



US012385212B2

(12) **United States Patent**
Sonoda et al.

(10) **Patent No.:** **US 12,385,212 B2**

(45) **Date of Patent:** **Aug. 12, 2025**

(54) **CONTROL SYSTEM, METHOD OF CONTROLLING WORK VEHICLE, AND WORK VEHICLE**

(71) Applicant: **KOMATSU LTD.**, Tokyo (JP)

(72) Inventors: **Takuya Sonoda**, Tokyo (JP); **Takeshi Kamimae**, Tokyo (JP); **Yukihisa Sakai**, Tokyo (JP)

(73) Assignee: **KOMATSU LTD.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 249 days.

(21) Appl. No.: **17/638,244**

(22) PCT Filed: **Jul. 7, 2020**

(86) PCT No.: **PCT/JP2020/026509**

§ 371 (c)(1),

(2) Date: **Feb. 25, 2022**

(87) PCT Pub. No.: **WO2021/065136**

PCT Pub. Date: **Apr. 8, 2021**

(65) **Prior Publication Data**

US 2022/0325499 A1 Oct. 13, 2022

(30) **Foreign Application Priority Data**

Sep. 30, 2019 (JP) 2019-179561

(51) **Int. Cl.**

E02F 3/84 (2006.01)

B62D 12/00 (2006.01)

E02F 9/08 (2006.01)

(52) **U.S. Cl.**

CPC **E02F 3/841** (2013.01); **B62D 12/00** (2013.01); **E02F 9/0841** (2013.01)

(58) **Field of Classification Search**

CPC **E02F 3/841**; **E02F 9/0841**; **E02F 9/2045**; **E02F 9/2087**; **B62D 12/00**; **A01B 69/008**

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2002/0014060 A1* 2/2002 Dillon A01D 41/02
56/14.6
2002/0072850 A1* 6/2002 McClure A01B 69/008
701/25
2008/0208461 A1 8/2008 Gharsalli et al.
2009/0069967 A1* 3/2009 Reed B62D 1/286
340/426.31

(Continued)

FOREIGN PATENT DOCUMENTS

CN 103269937 A 8/2013
CN 103850280 A 6/2014

(Continued)

Primary Examiner — Joan T Goodbody

Assistant Examiner — Godfrey Aleksander Maciorowski

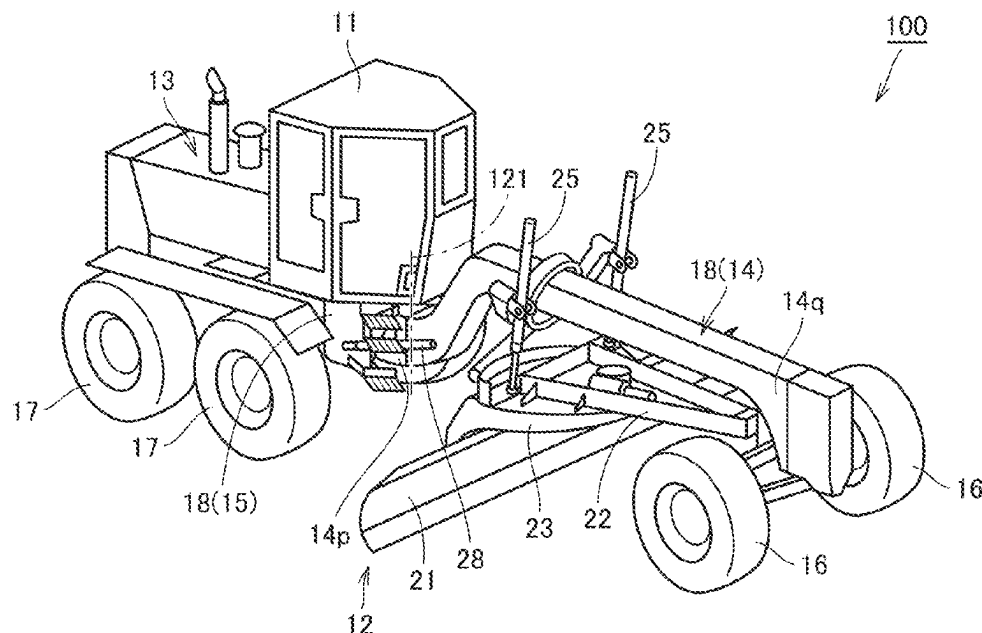
(74) *Attorney, Agent, or Firm* — Faegre Drinker Biddle & Reath LLP

(57)

ABSTRACT

A motor grader representing a work vehicle includes a steering mechanism and a control unit. The control unit generates a travel path of the motor grader based on a position and an azimuth of the motor grader and a direction of travel of the motor grader and controls the steering mechanism such that the motor grader travels along the generated travel path.

18 Claims, 14 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

2013/0192919	A1 *	8/2013	Subrt	B62D 6/002
				180/400
2014/0039753	A1	2/2014	Smits et al.	
2014/0151136	A1	6/2014	Boyle et al.	
2014/0257628	A1 *	9/2014	Lee	B62D 15/025
				701/34.4
2017/0151950	A1 *	6/2017	Lien	B60W 60/0051
2018/0037255	A1	2/2018	Takenaka et al.	
2020/0290672	A1 *	9/2020	Teranishi	E02F 9/2004

FOREIGN PATENT DOCUMENTS

CN	107406100	A	11/2017
CN	109716903	A	5/2019
JP	S53-115828	U	9/1978
JP	S64-054513	A	3/1989
JP	H07-172334	A	7/1995
JP	2511484	B2	6/1996
JP	2003-237619	A	8/2003
JP	2007-60982	A	3/2007
JP	2008-296681	A	12/2008
JP	2013-201958	A	10/2013
JP	2016-10336	A	1/2016
JP	2016-011024	A	1/2016
WO	WO-2012/083340	A1	6/2012
WO	WO-2017/110116	A1	6/2017
WO	WO-2019/054057	A1	3/2019

