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# (54) Wheel-type construction machine

(57) Overturning of a vehicle on an inclined road is prevented without the function of hydraulic suspension being impaired. When the current tilt angle θ for the body (2) is equal to or smaller than the maximum tolerable tilt angle θ m, the inflow and outflow of hydraulic oil for the respective hydraulic suspension cylinders (21) to (24) for the wheels (11) to (14) is made free. On the other hand, when the current tilt angle θ for the body (2) exceeds the maximum tolerable tilt angle θ m, the inflow and outflow of hydraulic oil for the respective hydraulic suspension cylinders (21) to (24) for the wheels (11) to (14) is locked. In a further invention, when it has been determined that the current tilt angle θ for the body (2) exceeds the maximum tolerable tilt angle θ m, the vehicle height is adjusted, and the posture of the body (2) is brought to near the horizontal posture so as to be equal to or smaller than the maximum tolerable tilt angle θ m. In a still further invention, when it has been determined that the body (2) is tilted, the vehicle height is adjusted, and the posture of the body (2) is brought to near the horizontal posture until the body (2) is in the horizontal posture.

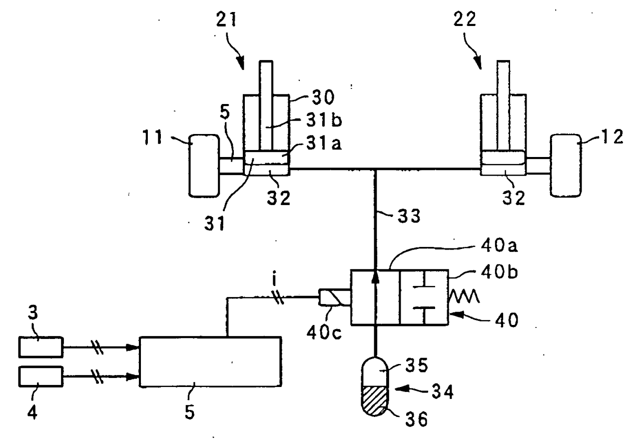


FIG. 3

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## Description

FIELD OF THE INVENTION

**[0001]** The present invention relates to a wheel-type construction machine, such as a wheel-type excavator, and particularly, to a wheel-type construction machine which is loaded with an apparatus for preventing the vehicle body from being overturned in the rolling directions.

BACKGROUND OF THE INVENTION

**[0002]** Referring to FIG. 1A, a wheel-type construction machine 1, when traveling on a public road, is legally requested by a rule in Japan to be not overturned in the rolling directions, i.e., in the rightward or leftward direction of the vehicle body on an inclined road 90 of the maximum tilt angle (for example, 30 degree).

**[0003]** Some of wheel-type construction machines are provided with a hydraulic suspension for each of the wheels.

**[0004]** When a construction machine equipped with hydraulic suspensions travels on an inclined road 90, the rod of the hydraulic suspension cylinder for a wheel 11 on the lower side of the inclined road 90 is retracted. In addition, a vibration during traveling, irregularities of the road surface, or the like will cause the rod in the hydraulic suspension cylinder to be retracted or extended. If the hydraulic suspension cylinder is retracted or extended, the positional relationship between the center of gravity of the vehicle 1 and the wheels is changed, which can result in that the rotation moment in the rolling directions may momentarily exceed the limit, and thus the vehicle 1 is likely to be overturned.

**[0005]** Referring to FIG. 1B, in a conventional commercially available construction machine 1, this problem has been alleviated by providing, in a pipe line 33 between a hydraulic oil chamber 32 for a hydraulic suspension cylinder 21 and an accumulator 34, a suspension lock relief valve 45 which is set at the pressure same as or higher than the pressure applied to the hydraulic suspension cylinder 21 on an inclined road 90 which inclination angle is equal to the maximum tilt angle.

**[0006]** The operation of the hydraulic circuit as shown in FIG. 1B is as follows:

**[0007]** When the tilt angle for the inclined road 90 is small, and the load imposed on the wheel 11 is low, the pressure of the hydraulic oil in the hydraulic oil chamber 32 of the hydraulic suspension cylinder 21 is lower than the setting pressure for the suspension locking relief valve 45, and thus the suspension locking relief valve 45 is closed.

