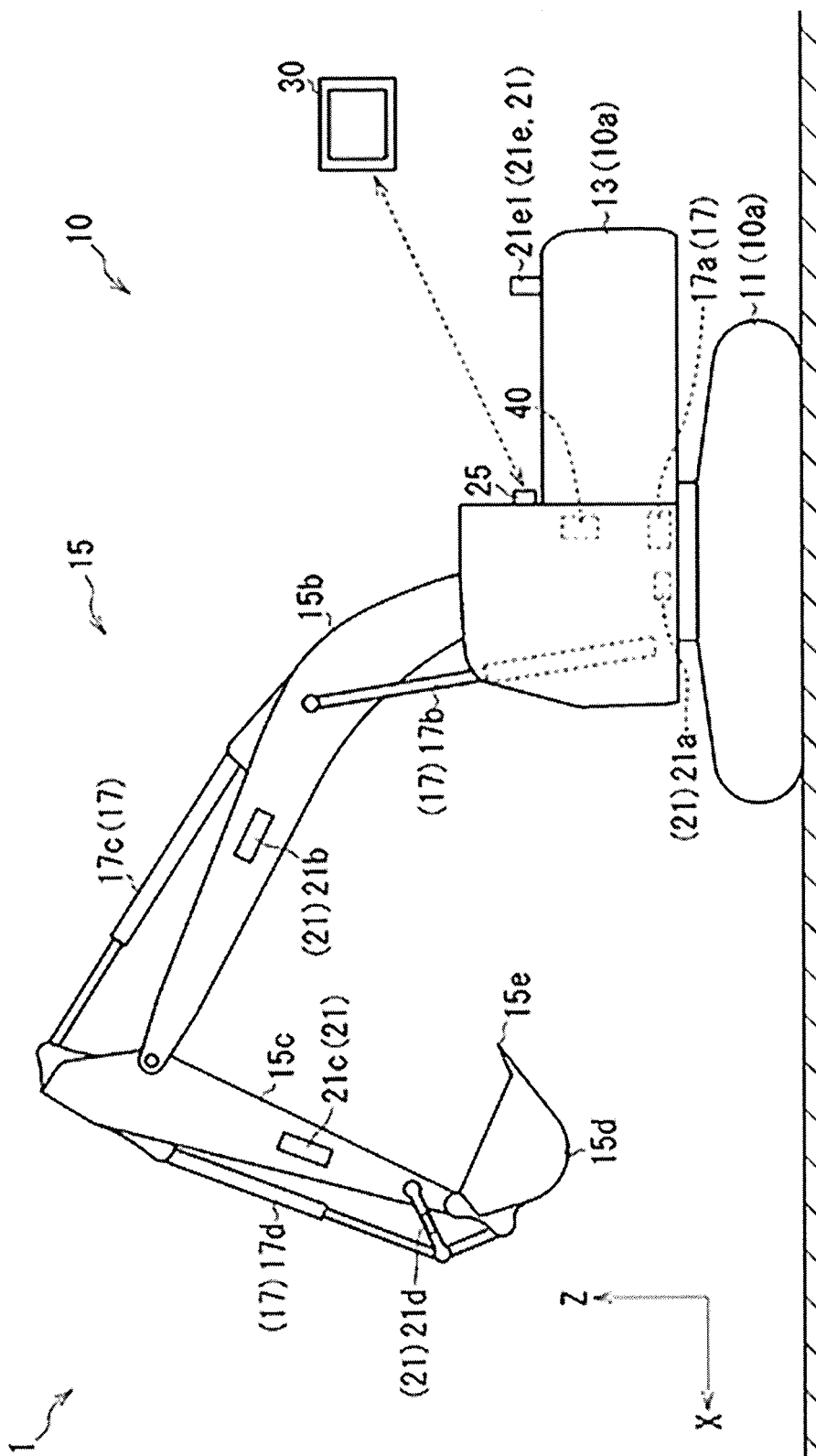


FIG.2

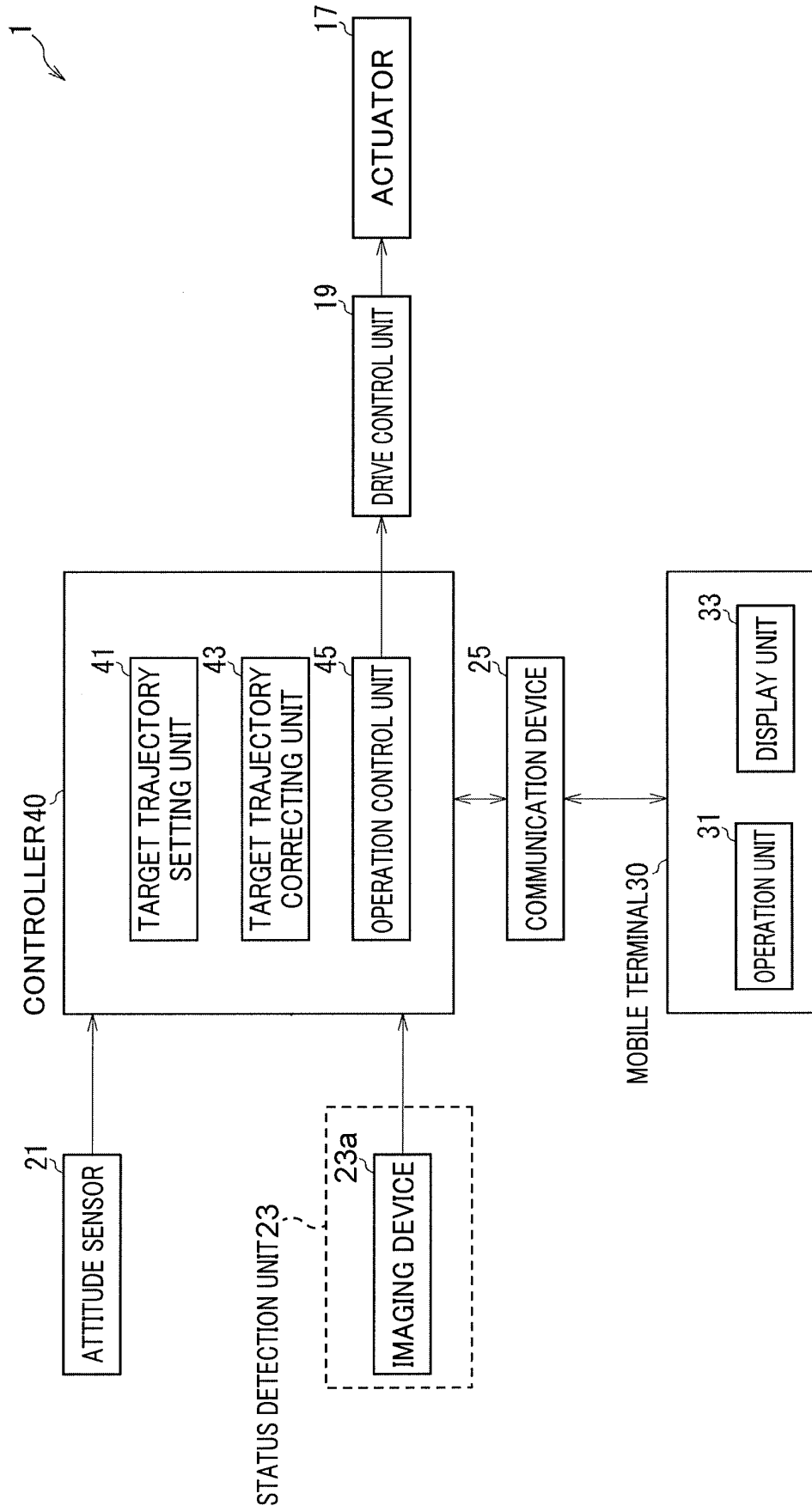


FIG.3

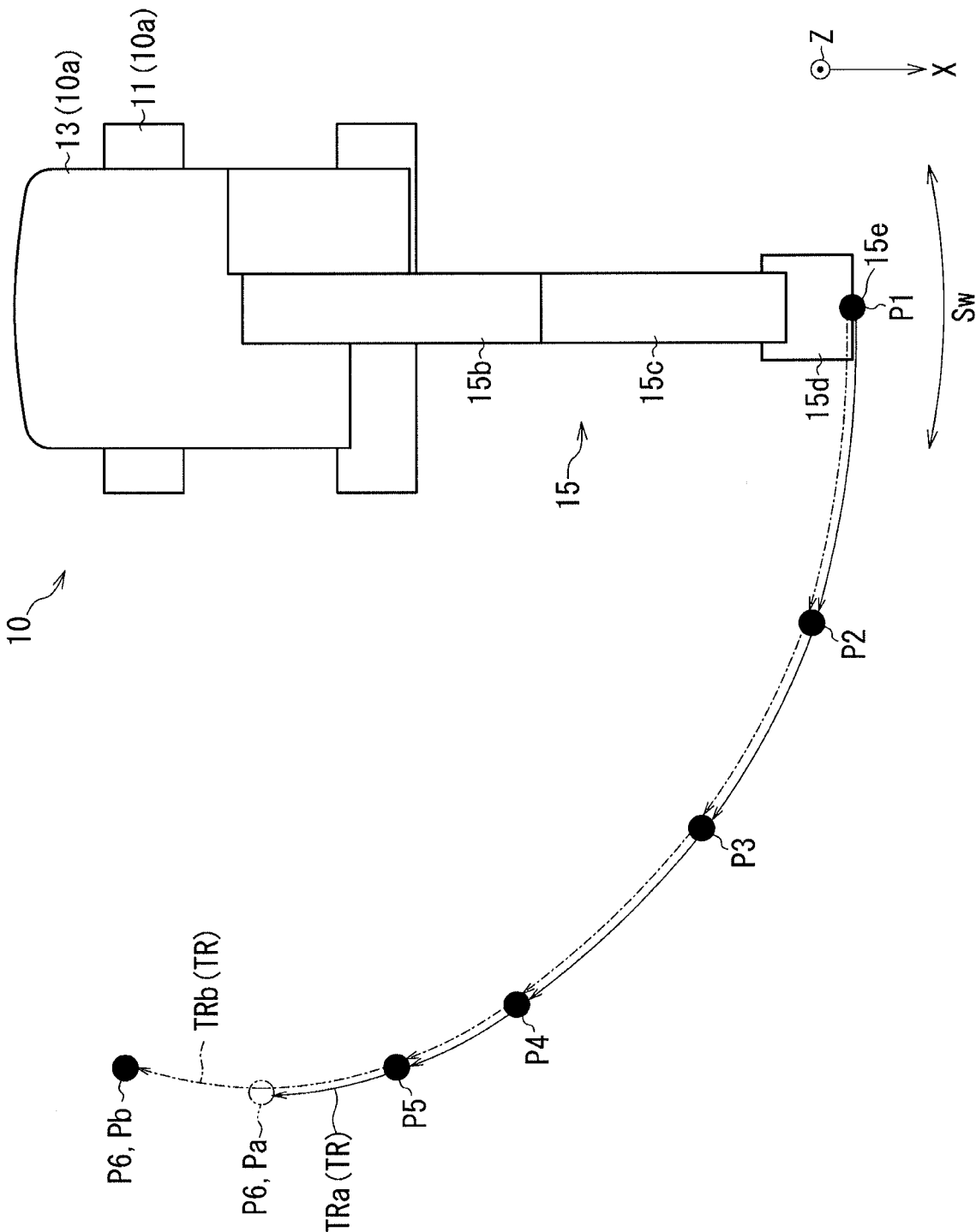


FIG.4

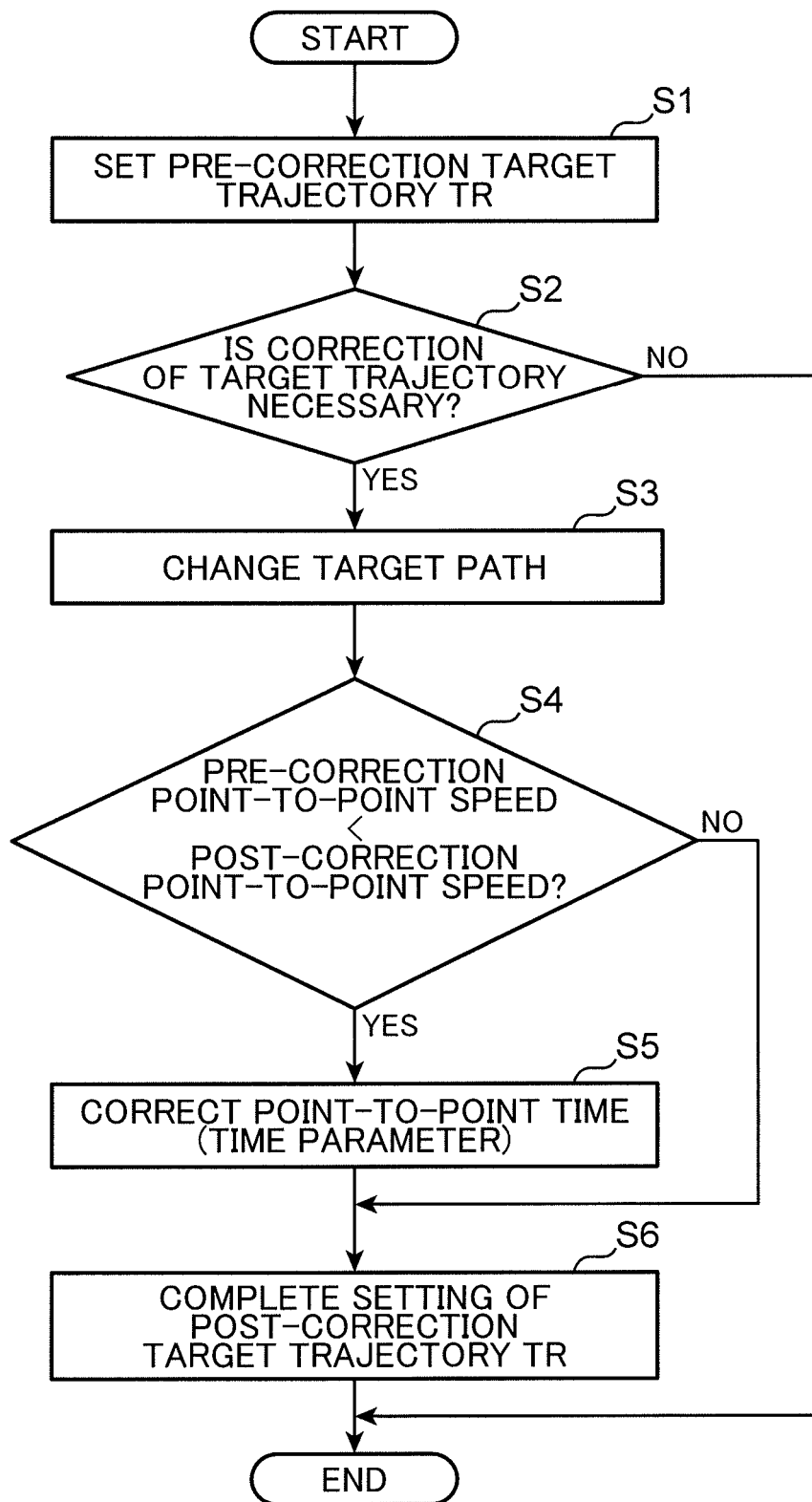


FIG.5

PRE-CORRECTION TARGET TRAJECTORY TR_a

TARGET POINT P	P1	P2	P3	P4	P5	P6, P _a
X	4500	4900	5200	5600	5900	6000
Z	1000	600	400	200	100	0
X _i	160	170	175	180	180	180
S _w	90	60	40	20	10	0
POINT-TO-POINT TIME	1	1	1	1	1	1
SLEWING SPEED		30	20	20	10	10

FIG.6

POST-CORRECTION TARGET TRAJECTORY TR_b

TARGET POINT P	P1	P2	P3	P4	P5	P6, Pb
X	4500	4900	5200	5600	5900	6000
Z	1000	600	400	200	100	0
Xi	160	170	175	180	180	180
Sw	90	60	40	20	10	-10
POINT-TO-POINT TIME	1	1	1	1	1	2
SLEWING SPEED		30	20	20	10	10