* cited by examiner

FIG. 1

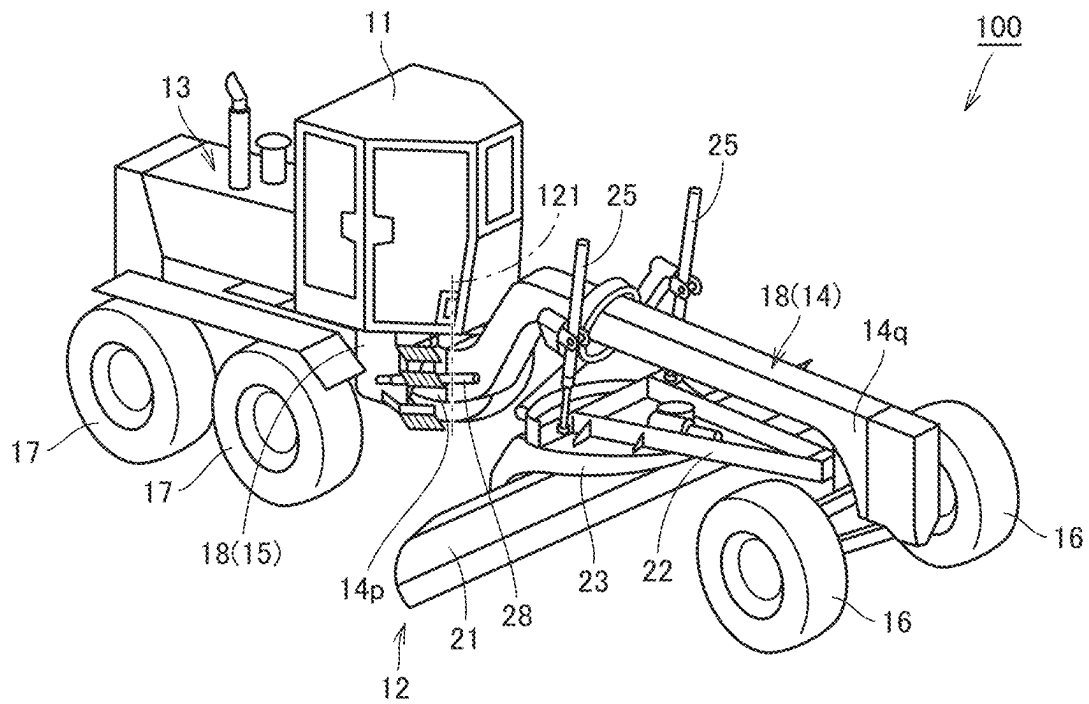


FIG.2

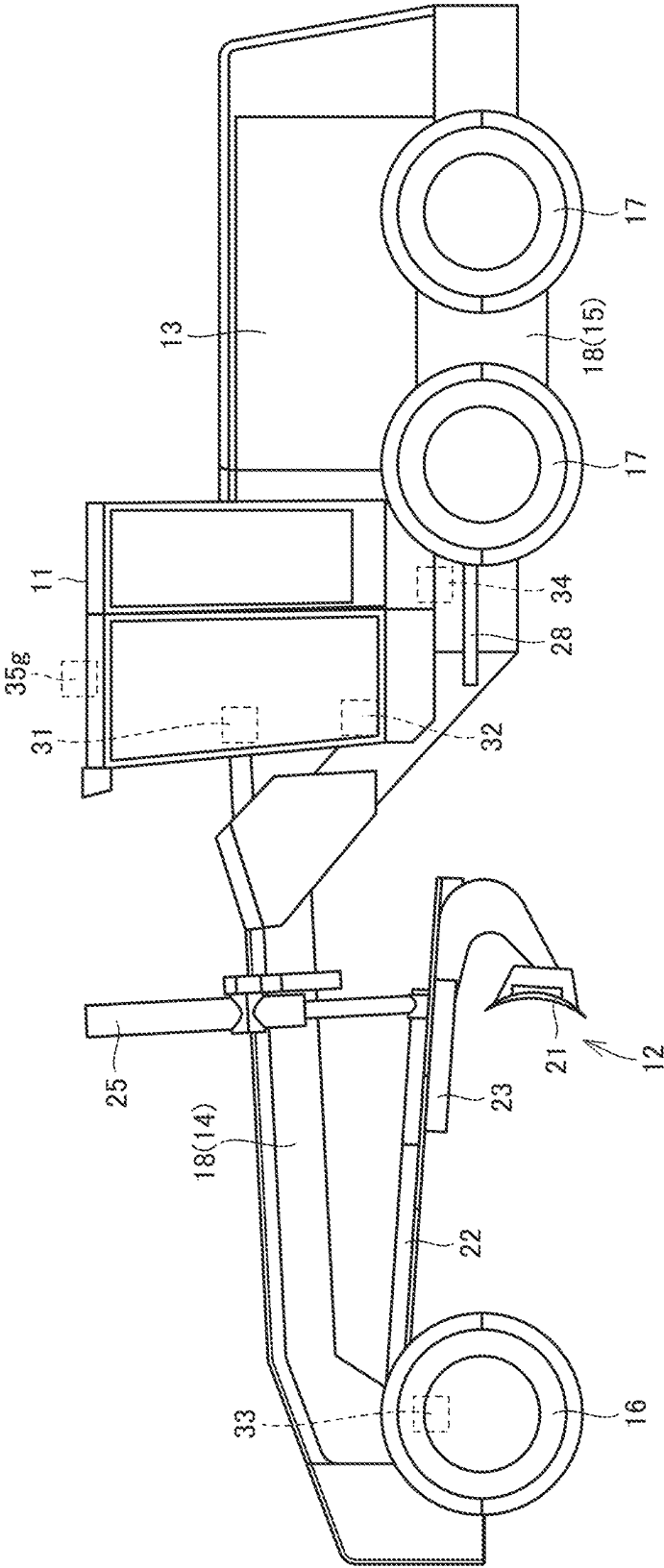


FIG.3

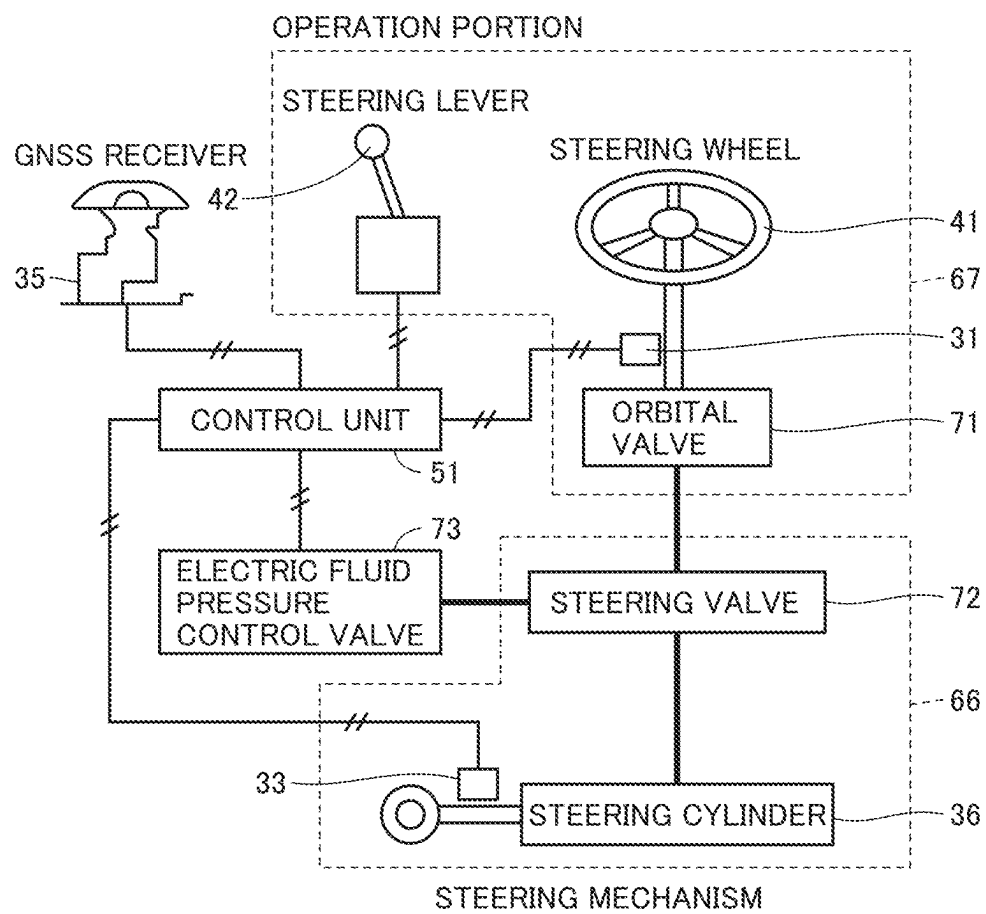


FIG. 4

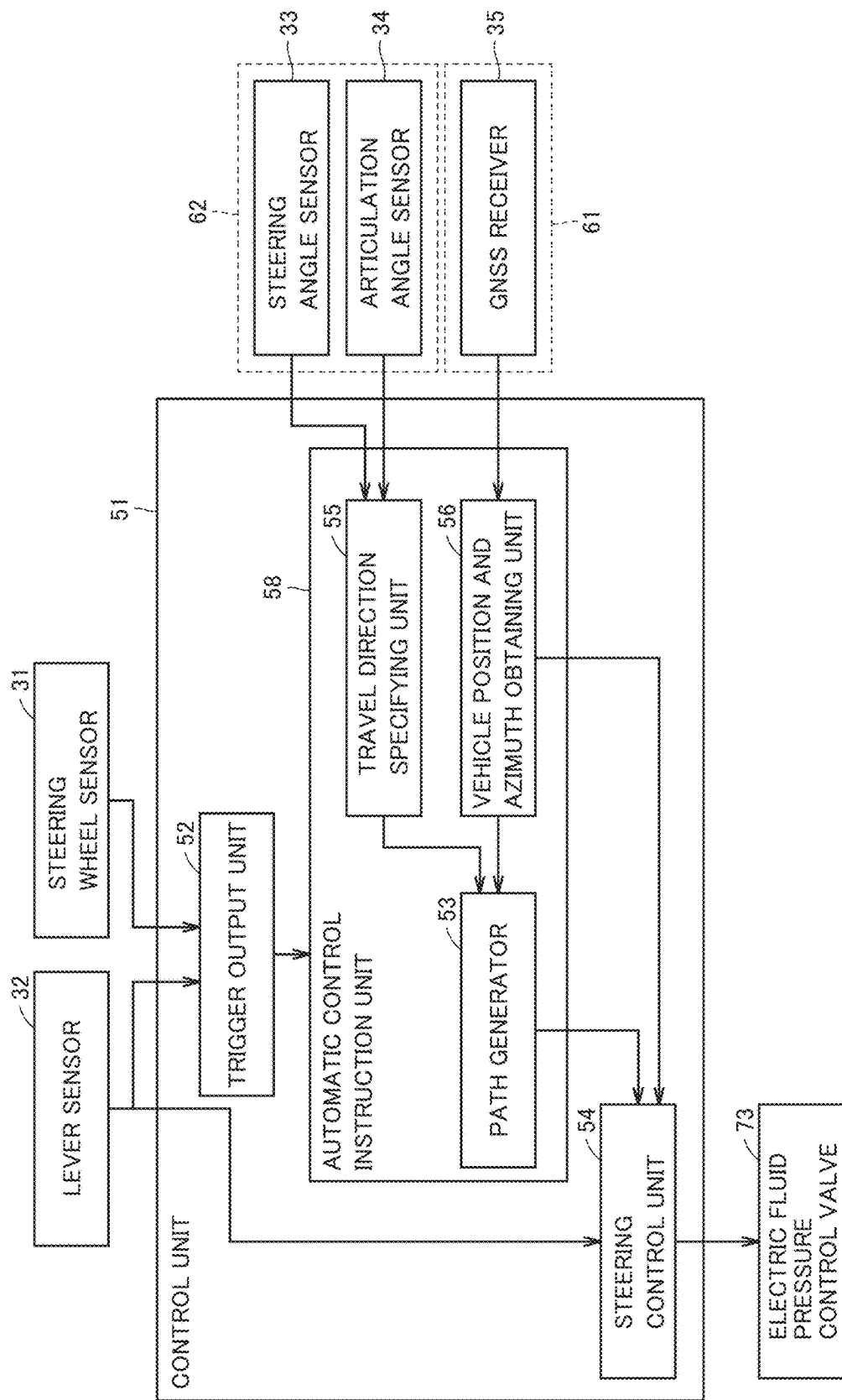


FIG. 5

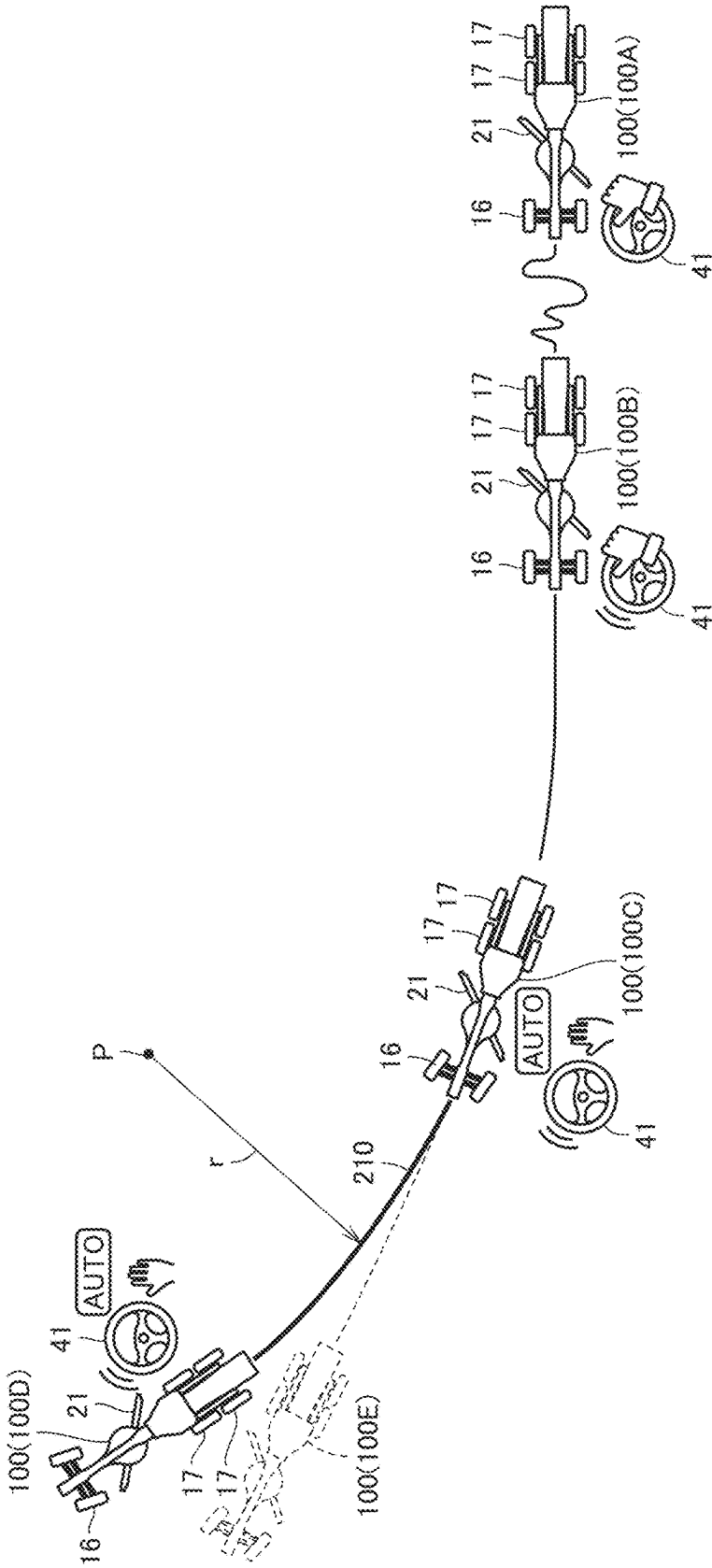


