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Inventor(s)	Sonoda; Takuya et al.

Control system, method of controlling work vehicle, and work vehicle

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.

Inventors:	**Sonoda; Takuya (Tokyo, JP), Kamimae; Takeshi (Tokyo, JP), Sakai; Yukihisa (Tokyo, JP)**
Applicant:	**KOMATSU LTD.** (Tokyo, JP)
Family ID:	**1000008750641**
Assignee:	**KOMATSU LTD. (Tokyo, JP)**
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Primary Examiner: Goodbody; Joan T

Assistant Examiner: Maciorowski; Godfrey Aleksander

Attorney, Agent or Firm: Faegre Drinker Biddle & Reath LLP

Background/Summary

TECHNICAL FIELD

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

BACKGROUND ART

(2) 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

(3) PTL 1: US Patent Publication No. 2008/0208461

SUMMARY OF INVENTION

Technical Problem

(4) 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.

(5) 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

(6) 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.

(7) 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.

(8) 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 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

(9) 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.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) FIG. **1** is a perspective view showing a motor grader in a first embodiment.
(2) FIG. **2** is a side view showing the motor grader in FIG. **1**.
(3) FIG. **3** is a system diagram showing a configuration involved with steering of the motor grader in FIG. **1**.
(4) FIG. **4** is a block diagram showing a configuration involved with an operation assistance system of the motor grader in FIG. **1**.
(5) FIG. **5** is a top view schematically showing the motor grader, automatic steering control of which is started in revolution.
(6) FIG. **6** is a top view showing a travel path generated by the motor grader in FIG. **5**.
(7) FIG. **7** is a top view schematically showing the motor grader, automatic steering control of which is started in linear travel.
(8) FIG. **8** is a top view showing a behavior of the motor grader when load is applied to a blade.
(9) 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.
(10) 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.
(11) FIG. **11** is a flowchart showing a method of controlling the motor grader in the first embodiment.
(12) FIG. **12** is a block diagram showing a modification of the configuration involved with the operation assistance system in FIG. **4**.
(13) FIG. **13** is a diagram showing a concept of a system for controlling a steering mechanism of the motor grader.
(14) FIG. **14** is a perspective view showing a crawler dozer.
(15) FIG. **15** is a system diagram showing a configuration involved with steering of the crawler dozer in FIG. **14**.
(16) 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
(17) 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
(18) 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**.
(19) 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 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**.
(20) 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.

(21) 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**.

(22) 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.

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

(24) 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**.

(25) 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**.

(26) 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**.

(27) 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.

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

(29) Draw bar **22** is provided below front frame **14**. Draw bar **22** has a front end swingably coupled to tip end **14***q* 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.

(30) 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.

(31) 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.

(32) 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.

(33) 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.

(34) 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**.

(35) 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**.

(36) 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.

(37) 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**.

(38) 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**.

(39) 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 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.

(40) 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.

(41) 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.

(42) 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**.

(43) 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**.

(44) 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 ±0.5° is determined as being small.

(45) 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**.
(46) 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 **35***g* (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 **35***g* 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**.
(47) 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**.
(48) 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 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.
(49) 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.
(50) Control unit **51** includes a trigger output unit **52**, an automatic control instruction unit **58**, and a steering control unit **54**.
(51) 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**.
(52) 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.
(53) 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.
(54) 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**.
(55) 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**.
(56) 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.
(57) 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.

(58) 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**.
(59) 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).
(60) 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.
(61) 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**.
(62) 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°.
(63) As shown in FIGS. **4** and **5**, motor grader **100** travels to sequentially move to positions shown with a motor grader **100**A, a motor grader **100**B, a motor grader **100**C, and a motor grader **100**D (which are referred to as a “position **100**A”, a “position **100**B”, a “position **100**C”, and a “position **100**D”, respectively below).
(64) While motor grader **100** moves from position **100**A to position **100**B, 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.
(65) While motor grader **100** moves from position **100**B to position **100**C, 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.
(66) While motor grader **100** moves from position **100**C to position **100**D, 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.
(67) 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 θs sensed by steering angle sensor **33**.