Therefore, the hydraulic oil chamber 32 in the hydraulic suspension cylinder 21 is disconnected from the accumulator 34, and thus no repulsive force due to the elasticity of the gas is generated in the accumulator 34. In this state, if a load is imposed on the wheel 11, the hydraulic suspension cylinder 21 will be neither retracted nor extended (i.e., the piston 31a will not perform sliding movements, the rod 31b not performing vertical movements). This state is called a "hydraulic suspension locked state".

**[0008]** On the other hand, when the load imposed on the wheel 11 is increased, resulting in the pressure of the hydraulic oil in the hydraulic oil chamber 32 of the hydraulic suspension cylinder 21 being increased to exceed the setting pressure for the suspension locking relief valve 45 (i.e., the pressure at the maximum tilt angle), the suspension locking relief valve 45 is shifted to the open position. In this state, as the pressure in the hydraulic oil chamber 32 of the hydraulic suspension cylinder 21 is increased, the high-pressure gas in the gas chamber 36 in the accumulator 34, which is connected to the hydraulic oil chamber 32, is compressed, thereby generating a repulsive force due to the elasticity of the gas. As a result, as the load imposed on the wheel 11 is changed, the hydraulic suspension cylinder 21 is retracted or extended (i.e., the piston 31a performs sliding movements, the rod 31b being moved vertically). This state is called a "hydraulic suspension operating state".

**[0009]** In addition to the conventional art described above, the following documents are available as those indicating the general state-of-the art.

**[0010]** Japanese patent application publication No. 5-345509 discloses an invention which determines the. increase in the amount of rolling in the turning based on the vehicle speed and the steering angle, and decreases the tilt of a vehicle toward the outside thereof resulting from the centrifugal force by increasing the damping force of the shock absorber according to the determination.

**[0011]** Japanese patent application publication No. 2000-302063 discloses an invention which locks the differential gear in the rear body for preventing the overturning of the rear body when the tilt angle for the rear body of an articulate vehicle in the rightward or leftward direction exceeds the overturning threshold value.

**[0012]** Japanese patent application publication No. 5-139132 discloses an invention which provides an acceleration sensor for a hydraulic cylinder of a wheel-type excavator, and controls the inflow and outflow of hydraulic oil for hydraulic cylinder for suppressing the vertical jolt of the body based on the result of detection by the acceleration sensor in cargo work.

**[0013]** Japanese patent application publication No. 2000-507648 discloses an invention which calculates the effective center of gravity of the vehicle for indicating it on the display, based on the results of detection by a plurality of tilt sensors provided for the vehicle.

**[0014]** Japanese patent application publication No. 7-266826 discloses an invention which switches over the damping force of the shock absorber to suppress the occurrence of nosedive and squat of the body according to the tilt angle detected by the tilt angle sensor.

**[0015]** Japanese patent application publication No. 2001-334816 discloses an invention for a vehicle structured such that the frame swings with respect to the axle, which restricts or permits the swing of the frame during the turning for allowing the vehicle to be stably turned, based on the frame swing angle, the vehicle speed, the position of center of gravity of the load, the steering angle, the steering angular velocity, and the like.

**[0016]** According to the conventional art as illustrated in FIG. 1, when the construction machine 1 is traveling on an inclined road 90 which inclination angle is equal to or smaller than the maximum tilt angle, the "hydraulic suspension locked state" is given. As a result, the overturning can be positively prevented.

**[0017]** However, even when the construction machine 1 is traveling on a flat road surface, the "hydraulic suspension locked state" is given, except when an excessive load higher than the setting pressure is applied. As a result, the shocks applied by the irregularities of the road surface to the vehicle 1 cannot be effectively absorbed, and such an ill effect as the riding comfort being deteriorated is caused.

## SUMMARY OF THE INVENTION

**[0018]** The present invention has been made in view of the above circumstances and provides a solution to the problem of preventing the overturning on an inclined road which inclination angle is equal to or smaller than the maximum tolerable tilt angle without impairing the function of the hydraulic suspensions.

**[0019]** Incidentally, the above-mentioned Japanese patent application publication No. 5-345509 provides an invention which solves the problem of suppressing the increase in the amount of rolling in the turning, thus differing from the present invention which gives a solution to the problem of preventing the overturning on an inclined road which inclination angle is equal to or smaller than the maximum tilt angle.