FIG. 6

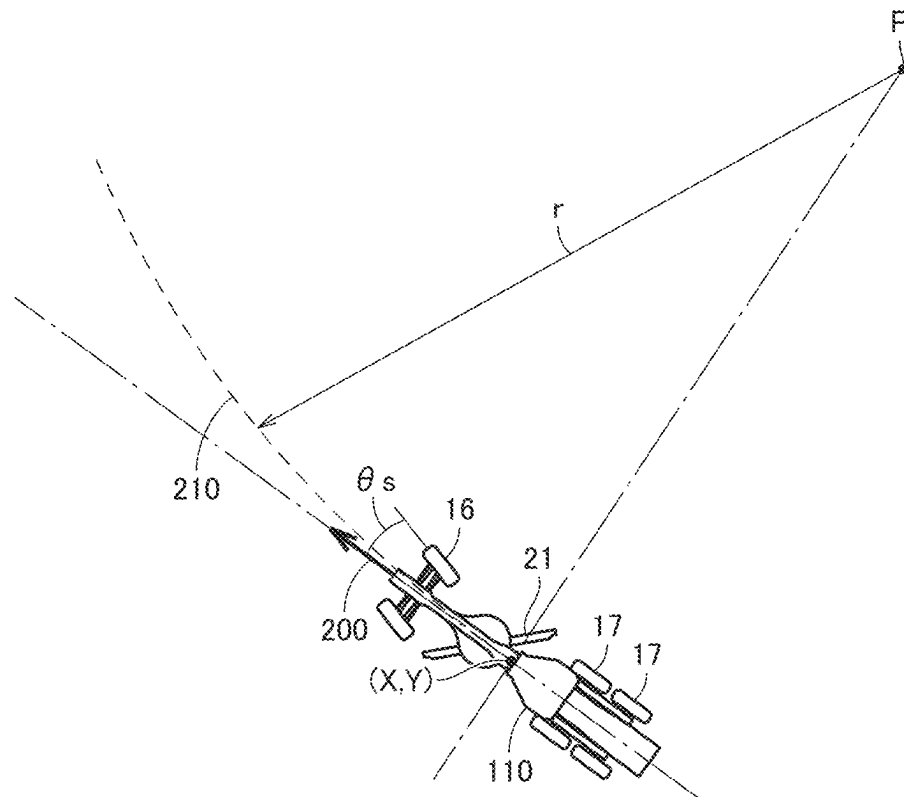


FIG. 7

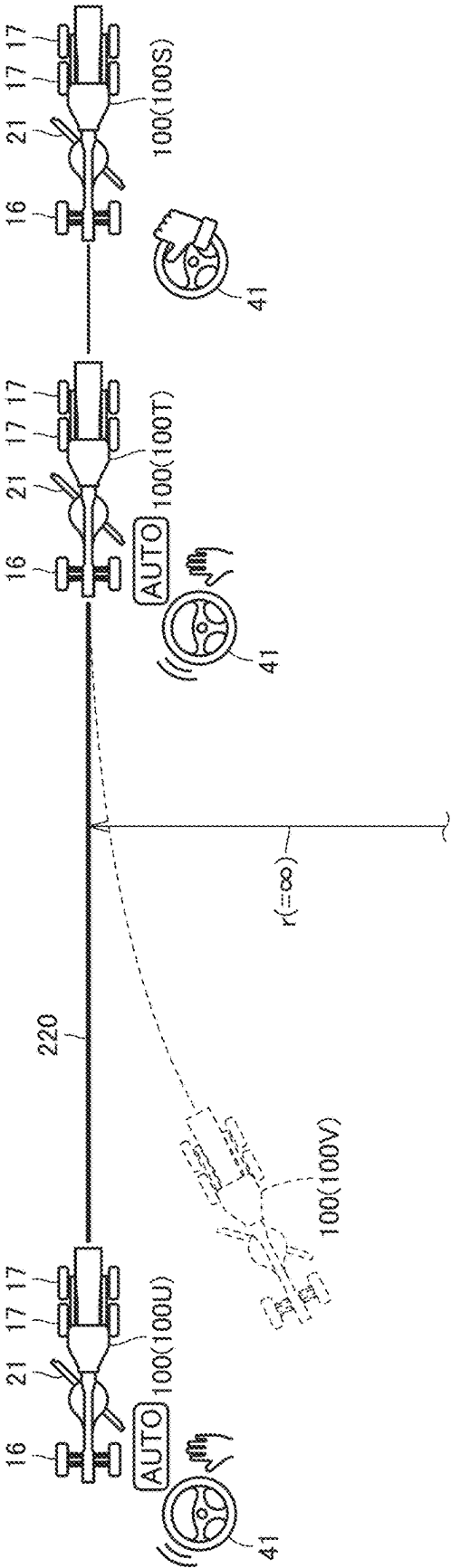


FIG.8

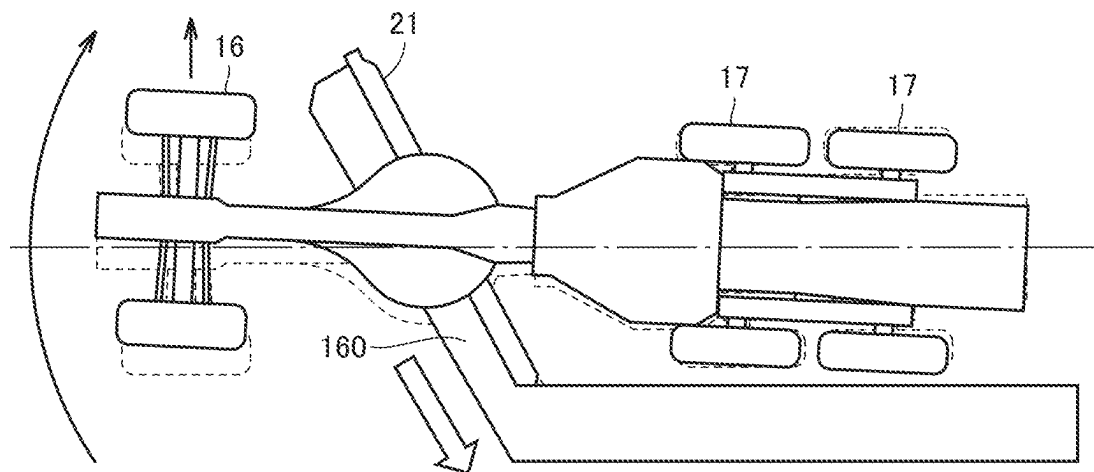


FIG.9

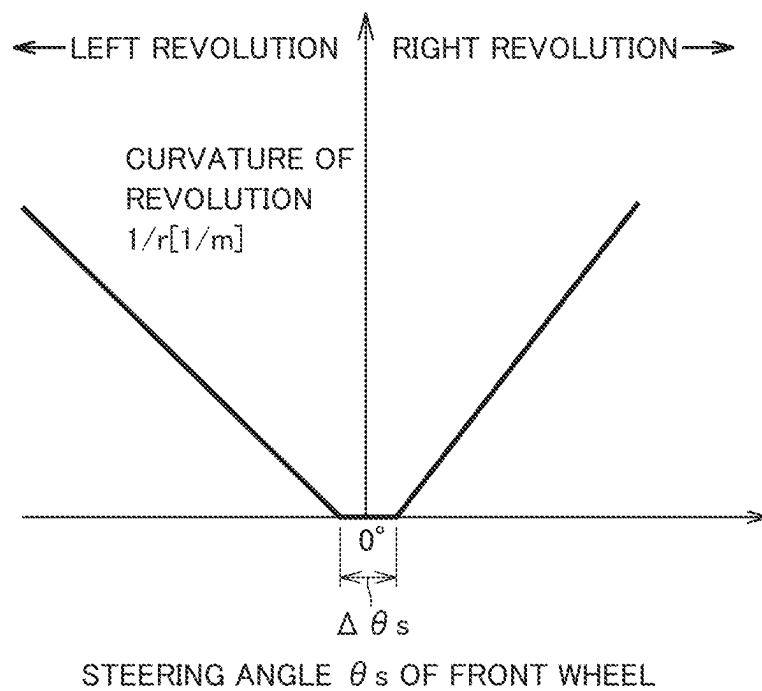


FIG.10

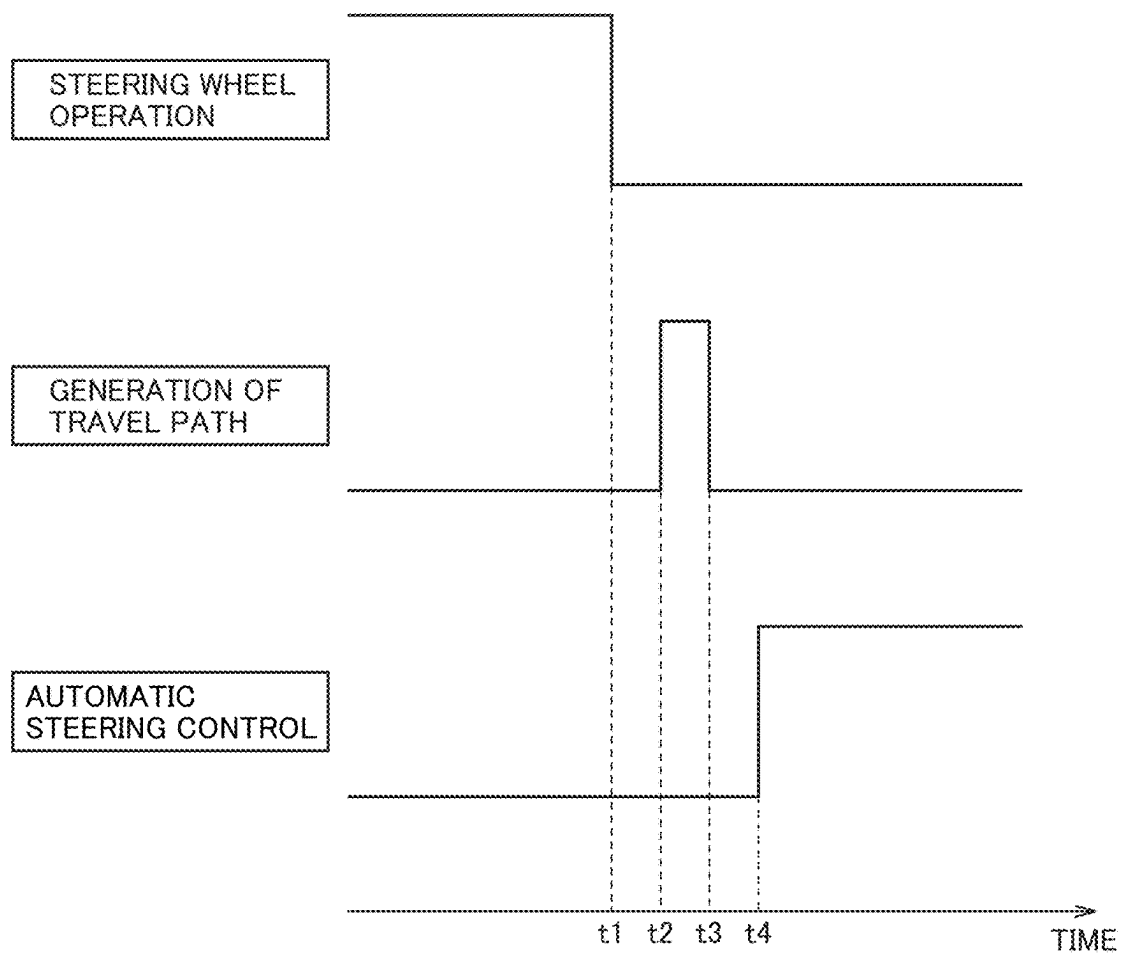


FIG.11