FIG.7

PRE-CORRECTION TARGET TRAJECTORY TR_a

TARGET POINT P	P1	P2	P3	P4	P5	P6, P _a
X	4500	4900	5200	5600	5900	6000
Z	1000	600	400	200	100	0
X _i	160	170	175	180	180	180
Sw	90	60	40	20	10	10
POINT-TO-POINT TIME	1	1	1	1	1	1
SLEWING SPEED		30	20	20	10	0

↑
REFERENCE TARGET POINT

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/023302

A. CLASSIFICATION OF SUBJECT MATTER*E02F 3/43*(2006.01)i; *E02F 9/20*(2006.01)i

FI: E02F9/20 N; E02F3/43 C

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)

E02F3/43; E02F9/20

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 1971-2022
 Registered utility model specifications of Japan 1996-2022
 Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2019-163603 A (KOBELCO CONSTRUCTION MACHINERY CO., LTD.) 26 September 2019 (2019-09-26) entire text, all drawings	1-11
A	US 2004/0267404 A1 (DANKO, George) 30 December 2004 (2004-12-30) entire text, all drawings	1-11
A	JP 2016-089559 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 23 May 2016 (2016-05-23) entire text, all drawings	1-11
A	JP 2000-064359 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 29 February 2000 (2000-02-29) entire text, all drawings	1-11

☐ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

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Date of the actual completion of the international search

27 July 2022

Date of mailing of the international search report

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Name and mailing address of the ISA/JP

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Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/023302

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2019-163603 A	26 September 2019	US 2021/0040710 A1 entire text, all drawings EP 3744907 A1 CN 111788359 A	
US 2004/0267404 A1	30 December 2004	CA 2458979 A1 entire text, all drawings	
JP 2016-089559 A	23 May 2016	(Family: none)	
JP 2000-064359 A	29 February 2000	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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