**[0020]** Also, the above-mentioned Japanese patent application publication No. 2000-302063 provides an invention which locks the differential gear for preventing the overturning of the rear body, thus differing from the present invention which presupposes a vehicle provided with hydraulic suspensions.

**[0021]** Also, the above-mentioned Japanese patent application publication No. 5-139132 provides an invention which solves the problem of suppressing the vertical jolt of the body, thus differing from the present invention which gives a solution to the problem of preventing the overturning on an inclined road which inclination angle is equal to or smaller than the maximum tilt angle.

**[0022]** Also, the above-mentioned Japanese patent application publication No. 2001-507648 provides an invention which relates only to calculating the effective center of gravity of the vehicle for indicating it on the display, thus differing from the present invention which controls the hydraulic suspensions for prevention of the overturning.

**[0023]** Also, the above-mentioned Japanese patent application publication No. 7-266826 provides an invention which solves the problem of suppressing the occurrence of nosedive and squat of the body, and thus differs from the present invention which controls the hydraulic suspensions for prevention of the overturning.

**[0024]** Also, the above-mentioned Japanese patent application publication No. 2001-334816 provides an invention which solves the problem of turning the vehicle with stability, thus differing from the present invention which controls the hydraulic suspensions for prevention of the overturning.

**[0025]** A first aspect of the present invention provides a wheel-type construction machine 1 having a body 2 that is connected to wheels 11, 12 through hydraulic suspension cylinders 21, 22, comprising a tilt angle sensor 3 for detecting a tilt angle in rolling directions of the body 2; a vehicle speed sensor 4 for detecting a vehicle speed; and a controller 5 for performing a control of shutting off inflow and outflow of a hydraulic oil for the hydraulic suspension cylinders 21, 22 when the tilt angle detected by the tilt angle sensor 3 exceeds a maximum tolerable tilt angle based on detection values given by the tilt angle sensor 3 and the vehicle speed sensor 4.

**[0026]** A second aspect of the present invention provides the wheel-type construction machine of the first aspect of the present invention, wherein the maximum tolerable tilt angle is determined according to a vehicle speed detected by the vehicle speed sensor 4.

**[0027]** A third aspect of the present invention provides a wheel-type construction machine 1 having a body 2 that is connected to wheels 11, 12 through hydraulic suspension cylinders 21, 22, comprising: a tilt angle sensor 3 for detecting a tilt angle in rolling directions of the body 2; vehicle height adjusting means 33, 34, 51, 52, 55 for adjusting a vehicle height by controlling inflow and outflow of a hydraulic oil for the hydraulic suspension cylinders 21, 22; and controlling means 5 for controlling the vehicle height adjusting means 33, 34, 51, 52, 55 to bring the tilt angle of the body 2 to being equal to or smaller than the maximum tolerable tilt angle when the tilt angle detected by the tilt angle sensor 3 exceeds a maximum tolerable tilt angle.

**[0028]** A fourth aspect of the present invention provides a wheel-type construction machine 1 with which a body 2 is connected to wheels 11, 12 through hydraulic suspension cylinders 21, 22, comprising a tilt angle sensor 3 for detecting a tilt angle in the rolling directions ofthe body 2; vehicle height adjusting means 33, 34, 51, 52, 55 for adjusting a vehicle height by controlling inflow and outflow of a hydraulic oil for the hydraulic suspension cylinders 21, 22; and controlling means 5 for controlling the vehicle height adjusting means 33, 34, 51, 52, 55 to bring the body 2 close to the horizontal posture according to the tilt angle detected by the tilt angle sensor 3.

**[0029]** According to the first aspect of the present invention, as illustrated in FIG. 6, when the vehicle 1 is standing (i.e., not travelling), the "hydraulic suspension locked state" is given based on the detection values given by the tilt angle sensor 3 and the vehicle speed sensor 4 regardless of the tilt angle; when the vehicle 1 is traveling, and the tilt angle is equal to or smaller than the maximum tolerable tilt angle θ m, the "hydraulic suspension operating state" is given; and when the vehicle 1 is traveling, and the tilt angle exceeds the maximum tolerable tilt angle θ m, the "hydraulic suspension locked state" is given.