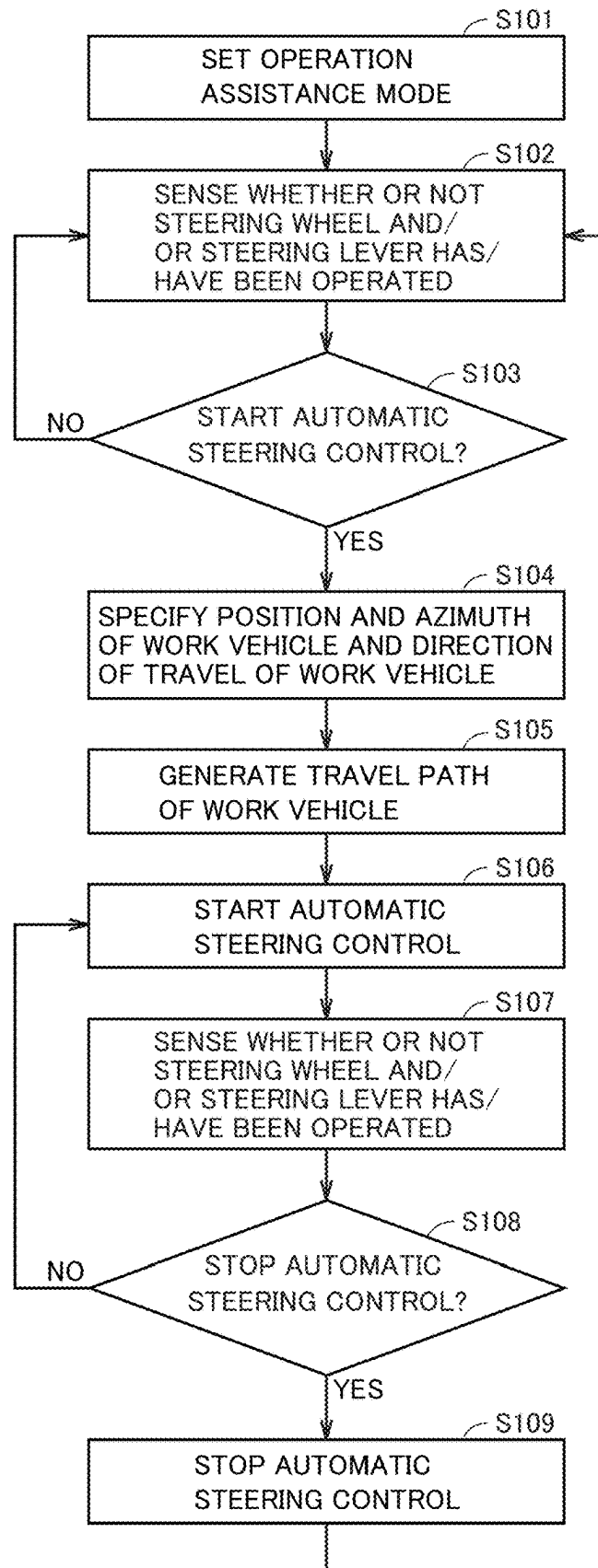


FIG.12

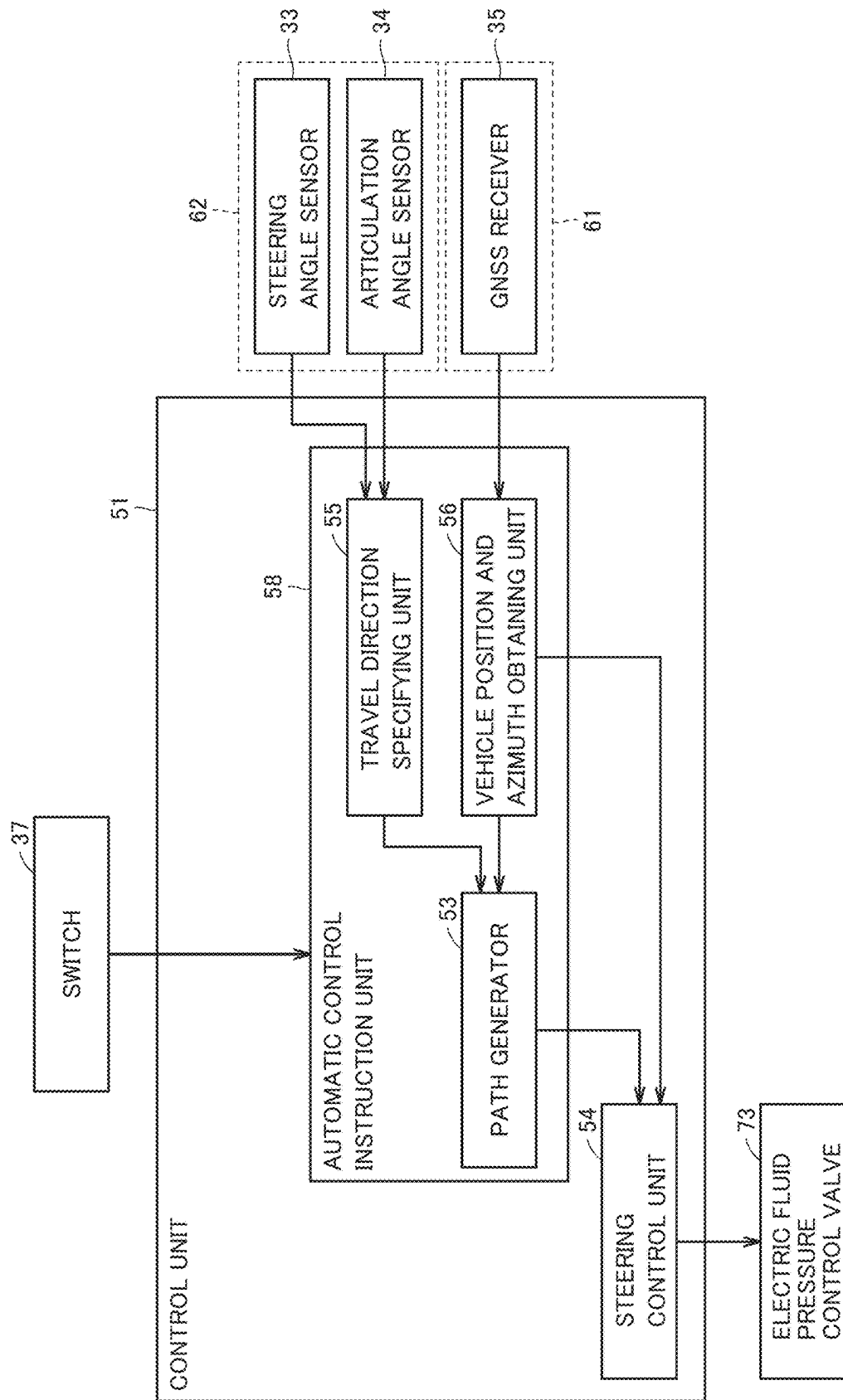


FIG.13

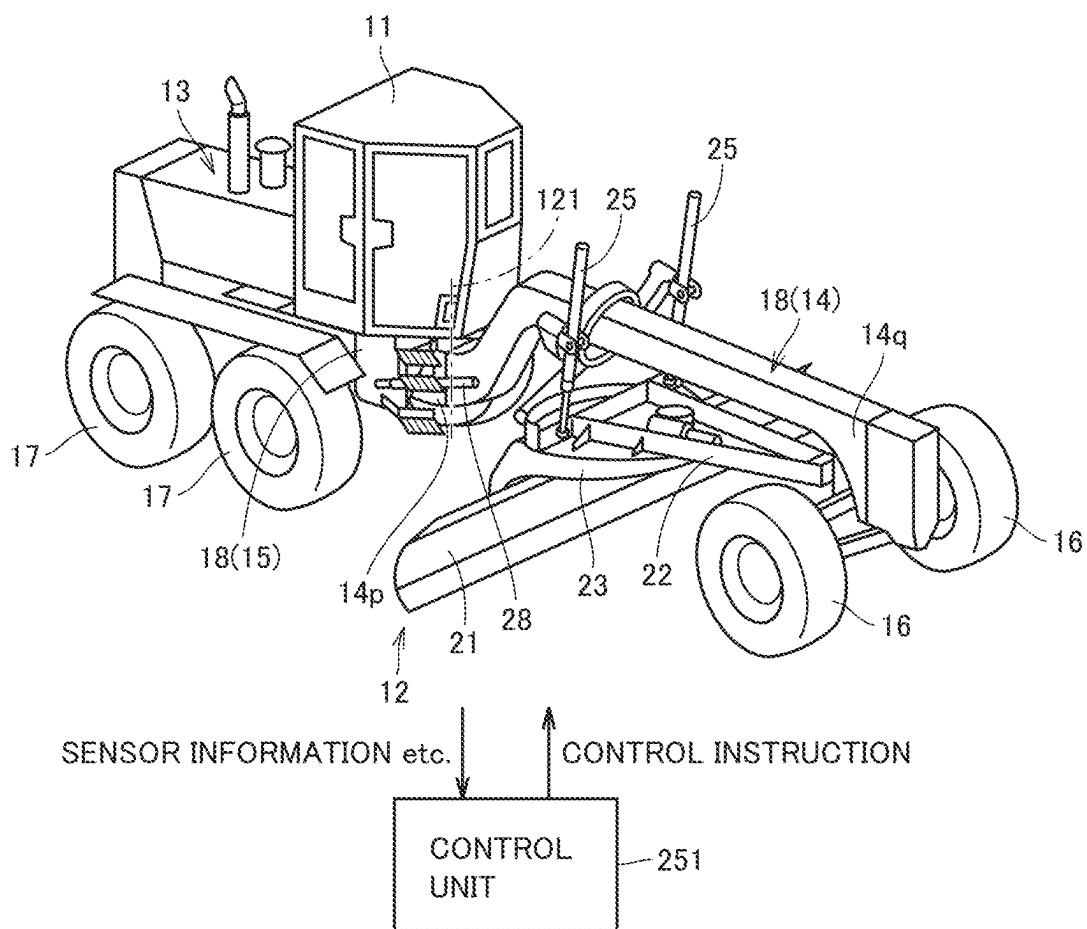


FIG.14

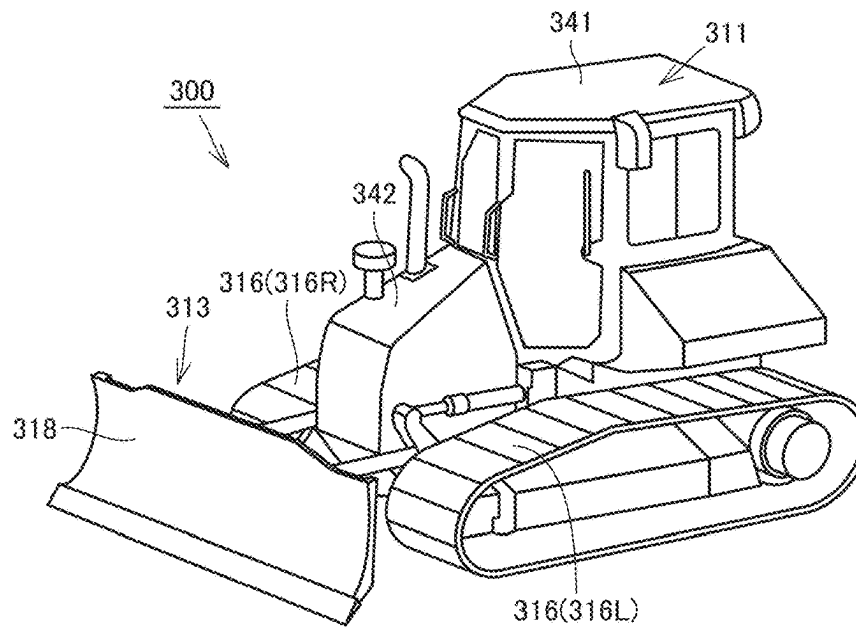


FIG.15

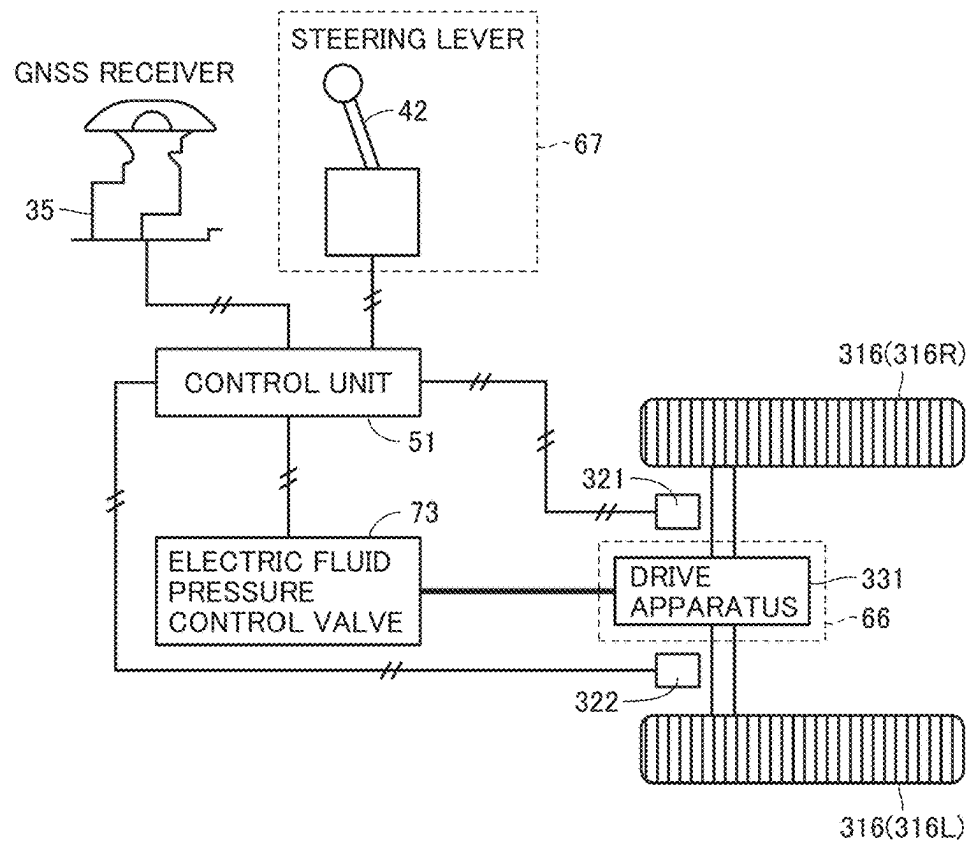
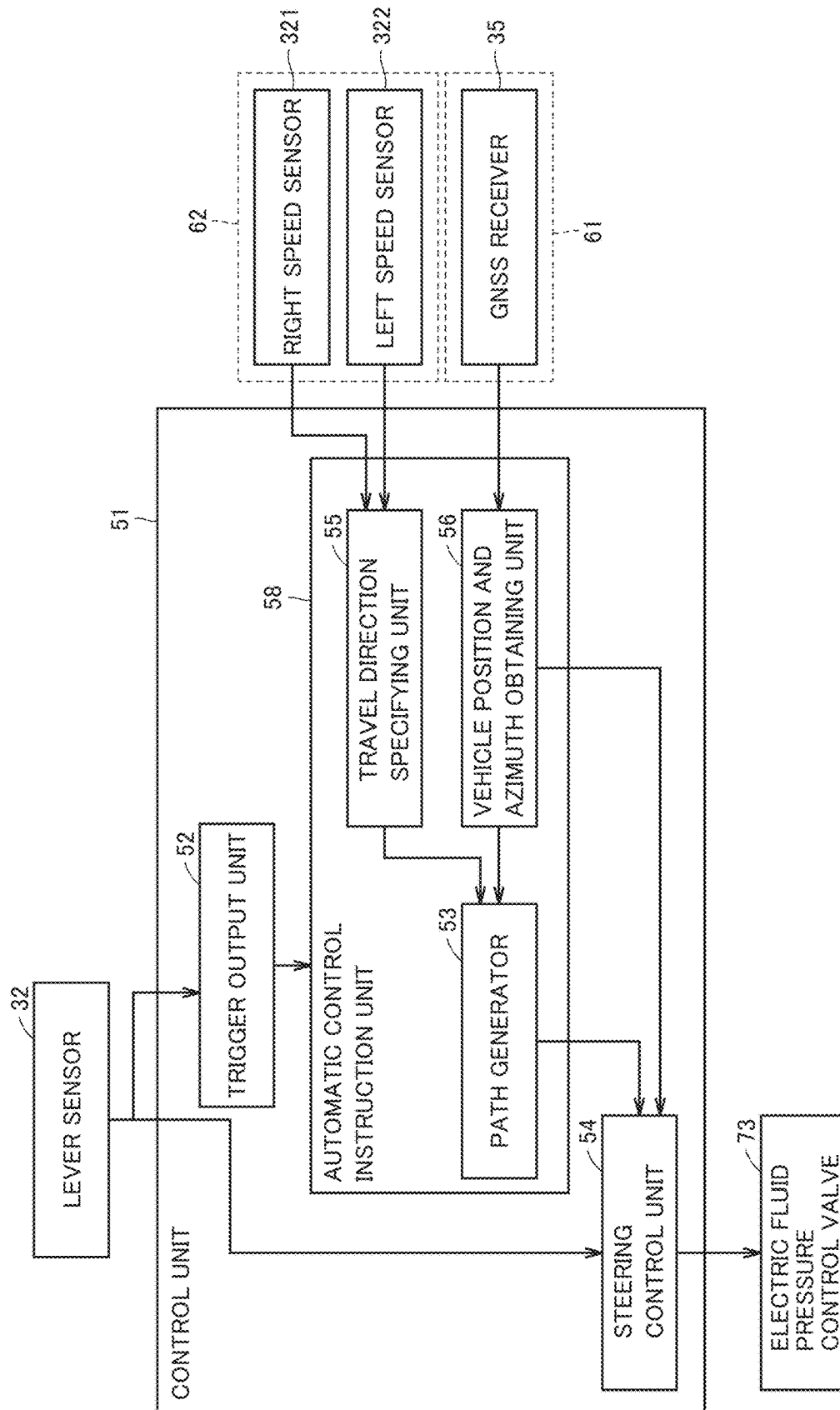