(68) 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 obtaining 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 θs.
(69) As shown in FIGS. **4** and **5**, during automatic steering control from position **100**C to position **100**D, 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 **100**E 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**.
(70) 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**.
(71) FIG. **7** is a top view schematically showing the motor grader, automatic steering control of which is started in linear travel.
(72) As shown in FIGS. **4** and **7**, motor grader **100** travels to sequentially move to positions shown with a motor grader **100**S, a motor grader **100**T, and a motor grader **100**U (which are referred to as a “position **100**S”, a “position **100**T”, and a “position **100**U”, respectively below).
(73) While motor grader **100** moves from position **100**S to position **100**T, 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.
(74) While motor grader **100** moves from position **100**T to position **100**U, 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.
(75) 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 θs=0° sensed by steering angle sensor **33**.
(76) 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.
(77) During automatic steering control from position **100**T to position **100**U, 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 **100**V 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**.
(78) 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.
(79) 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.
(80) 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.
(81) 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.
(82) 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.
(83) 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**.
(84) 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.
(85) As shown in FIGS. **4** and **9**, when steering angle θs of front wheel **16** is within a range of small Δθs with 0° being defined as the center, travel direction specifying unit **55** may determine steering angle θs as 0° and specify the direction of travel of motor grader **100** as the direction of linear travel. Magnitude of Δθs may be set, for example, to 1° or 1.5°.
(86) 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.
(87) 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.
(88) 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.
(89) 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 s≤(t**2**−t**1**)≤1 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 s≤(t**4**−t**1**)≤2 s).
(90) 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.
(91) 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 (S**101**). The operation assistance mode is set, for example, by turn-on of a mode setting switch provided in cab **11** by an operator.
(92) 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** (S**102**).
(93) 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**.
(94) Then, automatic control instruction unit **58** determines whether or not to start automatic steering control (S**103**).
(95) In step S**102**, 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 S**102**.
(96) In step S**102**, 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 (S**103**). Then, the process proceeds to step S**104**.
(97) 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** (S**104**).
(98) 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** (S**105**).
(99) 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** (S**106**).
(100) After step S**106** is started, step S**107** 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 S**108** 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 S**108** to stop automatic steering control, steering control unit **54** stops automatic steering control (S**109**). Thereafter, the process returns to step S**102**.
(101) 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.
(102) 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.
(103) 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.
(104) According to such a configuration, the operator can start automatic steering control at timing further intended by himself/herself.
(105) The configuration and effects of motor grader **100** and a method of controlling the same in the present embodiment described above will be summarized.
(106) Motor grader **100** as the work vehicle includes steering mechanism **66** and control unit **51**. 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.
(107) 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.
(108) 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.
(109) 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.
(110) 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**.
(111) 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**.
(112) 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**.
(113) According to such a configuration, a global position and azimuth of motor grader **100** can

readily be specified.
(114) 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**.
(115) 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**.
(116) 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.
(117) 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.
(118) 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.
(119) Control unit **51** may start control of steering mechanism **66** after a state in which the operation onto operation portion **67** is stopped continues for a prescribed period. Control unit **51** may generate the travel path of motor grader **100** during the prescribed period.
(120) 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.
(121) Control unit **51** stops control of steering mechanism **66** when the operation onto operation portion **67** is resumed.
(122) 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.
(123) 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**.
(124) 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.
(125) 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** (S**105**) and controlling steering mechanism **66** such that motor grader **100** travels along the generated travel path (S**106**).
(126) The generating a travel path (S**105**) 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.
(127) According to such a configuration, the operation assistance system with which burden imposed on the operator is sufficiently lessened can be realized.
(128) 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.

(129) 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.
(130) 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.
(131) The control system that controls steering mechanism **66** of the motor grader includes a control unit **251** that generates 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
(132) 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.
(133) 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**.
(134) 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** (**316**R and **316**L). Vehicular body **311** is provided on the pair of left and right tow apparatuses **316** (**316**R and **316**L). 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.
(135) The pair of left and right tow apparatuses **316** (**316**R and **316**L) is an apparatus for travel of crawler dozer **300**. The pair of left and right tow apparatuses **316** (**316**R and **316**L) includes, for example, a crawler belt and a final reduction gear. As the pair of left and right tow apparatuses **316** (**316**R and **316**L) is rotationally driven, crawler dozer **300** travels.
(136) 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**.
(137) 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) **316**R and left tow apparatus (second tow apparatus) **316**L independently of each other.
(138) 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 **316**R and left tow apparatus **316**L with pressure oil from electric fluid pressure control valve **73**. When right tow apparatus **316**R and left tow apparatus **316**L are equal in rotation speed to each other, crawler dozer **300** travels straight. When right tow apparatus **316**R is higher in rotation speed than left tow apparatus **316**L, crawler dozer **300** revolves toward forward left. When left tow apparatus **316**L is higher in rotation speed than right tow apparatus **316**R, crawler dozer **300** revolves toward forward right.
(139) 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**.
(140) 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 **316**R and provides a signal indicating the sensed rotation speed of tow apparatus **316**R to control unit **51**. Left speed sensor **322** senses a rotation speed of left tow apparatus **316**L and provides a signal indicating the sensed rotation speed of tow apparatus **316**L to control unit **51**.
(141) As shown in FIG. **16**, control unit **51** includes trigger output unit **52**, automatic control instruction unit **58**, and steering control unit **54**.
(142) 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**.
(143) Automatic control instruction unit **58** includes vehicle position and azimuth obtaining unit **56**, travel direction specifying unit **55**, and path generator **53**.
(144) 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 **316**R from right speed sensor **321** and the signal indicating the rotation speed of tow apparatus **316**L 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**.
(145) 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 **316**R and the rotation speed of left tow apparatus **316**L.
(146) According to crawler dozer **300** thus constructed, effects described in the first embodiment can similarly be achieved.
(147) 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
(148) **11**, **341** cab; **12**, **313** work implement; **13**, **342** engine compartment; **14** front frame; **14***p* base end; **14***q* 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; **35***g* 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**, **316**L, **316**R tow apparatus; **321** right speed sensor; **322** left speed sensor; **331** drive apparatus

Claims

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.

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 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.