**[0030]** With this configuration of the first aspect of the present invention, overturning of the vehicle when traveling on the inclined road can be prevented without the function of the hydraulic suspensions being impaired. In addition, when the vehicle is either standing or working, the "hydraulic suspension locked state" is given, thereby the overturning caused by the jolt as a result of the work can be prevented.

**[0031]** According to the second aspect of the present invention, as illustrated in FIG. 5, because the maximum tolerable tilt angle θ m is set according to the value of vehicle speed V, the breadth of tolerable tilt angle when the vehicle is standing and travels at low speed is greater than that for the first invention 1 (steps 202 to 205).

**[0032]** According to the third aspect of the present invention, as illustrated in FIG. 11, when it has been determined that the tilt angle θ for the body 2 exceeds the maximum tolerable tilt angle θ m, the vehicle height adjusting means 33, 34, 51, 52, 55 is controlled to adjust the vehicle height for bringing the tilt angle θ for the body 2 to within the maximum tolerable tilt angle θ m (steps 702 to 705).

**[0033]** According to the fourth aspect of the present invention, as illustrated in FIG. 9, when it has been determined that the body 2 is tilted, the vehicle height adjusting means 33, 34, 51, 52, 55 is controlled to adjust the vehicle height, according to the tilt angle θ, for bringing the tilt angle θ for the body 2 closer to horizontal posture until the body 2 is in the horizontal posture (the tilt angle being zero) or in a substantially horizontal posture (steps 502 to 505).

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0034]** Embodiments of the present invention will be described in detail based on the following figures, wherein:

FIG. 1A illustrates a vehicle being positioned on an inclined road;
FIG. 1B illustrates a configuration of a conventional overturning prevention apparatus;
FIG. 2 is a side view of a wheel-type excavator illustrating a vehicle in embodiments of the present invention;
FIG. 3 is a diagram illustrating a hydraulic circuit for the vehicle as shown in FIG. 2;
FIG. 4 is a flow chart illustrating the procedure for processing in an embodiment 1;
FIG. 5 is a flow chart illustrating the procedure for processing in an embodiment 2;
FIG. 6 is a flow chart illustrating the procedure for processing in an embodiment 3;
FIG. 7 is a flow chart illustrating the procedure for processing in. an embodiment 4;
FIG. 8 is a diagram illustrating another hydraulic circuit for vehicle that has a configuration different from that as shown in FIG. 3;
FIG. 9 is a flow chart illustrating the procedure for processing in an embodiment 5;
FIG. 10 is a flow chart illustrating the procedure for processing in an embodiment 6; and
FIG. 11 is a flow chart illustrating the procedure for processing in an embodiment 7.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0035]** Embodiments of the vehicle overturning prevention apparatus according to the present invention will be described with reference to the accompanying drawings

**[0036]** FIG. 2 is a side view of a vehicle employed in embodiments by way of example, which indicates the locations where respective sensors and a controller are disposed. In the embodiments, a wheel-type excavator 1 comprising two axles and four wheels is adopted as an example of a vehicle.

**[0037]** On the front side of a body 2 of the wheel-type excavator 1, left-hand and right-hand wheels 11, 12 are provided. Also on the rear side of the body 2, left-hand and right-hand wheels 13, 14 are provided. To the body 2, a work machine 6 is connected. The body 2 essentially consists of a base carrier 2b to which the wheels are mounted, and a rotating superstructure 2a on which a cabin 2c is loaded and with which the work machine 6 is connected.

**[0038]** In the cabin 2c of the body 2 is provided a tilt angle sensor 3 for detecting the tilt angle θ in the rightward or leftward direction, i.e., the rolling directions of the body 2. the wheels 11 to 14 are provided with a vehicle speed sensor 4 which detects the vehicle speed V by detecting the number of revolutions per unit time of the wheel. The vehicle speed sensor 4 may detects the vehicle speed other than by detecting the number of revolutions per unit time of the wheel. For example, the vehicle speed sensor 4 may detects the vehicle speed by detecting the speed relative to the ground.

**[0039]** In a prescribed location in the body 2 is provided a controller 5 which inputs the detection signals from the respective sensors 3, 4, and outputs a control signal i.