FIG. 16



1

CONTROL SYSTEM, METHOD OF CONTROLLING WORK VEHICLE, AND WORK VEHICLE

TECHNICAL FIELD

The present disclosure relates to a control system, a method of controlling a work vehicle, and a work vehicle.

BACKGROUND ART

For example, US Patent Publication No. 2008/0208461 (PTL 1) discloses a motor grader including an automated steering system. The automated steering system includes a path generator configured to generate a path along which the vehicle can travel based on data on a position of a vehicle, a map of a work site, or a parameter representing a condition of travel of the vehicle and a path tracker configured to guide the vehicle along the path generated by the path generator.

CITATION LIST

Patent Literature

PTL 1: US Patent Publication No. 2008/0208461

SUMMARY OF INVENTION

Technical Problem

In the motor grader disclosed in PTL 1, with the use of the automated steering system, an attempt is made to lessen burden imposed on an operator who controls steering. The operator, however, has to enter various types of information necessary for generation of a travel path of a vehicle in advance into the path generator, and hence burden imposed on the operator has not sufficiently been lessened.

An object of the present disclosure is to provide a control system, a method of controlling a work vehicle, and a work vehicle that realize an operation assistance system with which burden imposed on an operator is sufficiently lessened.

Solution to Problem

A control system according to the present disclosure is a control system that controls a steering mechanism of a work vehicle. The control system includes a control unit. The control unit generates a travel path of the work vehicle based on a position and an azimuth of the work vehicle and a direction of travel of the work vehicle and controls the steering mechanism of the work vehicle such that the work vehicle travels along the generated travel path.

A method of controlling a work vehicle according to the present disclosure is a method of controlling a work vehicle including a steering mechanism. The method of controlling a work vehicle includes generating a travel path of the work vehicle based on a position and an azimuth of the work vehicle and a direction of travel of the work vehicle and controlling the steering mechanism such that the work vehicle travels along the generated travel path.

A work vehicle according to the present disclosure includes a steering mechanism and a control unit. The control unit generates a travel path of the work vehicle based on a position and an azimuth of the work vehicle and a

2

direction of travel of the work vehicle and controls the steering mechanism such that the work vehicle travels along the generated travel path.

Advantageous Effects of Invention

According to the present disclosure, a control system, a method of controlling a work vehicle, and a work vehicle that realize an operation assistance system with which burden imposed on an operator is sufficiently lessened can be provided.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a perspective view showing a motor grader in a first embodiment.

FIG. 2 is a side view showing the motor grader in FIG. 1.

FIG. 3 is a system diagram showing a configuration involved with steering of the motor grader in FIG. 1.

FIG. 4 is a block diagram showing a configuration involved with an operation assistance system of the motor grader in FIG. 1.

FIG. 5 is a top view schematically showing the motor grader, automatic steering control of which is started in revolution.

FIG. 6 is a top view showing a travel path generated by the motor grader in FIG. 5.

FIG. 7 is a top view schematically showing the motor grader, automatic steering control of which is started in linear travel.

FIG. 8 is a top view showing a behavior of the motor grader when load is applied to a blade.

FIG. 9 shows a graph of relation between a steering angle of a front wheel and a curvature of revolution of the motor grader in automatic steering control.

FIG. 10 is a timing chart showing relation among timing of an operation onto a steering wheel, timing of generation of a travel path, and timing of automatic steering control.

FIG. 11 is a flowchart showing a method of controlling the motor grader in the first embodiment.

FIG. 12 is a block diagram showing a modification of the configuration involved with the operation assistance system in FIG. 4.

FIG. 13 is a diagram showing a concept of a system for controlling a steering mechanism of the motor grader.

FIG. 14 is a perspective view showing a crawler dozer.

FIG. 15 is a system diagram showing a configuration involved with steering of the crawler dozer in FIG. 14.

FIG. 16 is a block diagram showing a configuration involved with the operation assistance system of the crawler dozer in FIG. 14.

DESCRIPTION OF EMBODIMENTS

An embodiment of the present disclosure will be described with reference to the drawings. The same or corresponding members in the drawings referred to below have the same reference characters allotted.

First Embodiment

FIG. 1 is a perspective view showing a motor grader in a first embodiment. FIG. 2 is a side view showing the motor grader in FIG. 1.

As shown in FIGS. 1 and 2, a motor grader 100 is a work machine that carries out land grading works or snow removing works while it travels. Motor grader 100 includes a front

3

frame 14, a rear frame 15, a pair of articulation cylinders 28, a cab 11 where an operator's seat is provided, an engine compartment 13, a front wheel 16 and a rear wheel 17, and a work implement 12.

In the description below, a fore/aft direction refers to a fore/aft direction of an operator who sits in an operator's seat in cab 11. A direction in which the operator sitting in the operator's seat faces is defined as the fore direction and a direction behind the operator sitting in the operator's seat is defined as the aft direction. A lateral direction refers to a lateral direction of the operator who sits in the operator's seat. A right side and a left side at the time when the operator sitting in the operator's seat faces front are defined as the right direction and the left direction, respectively. An upward/downward direction is a direction orthogonal to the plane including the fore/aft direction and the lateral direction. A side where the ground is located is defined as a lower side and a side where the sky is located is defined as an upper side.

Front frame 14 and rear frame 15 form a vehicular body frame 18 of motor grader 100. Front frame 14 is provided in front of rear frame 15.

Front frame 14 is pivotably connected to rear frame 15 around a pivot center 121. Front frame 14 is pivotably connected to rear frame 15 by a central pin (not shown) provided on an axis of pivot center 121. Pivot center 121 corresponds to an axis that extends in the upward/downward direction. Pivot center 121 is located in the center of motor grader 100 in the lateral direction.

Front frame 14 extends forward from pivot center 121. Front frame 14 includes a base end 14p pivotably coupled to rear frame 15 and a tip end 14q provided opposite to base end 14p. Rear frame 15 extends rearward from pivot center 121.

The pair of articulation cylinders 28 is provided on left and right sides with front frame 14 lying therebetween. Articulation cylinder 28 is a hydraulic cylinder that is driven to extend and retract by a hydraulic pressure. Articulation cylinder 28 has one end in a direction of extending and retracting pivotably coupled to front frame 14 and has the other end in the direction of extending and retracting pivotably coupled to rear frame 15. As articulation cylinder 28 is driven to extend and retract, front frame 14 pivots with respect to rear frame 15 around pivot center 121.

Cab 11 is carried on rear frame 15. Cab 11 delimits an indoor space which an operator enters. In cab 11, in addition to the operator's seat, a steering wheel 41 and a steering lever 42 (see FIG. 3 which will be described later) for a steering operation, a plurality of levers for operating work implement 12, and various displays are provided. Cab 11 may be carried on front frame 14.

Engine compartment 13 is provided in the rear of cab 11. Engine compartment 13 is supported by rear frame 15. An engine is accommodated in engine compartment 13.

Front wheel 16 and rear wheel 17 are running wheels. Front wheel 16 is rotatably attached to front frame 14. Front wheel 16 is steerably attached to front frame 14. Front wheel 16 laterally moves to vary an angle that it forms with respect to the fore/aft direction. Front wheel 16 is a steerable wheel. Rear wheel 17 is rotatably attached to rear frame 15. Driving force from the engine is transferred to rear wheel 17. Though FIG. 1 shows six running wheels in total including two front wheels 16, one on each side, and four rear wheels 17, two on each side, the number and arrangement of front wheels and rear wheels are not limited as such.

Work implement 12 is provided between front wheel 16 and rear wheel 17 in the fore/aft direction. Work implement

4

12 is supported by front frame 14. Work implement 12 includes a blade 21, a draw bar 22, a swing circle 23, and a pair of lift cylinders 25.

Draw bar 22 is provided below front frame 14. Draw bar 22 has a front end swingably coupled to tip end 14q of front frame 14. The pair of lift cylinders 25 is provided on left and right sides with front frame 14 lying therebetween. Draw bar 22 has a rear end supported by front frame 14 with the pair of lift cylinders 25 being interposed.

As the pair of lift cylinders 25 extends and retracts, the rear end of draw bar 22 can move upward and downward with respect to front frame 14. As the pair of lift cylinders 25 is each driven to retract, a height of blade 21 with respect to front frame 14 and front wheel 16 is adjusted upward. As the pair of lift cylinders 25 is each driven to extend, the height of blade 21 with respect to front frame 14 and front wheel 16 is adjusted downward.

Draw bar 22 is swingable upward and downward around an axis along the fore/aft direction by extending and retracting of the pair of lift cylinders 25 different from each other.

Swing circle 23 is provided below draw bar 22. Swing circle 23 is revolvably coupled to draw bar 22. Swing circle 23 is revolvable clockwise and counterclockwise around an axis along the upward/downward direction.

Blade 21 is provided below swing circle 23. Blade 21 is provided as being opposed to the ground. Blade 21 is supported by swing circle 23. With revolving motion of swing circle 23, blade 21 revolves to vary an angle (a blade propulsion angle) that it forms with respect to the fore/aft direction in a top view. An axis of revolution of blade 21 is an axis extending along the upward/downward direction.

FIG. 3 is a system diagram showing a configuration involved with steering of the motor grader in FIG. 1. As shown in FIG. 3, motor grader 100 further includes a steering mechanism 66, a control unit 51, and an operation portion 67.

Steering mechanism 66 is a mechanism that controls a direction of travel of motor grader 100. Control unit 51 controls steering of motor grader 100. Control unit 51 controls operations of steering mechanism 66. Operation portion 67 is provided in cab 11. Operation portion 67 is operated by an operator to move steering mechanism 66.

Operation portion 67 includes a steering wheel 41 and a steering lever 42. Steering wheel 41 is provided in front of the operator's seat in cab 11. Steering wheel 41 is, for example, a steering wheel in a shape of a wheel, and rotationally operated by an operator. Steering lever 42 is provided at a position distant from steering wheel 41. Steering lever 42 is provided, for example, laterally to the operator's seat in cab 11. Steering lever 42 is tilted by the operator.

Motor grader 100 further includes an electric fluid pressure control valve 73. Operation portion 67 further includes an orbital valve 71. Steering mechanism 66 includes a steering valve 72 and a steering cylinder 36.

Electric fluid pressure control valve 73 supplies pressure oil to steering valve 72. Control unit 51 controls electric fluid pressure control valve 73 based on an operation signal from steering lever 42. Orbital valve 71 supplies pressure oil to steering valve 72 in accordance with a rotational operation onto steering wheel 41.

Steering valve 72 supplies pressure oil to steering cylinder 36. Steering valve 72 is controlled by pressure oil supplied from electric fluid pressure control valve 73 and orbital valve 71. With pressure oil from steering valve 72, steering cylinder 36 laterally moves front wheel 16 to vary an angle that it forms with respect to the fore/aft direction of front

5

wheel 16. As front wheel 16 is leaned to the left, motor grader 100 revolves toward forward left along an arc. As front wheel 16 is leaned to the right, motor grader 100 revolves toward forward right along an arc.

According to such a configuration, as an operator operates steering wheel 41 or steering lever 42, steering cylinder 36 extends or retracts so that front wheel 16 laterally moves.

FIG. 4 is a block diagram showing a configuration involved with an operation assistance system of the motor grader in FIG. 1. As shown in FIGS. 2 to 4, control unit 51 controls operations of the operation assistance system of motor grader 100 which will be described below.

Motor grader 100 further includes a steering wheel sensor 31 and a lever sensor 32. Steering wheel sensor 31 senses an operation onto steering wheel 41. Lever sensor 32 senses an operation onto steering lever 42.

Steering wheel sensor 31 generates an operation signal when it senses an operation onto steering wheel 41 by an operator and provides the operation signal to control unit 51. Steering wheel sensor 31 is, for example, a shaft displacement sensor that detects displacement of an angle of a steering wheel shaft caused by rotation of steering wheel 41. Lever sensor 32 generates an operation signal when it senses an operation onto steering lever 42 by the operator and provides the operation signal to control unit 51. Lever sensor 32 is, for example, a position sensor that detects an angular position of steering lever 42.

Steering wheel sensor 31 may have a dead zone so as not to generate an operation signal when an amount of rotational operation of steering wheel 41 is small. Similarly, lever sensor 32 may have a dead zone so as not to generate an operation signal when an amount of operation to tilt steering lever 42 is small. By way of example, an amount of operation onto steering wheel 41 or steering lever 42 at the time when a steering angle of front wheel 16 which will be described later is varied within a range of $\pm 0.5^\circ$ is determined as being small.

Motor grader 100 further includes a first sensing unit 61 and a second sensing unit 62. First sensing unit 61 senses information on a position and an azimuth of motor grader 100. Second sensing unit 62 senses information on a direction of travel of motor grader 100.

First sensing unit 61 includes a global navigation satellite system (GNSS) receiver 35. GNSS receiver 35 is, for example, a receiver for a global positioning system (GPS). An antenna 35g (see FIG. 2) of GNSS receiver 35 is arranged, for example, in a ceiling of cab 11. GNSS receiver 35 receives a navigation signal from a satellite, calculates a position of antenna 35g based on the navigation signal, and generates vehicular body position data. GNSS receiver 35 provides position and azimuth data of motor grader 100 to control unit 51.

Second sensing unit 62 includes a steering angle sensor 33 and an articulation angle sensor 34. Steering angle sensor 33 senses a steering angle of front wheel 16 (an angle formed by front wheel 16 with respect to the fore-aft direction) and generates a signal indicating the sensed steering angle. Steering angle sensor 33 provides a signal indicating the steering angle to control unit 51. Articulation angle sensor 34 senses an angle of articulation (an angle of coupling) between front frame 14 and rear frame 15 and generates a signal indicating the sensed angle of articulation. Articulation angle sensor 34 provides a signal indicating the angle of articulation to control unit 51.

As shown in FIG. 4, when a trigger for starting automatic control of steering mechanism 66 is provided, control unit 51 generates a travel path of motor grader 100 based on the

6

position and the azimuth of motor grader 100 and the direction of travel of motor grader 100 and controls steering mechanism 66 such that motor grader 100 travels along the generated travel path.

Control unit 51 starts control of steering mechanism 66 when an operation onto operation portion 67 is stopped. Control unit 51 stops control of steering mechanism 66 when an operation onto operation portion 67 is resumed.

Control unit 51 includes a trigger output unit 52, an automatic control instruction unit 58, and a steering control unit 54.

Trigger output unit 52 provides a trigger for starting or stopping control (automatic steering control which will be described later) of steering mechanism 66 based on a steering wheel 41 operation signal from steering wheel sensor 31 and/or a steering lever 42 operation signal from lever sensor 32.

Trigger output unit 52 provides a trigger for stopping automatic steering control (a stop trigger which will be described later) when the steering wheel 41 operation signal from steering wheel sensor 31 or the steering lever 42 operation signal from lever sensor 32 is provided.

Trigger output unit 52 provides a trigger for starting automatic steering control (a start trigger which will be described later) when the steering wheel 41 operation signal from steering wheel sensor 31 and the steering lever 42 operation signal from lever sensor 32 are not provided.

Automatic control instruction unit 58 includes a vehicle position and azimuth obtaining unit 56, a travel direction specifying unit 55, and a path generator 53.

Vehicle position and azimuth obtaining unit 56 obtains position and azimuth data of motor grader 100 from GNSS receiver 35. Position data of motor grader 100 obtained by vehicle position and azimuth obtaining unit 56 represents a position of motor grader 100 defined in a global coordinate system. Azimuth data of motor grader 100 obtained by vehicle position and azimuth obtaining unit 56 represents, for example, an azimuth corresponding to the front of motor grader 100.

Travel direction specifying unit 55 receives input of a signal indicating the steering angle from steering angle sensor 33 and a signal indicating the angle of articulation from articulation angle sensor 34. Travel direction specifying unit 55 specifies the direction of travel of motor grader 100 based on the provided steering angle and angle of articulation.

When the present disclosure is applied to a work vehicle not including the articulation mechanism, the direction of travel of the work vehicle may be specified only based on the steering angle of the front wheel provided in the vehicular body frame.

When a start trigger from trigger output unit 52 is provided, path generator 53 generates a travel path of motor grader 100 based on position and azimuth data of motor grader 100 obtained by vehicle position and azimuth obtaining unit 56 and the direction of travel of motor grader 100 specified by travel direction specifying unit 55.

Steering control unit 54 controls steering mechanism 66 such that motor grader 100 travels along the travel path generated by path generator 53. Specifically, steering control unit 54 provides a control signal to electric fluid pressure control valve 73 such that motor grader 100 travels along the travel path generated by path generator 53. Electric fluid pressure control valve 73 supplies pressure oil to steering valve 72 and controls steering cylinder 36 based on a signal from steering control unit 54 (start of automatic steering control).

When an operation onto operation portion 67 by the operator is resumed, trigger output unit 52 receives input of the steering wheel 41 operation signal from steering wheel sensor 31 or the steering lever 42 operation signal from lever sensor 32. Trigger output unit 52 thus provides a stop trigger. In this case, automatic control instruction unit 58 receives the stop trigger from trigger output unit 52 and stops automatic steering control.

In succession, automatic steering control carried out by control unit 51 will more specifically be described. FIG. 5 is a top view schematically showing the motor grader, automatic steering control of which is started in revolution. FIG. 6 is a top view showing a travel path generated by the motor grader in FIG. 5.

For the sake of brevity of description, FIGS. 5 and 6 and FIG. 7 which will be described later show an example in which only steering wheel 41 is used as operation portion 67 for moving front wheel 16 and front frame 14 and rear frame 15 are not bent with respect to each other, with front frame 14 and rear frame 15 forming an articulation angle of 0°.

As shown in FIGS. 4 and 5, motor grader 100 travels to sequentially move to positions shown with a motor grader 100A, a motor grader 100B, a motor grader 100C, and a motor grader 100D (which are referred to as a “position 100A”, a “position 100B”, a “position 100C”, and a “position 100D”, respectively below).

While motor grader 100 moves from position 100A to position 100B, the operator has motor grader 100 travel by operating steering wheel 41. During this period, trigger output unit 52 receives input of the steering wheel 41 operation signal from steering wheel sensor 31. Trigger output unit 52 provides the stop trigger. Automatic control instruction unit 58 receives the stop trigger from trigger output unit 52 and automatic steering control is not started.

While motor grader 100 moves from position 100B to position 100C, the operator has motor grader 100 revolve toward front right by operating steering wheel 41. During this period, trigger output unit 52 receives input of the steering wheel 41 operation signal from steering wheel sensor 31. Trigger output unit 52 provides the stop trigger. Automatic control instruction unit 58 receives the stop trigger from trigger output unit 52 and automatic steering control is not started.

While motor grader 100 moves from position 100C to position 100D, the operator does not operate steering wheel 41. During this period, trigger output unit 52 does not receive the steering wheel 41 operation signal from steering wheel sensor 31. Trigger output unit 52 provides the start trigger. Automatic control instruction unit 58 receives the start trigger from trigger output unit 52 and automatic steering control is started.

As shown in FIGS. 4 and 6, in the absence of input of the steering wheel 41 operation signal from steering wheel sensor 31 to trigger output unit 52, trigger output unit 52 provides the start trigger. When vehicle position and azimuth obtaining unit 56 receives the start trigger from trigger output unit 52, it obtains from GNSS receiver 35, the position of motor grader 100 expressed by a coordinate (X, Y) and the azimuth of motor grader 100 shown with an arrow 200. When travel direction specifying unit 55 receives the start trigger from trigger output unit 52, it specifies the direction of travel (direction of revolution) of motor grader 100 based on a steering angle θ_s sensed by steering angle sensor 33.

Path generator 53 generates a travel path 210 of motor grader 100 based on the position and the azimuth of motor grader 100 obtained by vehicle position and azimuth obtain-

ing unit 56 and the direction of travel of motor grader 100 specified by travel direction specifying unit 55. Travel path 210 is a path for revolving, with the position of motor grader 100 obtained by vehicle position and azimuth obtaining unit 56 being defined as a starting point, motor grader 100 in the direction of travel specified by travel direction specifying unit 55 with the azimuth of motor grader 100 obtained by vehicle position and azimuth obtaining unit 56 being defined as the reference. Travel path 210 is a path for revolving motor grader 100 at a constant radius of curvature r corresponding to steering angle θ_s .

As shown in FIGS. 4 and 5, during automatic steering control from position 100C to position 100D, steering control unit 54 compares travel path 210 of motor grader 100 generated by path generator 53 with the position of motor grader 100 obtained successively by vehicle position and azimuth obtaining unit 56. When deviation not smaller than a predetermined threshold value is produced between travel path 210 and the position of motor grader 100 as shown with a motor grader 100E in FIG. 5, steering control unit 54 controls steering cylinder 36 to set the position of motor grader 100 back to the position on travel path 210.

Thereafter, when trigger output unit 52 receives input of the steering wheel 41 operation signal from steering wheel sensor 31, steering control unit 54 stops automatic steering control, and in the absence of input of the steering wheel 41 operation signal from steering wheel sensor 31 to trigger output unit 52, steering control unit 54 resumes automatic steering control. When automatic steering control is resumed, path generator 53 generates a new travel path based on the position and the azimuth of motor grader 100 at that time and the direction of travel of motor grader 100.

FIG. 7 is a top view schematically showing the motor grader, automatic steering control of which is started in linear travel.

As shown in FIGS. 4 and 7, motor grader 100 travels to sequentially move to positions shown with a motor grader 100S, a motor grader 100T, and a motor grader 100U (which are referred to as a “position 100S”, a “position 100T”, and a “position 100U”, respectively below).

While motor grader 100 moves from position 100S to position 100T, the operator has motor grader 100 travel by operating steering wheel 41. During this period, trigger output unit 52 receives input of the steering wheel 41 operation signal from steering wheel sensor 31. Trigger output unit 52 provides the stop trigger. Automatic control instruction unit 58 receives the stop trigger from trigger output unit 52 and automatic steering control is not started.

While motor grader 100 moves from position 100T to position 100U, the operator does not operate steering wheel 41. During this period, trigger output unit 52 does not receive the steering wheel 41 operation signal from steering wheel sensor 31. Trigger output unit 52 provides the start trigger. Automatic control instruction unit 58 receives the start trigger from trigger output unit 52 and automatic steering control is started.

As in revolution, when trigger output unit 52 does not receive the steering wheel 41 operation signal from steering wheel sensor 31, trigger output unit 52 provides the start trigger. When vehicle position and azimuth obtaining unit 56 receives the start trigger from trigger output unit 52, it obtains the position and the azimuth of motor grader 100 from GNSS receiver 35. When travel direction specifying unit 55 receives the start trigger from trigger output unit 52, it specifies the direction of travel (a direction of linear travel) of motor grader 100 based on steering angle $\theta_s=0^\circ$ sensed by steering angle sensor 33.

Path generator 53 generates a travel path 220 of motor grader 100 based on the position and the azimuth of motor grader 100 obtained by vehicle position and azimuth obtaining unit 56 and the direction of travel of motor grader 100 specified by travel direction specifying unit 55. Travel path 220 is a path for having motor grader 100 travel straight in the direction of travel specified by travel direction specifying unit 55, with the position of motor grader 100 obtained by vehicle position and azimuth obtaining unit 56 being defined as a starting point and with the azimuth of motor grader 100 obtained by vehicle position and azimuth obtaining unit 56 being defined as the reference.

During automatic steering control from position 100T to position 100U, steering control unit 54 compares travel path 220 of motor grader 100 generated by path generator 53 with the position of motor grader 100 obtained successively by vehicle position and azimuth obtaining unit 56. When deviation not smaller than a predetermined threshold value is produced between travel path 220 and the position of motor grader 100 as shown with a motor grader 100V in FIG. 6, steering control unit 54 controls steering cylinder 36 to set the position of motor grader 100 back to the position on travel path 220.

FIG. 8 is a top view showing a behavior of the motor grader when load is applied to the blade. As shown in FIG. 8, in order to move deposits 160 such as soil or snow sideways, blade 21 is used as being obliquely tilted with respect to the lateral direction. In this case, as blade 21 receives load from deposits 160, the direction of travel of motor grader 100 is displaced sideways, or motor grader 100 wanders laterally due to variation in load applied by deposits 160. Without being limited to motor grader 100, a work vehicle generally travels on the ground with surface irregularities, and hence the direction of travel of the work vehicle tends to be displaced.

Therefore, the operator should operate also a control lever of work implement 12 while the operator operates steering wheel 41 or steering lever 42 or performs a leaning operation in order to adjust the direction of travel of motor grader 100. Since such operations require advanced techniques and concentration, excessive burden is imposed on the operator.

In contrast, in motor grader 100, when a trigger for starting automatic steering control is provided to automatic control instruction unit 58, the travel path of motor grader 100 is generated based on the position and the azimuth of motor grader 100 and the direction of travel of motor grader 100 and automatic steering control is carried out such that motor grader 100 travels along the generated travel path.

According to such a configuration, the operator can concentrate on operations of work implement 12 without performing an operation for adjusting the direction of travel of motor grader 100 during automatic steering control. Since the travel path of motor grader 100 is automatically generated based on the position and the azimuth of motor grader 100 and the direction of travel of motor grader 100, the operator does not have to provide in advance, input of a map of a work site or various parameters relating to a travel path. Therefore, the operation assistance system with which burden on the operator is sufficiently lessened can be realized.

Control unit 51 starts automatic steering control when the operation onto steering wheel 41 and steering lever 42 is stopped. According to such a configuration, the operator does not have to perform a special operation for starting automatic steering control, and hence burden on the operator can further be lessened.

When the operation onto steering wheel 41 or steering lever 42 is resumed, control unit 51 stops automatic steering

control. According to such a configuration, the operator can have motor grader 100 travel in an intended direction through the operation onto steering wheel 41 or steering lever 42.

FIG. 9 shows a graph of relation between a steering angle of the front wheel and a curvature of revolution of the motor grader in automatic steering control.

As shown in FIGS. 4 and 9, when steering angle θ_s of front wheel 16 is within a range of small $\Delta\theta_s$ with 0° being defined as the center, travel direction specifying unit 55 may determine steering angle θ_s as 0° and specify the direction of travel of motor grader 100 as the direction of linear travel. Magnitude of $\Delta\theta_s$ may be set, for example, to 1° or 1.5° .

FIG. 10 is a timing chart showing relation among timing of an operation onto the steering wheel, timing of generation of a travel path, and timing of automatic steering control.

As shown in FIGS. 4 and 10, control unit 51 may start automatic steering control after a state in which the operation onto steering wheel 41 and steering lever 42 is stopped continues for a prescribed period. Control unit 51 may generate the travel path of motor grader 100 during the prescribed period.

In the timing chart shown in FIG. 10, at time t_1 , the operator does not perform an operation onto steering wheel 41, so that trigger output unit 52 does not receive input of the steering wheel 41 operation signal from steering wheel sensor 31. Then, during a period from time t_2 to time t_3 , path generator 53 generates the travel path of motor grader 100. Then, at time t_4 , steering control unit 54 starts automatic steering control.

An interval from time t_1 to time t_2 is, for example, within a range not shorter than 0.5 s and not longer than 1 s ($0.5 \text{ s} \leq (t_2 - t_1) \leq 1 \text{ s}$). An interval from time t_1 to time t_4 is, for example, within a range not shorter than 1 s and not longer than 2 s ($1 \text{ s} \leq (t_4 - t_1) \leq 2 \text{ s}$).

According to such a configuration, automatic steering control is started after the state in which the operation onto steering wheel 41 and steering lever 42 is stopped continues for a prescribed period. Therefore, control unit 51 can be prevented from overacting to stop of the operation onto steering wheel 41 and steering lever 42 and starting automatic steering control. Since the travel path of motor grader 100 is generated during the prescribed period from stop of the operation onto steering wheel 41 and steering lever 42 until start of automatic steering control, transition to automatic steering control can smoothly be made.

FIG. 11 is a flowchart showing a method of controlling the motor grader in the first embodiment. As shown in FIGS. 4 and 11, initially, control unit 51 is set to an operation assistance mode (S101). The operation assistance mode is set, for example, by turn-on of a mode setting switch provided in cab 11 by an operator.

Then, steering wheel sensor 31 senses whether or not the operator has operated steering wheel 41, and lever sensor 32 senses whether or not the operator has operated steering lever 42 (S102).

In the present step, when steering wheel sensor 31 senses the operation onto steering wheel 41, the steering wheel 41 operation signal is provided to trigger output unit 52, and when steering wheel sensor 31 does not sense the operation onto steering wheel 41, the steering wheel 41 operation signal is not provided to trigger output unit 52. When lever sensor 32 senses the operation onto steering lever 42, the steering lever 42 operation signal is provided to trigger output unit 52, and when lever sensor 32 does not sense the operation onto steering lever 42, the steering lever 42 operation signal is not provided to trigger output unit 52.

11

Then, automatic control instruction unit **58** determines whether or not to start automatic steering control (S103).

In step S102, when the steering wheel **41** operation signal from steering wheel sensor **31** or the steering lever **42** operation signal from lever sensor **32** is provided to trigger output unit **52**, trigger output unit **52** provides the stop trigger to automatic control instruction unit **58**. In this case, automatic control instruction unit **58** determines not to start automatic steering control. Then, the process returns to step S102.

In step S102, when the steering wheel **41** operation signal from steering wheel sensor **31** and the steering lever **42** operation signal from lever sensor **32** are not provided to trigger output unit **52**, trigger output unit **52** provides the start trigger to automatic control instruction unit **58**. In this case, automatic control instruction unit **58** determines to start automatic steering control (S103). Then, the process proceeds to step S104.

Vehicle position and azimuth obtaining unit **56** specifies the position and the azimuth of motor grader **100** and travel direction specifying unit **55** specifies the direction of travel of motor grader **100** (S104).

Then, path generator **53** generates the travel path of motor grader **100** based on the position and the azimuth of motor grader **100** specified by vehicle position and azimuth obtaining unit **56** and the direction of travel of motor grader **100** specified by travel direction specifying unit **55** (S105).

Then, steering control unit **54** controls electric fluid pressure control valve **73** such that motor grader **100** travels along the travel path generated by path generator **53** (S106).

After step S106 is started, step S107 in which steering wheel sensor **31** senses whether or not the operator has operated steering wheel **41** and lever sensor **32** senses whether or not the operator has operated steering lever **42** and step S108 in which automatic control instruction unit **58** determines whether or not to stop automatic steering control are successively performed. When it is determined in step S108 to stop automatic steering control, steering control unit **54** stops automatic steering control (S109). Thereafter, the process returns to step S102.

FIG. **12** is a block diagram showing a modification of a configuration involved with the operation assistance system in FIG. **4**. As shown in FIG. **12**, in the present modification, motor grader **100** includes a switch **37**. Switch **37** is a switch for switching between start (on) of automatic steering control and stop (off) of automatic steering control.

Switch **37** is provided in cab **11**. A form of switch **37** is not particularly limited, and the switch may be provided as a push button or a lever. Switch **37** may be provided in a touch panel on a monitor.

In the present modification, when the operator performs an operation to turn switch **37** on, a trigger (start trigger) for starting automatic steering control is provided to automatic control instruction unit **58**. In succession, generation of the travel path of motor grader **100** and automatic steering control are sequentially carried out. When the operator performs an operation to turn switch **37** off, the stop trigger is provided to automatic control instruction unit **58** and automatic steering control is stopped.

According to such a configuration, the operator can start automatic steering control at timing further intended by himself/herself.

The configuration and effects of motor grader **100** and a method of controlling the same in the present embodiment described above will be summarized.

Motor grader **100** as the work vehicle includes steering mechanism **66** and control unit **51**. Control unit **51** generates

12

the travel path of motor grader **100** based on the position and the azimuth of motor grader **100** and the direction of travel of motor grader **100** and controls steering mechanism **66** such that motor grader **100** travels along the generated travel path.

According to such a configuration, control unit **51** generates the travel path of motor grader **100** based on the position and the azimuth of motor grader **100** and the direction of travel of motor grader **100** and controls steering mechanism **66** such that motor grader **100** travels along the travel path, and hence the operator is not required to perform bothersome operations. Therefore, the operation assistance system with which burden imposed on the operator is sufficiently lessened can be realized.

When a trigger for starting control of steering mechanism **66** is provided, control unit **51** generates the travel path of motor grader **100** based on the position and the azimuth of motor grader **100** and the direction of travel of motor grader **100** and controls steering mechanism **66** such that motor grader **100** travels along the generated travel path.

According to such a configuration, control unit **51** can determine whether or not to start control of steering mechanism **66** based on a predetermined trigger.

Motor grader **100** further includes first sensing unit **61** and second sensing unit **62**. First sensing unit **61** senses information on the position and the azimuth of motor grader **100**. Second sensing unit **62** senses information on the direction of travel of motor grader **100**.

According to such a configuration, control unit **51** can specify the position and the azimuth of motor grader **100** based on the information on the position and the azimuth of motor grader **100** sensed by first sensing unit **61** and specify the direction of travel of motor grader **100** based on the information on the direction of travel of motor grader **100** sensed by second sensing unit **62**.

First sensing unit **61** includes GNSS receiver **35**. Control unit **51** obtains the position and the azimuth of motor grader **100** with GNSS receiver **35**.

According to such a configuration, a global position and azimuth of motor grader **100** can readily be specified.

Motor grader **100** further includes front frame **14** and rear frame **15**. Front wheel **16** is provided in front frame **14**. Rear wheel **17** is provided in rear frame **15**.

Rear frame **15** is pivotably coupled to front frame **14**. Second sensing unit **62** includes steering angle sensor **33** and articulation angle sensor **34**. Steering angle sensor **33** senses the steering angle of front wheel **16**. Articulation angle sensor **34** senses the angle of articulation between front frame **14** and rear frame **15**. Control unit **51** specifies the direction of travel of motor grader **100** based on the steering angle sensed by steering angle sensor **33** and the angle of articulation sensed by articulation angle sensor **34**.

According to such a configuration, the direction of travel of motor grader **100** including the mechanism for steering front wheel **16** and the mechanism for articulation between front frame **14** and rear frame **15** can be specified.

Motor grader **100** further includes operation portion **67**. Operation portion **67** is operated to move steering mechanism **66**. Control unit **51** starts control of steering mechanism **66** when an operation onto operation portion **67** is stopped.

According to such a configuration, since the operation by the operator for starting control of steering mechanism **66** is not required, burden imposed on the operator can further be lessened.

Control unit **51** may start control of steering mechanism **66** after a state in which the operation onto operation portion

13

67 is stopped continues for a prescribed period. Control unit 51 may generate the travel path of motor grader 100 during the prescribed period.

According to such a configuration, control unit 51 can be prevented from overacting to stop of the operation onto operation portion 67 and starting control of steering mechanism 66. Since control unit 51 generates the travel path of motor grader 100 during the prescribed period from stop of the operation onto operation portion 67 until start of control of steering mechanism 66, transition to control of steering mechanism 66 can smoothly be made.

Control unit 51 stops control of steering mechanism 66 when the operation onto operation portion 67 is resumed.

According to such a configuration, when the operation onto operation portion 67 is resumed, steering mechanism 66 is operated in response to that operation, so that the operator can have motor grader 100 travel in a direction intended by himself/herself.

Motor grader 100 may include switch 37 as a switch that switches between start and stop of control of steering mechanism 66 by control unit 51.

According to such a configuration, the operator can start control of steering mechanism 66 by control unit 51 at timing further intended by himself/herself.

A method of controlling motor grader 100 includes generating a travel path of motor grader 100 based on a position and an azimuth of motor grader 100 and a direction of travel of motor grader 100 (S105) and controlling steering mechanism 66 such that motor grader 100 travels along the generated travel path (S106).

The generating a travel path (S105) includes generating the travel path of motor grader 100 based on the position and the azimuth of motor grader 100 and the direction of travel of motor grader 100 when a trigger for starting control of steering mechanism 66 is provided.

According to such a configuration, the operation assistance system with which burden imposed on the operator is sufficiently lessened can be realized.

Motor grader 100 further includes as steering mechanism 66 that controls the direction of travel of motor grader 100, a leaning mechanism that laterally leans front wheel 16 and an articulation mechanism that moves front frame 14 and rear frame 15 to form an articulation angle therebetween. Control of steering mechanism 66 by control unit 51 is not limited to automatic steering control for steering cylinder 36. Automatic control of the leaning mechanism, automatic control of the articulation mechanism, or automatic control of mechanisms from among the steering mechanism, the leaning mechanism, and the articulation mechanism may be applicable.

The work vehicle and a method of controlling the same in the present disclosure are applicable, for example, also to various work vehicles such as a wheel loader, a dump truck, or a crawler dozer, without being limited to the motor grader. In application to a wheel loader, the control unit may control an articulation angle between the front frame and the rear frame that are pivotably connected to each other.

FIG. 13 is a diagram showing a concept of a system for controlling the steering mechanism of the motor grader. Though an example in which motor grader 100 representing the work vehicle includes control unit 51 is described in the embodiment, as shown in FIGS. 3 and 13, steering mechanism 66 of the motor grader may be controlled by a control unit and an operation portion provided at a position distant from the motor grader.

The control system that controls steering mechanism 66 of the motor grader includes a control unit 251 that generates

14

the travel path of the motor grader based on the position and the azimuth of the motor grader and the direction of travel of the motor grader and controls steering mechanism 66 of the motor grader such that the motor grader travels along the generated travel path.

Second Embodiment

A configuration in an example in which the operation assistance system described in the first embodiment is applied to a crawler dozer will be described in the present embodiment. Description of a redundant configuration as in the first embodiment will not be repeated below.

FIG. 14 is a perspective view showing a crawler dozer. FIG. 15 is a system diagram showing a configuration involved with steering of the crawler dozer in FIG. 14.

As shown in FIG. 14, a crawler dozer 300 includes a vehicular body 311, a work implement 313, and a pair of left and right tow apparatuses 316 (316R and 316L). Vehicular body 311 is provided on the pair of left and right tow apparatuses 316 (316R and 316L). Vehicular body 311 includes a cab 341 and an engine compartment 342. Work implement 313 is provided in front of vehicular body 311. Work implement 313 includes a blade 318 for doing such works as excavation of soil and land grading.

The pair of left and right tow apparatuses 316 (316R and 316L) is an apparatus for travel of crawler dozer 300. The pair of left and right tow apparatuses 316 (316R and 316L) includes, for example, a crawler belt and a final reduction gear. As the pair of left and right tow apparatuses 316 (316R and 316L) is rotationally driven, crawler dozer 300 travels.

As shown in FIGS. 14 and 15, crawler dozer 300 includes steering mechanism 66, control unit 51, operation portion 67, and electric fluid pressure control valve 73.

Steering mechanism 66 includes a drive apparatus 331. Drive apparatus 331 is a hydraulic motor activated by a hydraulic pressure. Drive apparatus 331 can drive right tow apparatus (first tow apparatus) 316R and left tow apparatus (second tow apparatus) 316L independently of each other.

Operation portion 67 includes steering lever 42. Electric fluid pressure control valve 73 supplies pressure oil to drive apparatus 331. Control unit 51 controls electric fluid pressure control valve 73 based on an operation signal from steering lever 42. Drive apparatus 331 rotates right tow apparatus 316R and left tow apparatus 316L with pressure oil from electric fluid pressure control valve 73. When right tow apparatus 316R and left tow apparatus 316L are equal in rotation speed to each other, crawler dozer 300 travels straight. When right tow apparatus 316R is higher in rotation speed than left tow apparatus 316L, crawler dozer 300 revolves toward forward left. When left tow apparatus 316L is higher in rotation speed than right tow apparatus 316R, crawler dozer 300 revolves toward forward right.

FIG. 16 is a block diagram showing a configuration involved with the operation assistance system of the crawler dozer in FIG. 14. As shown in FIGS. 15 and 16, crawler dozer 300 includes lever sensor 32. Lever sensor 32 senses an operation onto steering lever 42.

Crawler dozer 300 further includes first sensing unit 61 and second sensing unit 62. First sensing unit 61 includes GNSS receiver 35. Second sensing unit 62 includes a right speed sensor 321 and a left speed sensor 322. Right speed sensor 321 senses a rotation speed of right tow apparatus 316R and provides a signal indicating the sensed rotation speed of tow apparatus 316R to control unit 51. Left speed sensor 322 senses a rotation speed of left tow apparatus

316L and provides a signal indicating the sensed rotation speed of tow apparatus 316L to control unit 51.

As shown in FIG. 16, control unit 51 includes trigger output unit 52, automatic control instruction unit 58, and steering control unit 54.

Trigger output unit 52 provides a trigger for starting or stopping control of steering mechanism 66 based on a steering lever 42 operation signal from lever sensor 32.

Automatic control instruction unit 58 includes vehicle position and azimuth obtaining unit 56, travel direction specifying unit 55, and path generator 53.

Vehicle position and azimuth obtaining unit 56 obtains position and azimuth data of crawler dozer 300 from GNSS receiver 35. Travel direction specifying unit 55 specifies the direction of travel of crawler dozer 300 based on the signal indicating the rotation speed of tow apparatus 316R from right speed sensor 321 and the signal indicating the rotation speed of tow apparatus 316L from left speed sensor 322. When the start trigger from trigger output unit 52 is provided, path generator 53 generates the travel path of crawler dozer 300 based on the position and azimuth data of crawler dozer 300 obtained by vehicle position and azimuth obtaining unit 56 and the direction of travel of crawler dozer 300 specified by travel direction specifying unit 55.

Steering control unit 54 controls steering mechanism 66 such that crawler dozer 300 travels along the travel path generated by path generator 53. Specifically, steering control unit 54 provides a control signal to electric fluid pressure control valve 73 such that crawler dozer 300 travels along the travel path generated by path generator 53. Electric fluid pressure control valve 73 supplies pressure oil to drive apparatus 331 based on a signal from steering control unit 54 and controls the rotation speed of right tow apparatus 316R and the rotation speed of left tow apparatus 316L.

According to crawler dozer 300 thus constructed, effects described in the first embodiment can similarly be achieved.

It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present invention is defined by the terms of the claims rather than the description above and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

11, 341 cab; 12, 313 work implement; 13, 342 engine compartment; 14 front frame; 14p base end; 14q tip end; 15 rear frame; 16 front wheel; 17 rear wheel; 18 vehicular body frame; 21, 318 blade; 22 draw bar; 23 swing circle; 25 lift cylinder; 28 articulation cylinder; 31 steering wheel sensor; 32 lever sensor; 33 steering angle sensor; 34 articulation angle sensor; 35 GNSS receiver; 35g antenna; 36 steering cylinder; 37 switch; 38 IMU; 41 steering wheel; 42 steering lever; 51, 251 control unit; 52 trigger output unit; 53 path generator; 54 steering control unit; 55 travel direction specifying unit; 56 vehicle position and azimuth obtaining unit; 57 rate-of-change calculator; 58 automatic control instruction unit; 59 position and direction calculator; 61 first sensing unit; 62 second sensing unit; 63 third sensing unit; 66 steering mechanism; 67 operation portion; 71 orbital valve; 72 steering valve; 73 electric fluid pressure control valve; 100 motor grader; 121 pivot center; 160 deposit; 210, 220 travel path; 300 crawler dozer; 311 vehicular body; 316, 316L, 316R tow apparatus; 321 right speed sensor; 322 left speed sensor; 331 drive apparatus

The invention claimed is:

1. A control system that controls a steering mechanism of a work vehicle, the control system comprising:

a control unit; and

both of a steering wheel and a steering lever operated to move the steering mechanism of the work vehicle, wherein

the control unit:

generates a travel path of the work vehicle based on a position and an azimuth of the work vehicle and a direction of travel of the work vehicle at a time when both of a rotational operation onto the steering wheel is stopped and a tilt operation onto the steering lever are stopped, and

controls the steering mechanism of the work vehicle such that the work vehicle travels along the generated travel path.

2. The control system according to claim 1, wherein the control unit starts control of the steering mechanism of the work vehicle after a state in which both of the rotational operation onto portion steering wheel is stopped and the tilt operation onto the steering lever is stopped continues for a prescribed period.

3. The control system according to claim 2, wherein the control unit generates the travel path of the work vehicle during the prescribed period.

4. The control system according to claim 1, wherein the control unit stops control of the steering mechanism of the work vehicle when both of the rotational operation onto the steering wheel is resumed and the tilt operation onto the steering lever is resumed.

5. The control system according to claim 1, further comprising a switch that switches between start and stop of control of the steering mechanism of the work vehicle by the control unit.

6. The control system according to claim 1, wherein the travel path includes a path for revolving the work vehicle at a constant radius of curvature corresponding to a steering angle with the position of the work vehicle being defined as a starting point.

7. A method of controlling a work vehicle including a steering mechanism, the method comprising:

generating a travel path of the work vehicle based on a position and an azimuth of the work vehicle and a direction of travel of the work vehicle at a time when both of a rotational operation onto a steering wheel is stopped and a tilt operation onto a steering lever is stopped; and

controlling the steering mechanism such that the work vehicle travels along the generated travel path.

8. The method of controlling a work vehicle according to claim 7, wherein

the steering mechanism includes a steering cylinder and a steering valve for controlling the steering cylinder, and the steering cylinder moves a steerable wheel to change an angle formed by the steerable wheel with respect to a fore/aft direction by pressure oil from the steering valve.

9. The method of controlling a work vehicle according to claim 7, wherein

the steering mechanism includes a drive apparatus that rotationally drives a pair of a first tow apparatus and a second tow apparatus located on left and right sides, and

the drive apparatus controls a rotation speed of the first tow apparatus and a rotation speed of the second tow apparatus independently of each other.

17

10. The method of controlling a work vehicle according to claim 7, wherein

the travel path includes a path for revolving the work vehicle at a constant radius of curvature corresponding to a steering angle with the position of the work vehicle being defined as a starting point.

11. A work vehicle comprising:

a steering mechanism;

both of a steering wheel and a steering lever operated to move the steering mechanism of the work vehicle; and

a control unit that generates a travel path of the work vehicle based on a position and an azimuth of the work vehicle and a direction of travel of the work vehicle at a time when both of a rotational operation onto the steering wheel is stopped and a tilt operation onto the steering lever is stopped, and controls the steering mechanism such that the work vehicle travels along the generated travel path.

12. The work vehicle according to claim 11, further comprising:

a first sensing unit that senses information on the position and the azimuth of the work vehicle; and

a second sensing unit that senses information on the direction of travel of the work vehicle.

13. The work vehicle according to claim 12, wherein the first sensing unit includes a GNSS receiver, and the control unit obtains the position and the azimuth of the work vehicle with the GNSS receiver.

14. The work vehicle according to claim 12, further comprising a vehicular body frame where a front wheel is provided, wherein

the second sensing unit includes a steering angle sensor that senses a steering angle of the front wheel, and

18

the control unit specifies the direction of travel of the work vehicle based on the steering angle sensed by the steering angle sensor.

15. The work vehicle according to claim 14, wherein the vehicular body frame includes a front frame where the front wheel is provided and a rear frame where a rear wheel is provided, the rear frame being pivotably coupled to the front frame,

the second sensing unit further includes an articulation angle sensor that senses an angle of articulation between the front frame and the rear frame, and

the control unit specifies the direction of travel of the work vehicle further based on the steering angle sensed by the steering angle sensor.

16. The work vehicle according to claim 11, wherein the steering mechanism includes a steering cylinder and a steering valve for controlling the steering cylinder, and the steering cylinder moves a steerable wheel to change an angle formed by the steerable wheel with respect to a fore/aft direction by pressure oil from the steering valve.

17. The work vehicle according to claim 11, wherein the steering mechanism includes a drive apparatus that rotationally drives a pair of a first tow apparatus and a second tow apparatus located on left and right sides, and

the drive apparatus controls a rotation speed of the first tow apparatus and a rotation speed of the second tow apparatus independently of each other.

18. The work vehicle according to claim 11, wherein the travel path includes a path for revolving the work vehicle at a constant radius of curvature corresponding to a steering angle with the position of the work vehicle being defined as a starting point.

* * * * *