**[0040]** The body 2 is connected to the respective wheels 11 to 14 through a hydraulic suspension cylinder

21 to 24. In the following description, a hydraulic suspension cylinder is provided for each of the wheels. However, a different configuration may be adopted in which only the front wheels are provided with a hydraulic suspension cylinder 21, 22.

**[0041]** FIG. 3 shows a hydraulic circuit which controls the inflow and outflow of the hydraulic oil for the hydraulic suspension cylinders 21, 22 for the left-hand and right-hand front wheels 11, 12.

**[0042]** The hydraulic suspension cylinder 21 essentially consists of an outer tube 30, and an inner tube 31 which slides in the outer tube 30. The inner tube 31 essentially consists of a piston 31a and a rod 31b connected to the piston 31a. The rod 31b of the inner tube 31 is connected to the body 2, and the outer tube 30 is connected to the wheel 11 through a suspension member, such as a link or an arm. The outer tube 30 and the piston 31a of the inner tube 31 forms a hydraulic oil chamber 32. The hydraulic oil chamber 32 is connected with a hydraulic oil chamber 35 of an accumulator 34 through a pipe line 33. In a gas chamber 36 of the accumulator 34, high-pressure air or high-pressure nitrogen gas, for example, is sealed. The hydraulic oil chamber 32 of the hydraulic suspension cylinder 21 is connected to another hydraulic oil chamber 32 of the hydraulic suspension cylinder.

**[0043]** In the pipe line 33, a control valve 40 is connected. The control valve 40 has two valve positions, i. e., a connecting position 40a and a disconnecting position 40b, and is operated in accordance with a control signal i (ON-OFF signal i) which is applied to an electromagnetic solenoid 40c. To the electromagnetic solenoid 40c of the control valve 40, a control signal i from the controller 5 is applied. When an ON control signal i is applied to the electromagnetic solenoid 40c of the control valve 40, the control valve 40 is shifted to the connecting position 40a, while, when an OFF control signal i is applied to the electromagnetic solenoid 40c of the control valve 40, the control valve 40 shifts to the disconnecting position 40b.

**[0044]** When the control valve 40 is in the connecting position 40a, a change in the pressure in the hydraulic oil chamber 32 of the hydraulic suspension cylinder 21 causes the pressure in the hydraulic oil chamber 35 of the accumulator 34 to change due to the mutual connection between the hydraulic oil chambers 32, 35, thus, with an increase in the pressure in the hydraulic oil chamber 32, the high-pressure gas in the gas chamber 36 is compressed, generating a repulsive force due to the elasticity of the gas. Thus, as the load imposed on the wheel 11 is changed, the hydraulic suspension cylinder 21 is retracted or extended (the piston 31a performs sliding movements, the rod 31b being moved vertically). This state is called a "hydraulic suspension operating state".

**[0045]** On the other hand, when the control valve 40 is in the disconnecting position 40b, the hydraulic oil chamber 32 of the hydraulic suspension cylinder 21 and the hydraulic oil chamber 35 of the accumulator 34 are disconnected from each other, and therefore the repulsive force will not be generated. With this configuration, even if the wheel 11 is applied to a load, the hydraulic suspension cylinder 21 will not be retracted or extended (the piston 31a will not perform sliding movements, the rod 31b not performing vertical movements). This state is called a "hydraulic suspension locked state".

**[0046]** Although the above description has been given about the hydraulic suspension cylinder 21 provided for the wheel 11, the same description is applicable to the hydraulic suspension cylinder 22 provided for the wheel 12. Also, the same description can be applied to the hydraulic suspension cylinders 23, 24 provided for the wheels 13, 14, respectively.

**[0047]** Next, the embodiments 1 through 4 which are based on the configuration as shown in FIG. 3 will be described.

## EMBODIMENT 1

**[0048]** FIG. 4 illustrates the procedure for the processing performed in the embodiment 1, which is carried out by the controller 5.

**[0049]** Referring to FIG. 4, a detection signal from the tilt angle sensor 3 is inputted into the controller 5 (at step 101), and it is determined whether or not the current tilt angle for the body 2 is equal to or smaller than the maximum tolerable tilt angle $\theta$ m (at step 102). The maximum tolerable tilt angle $\theta$ m is defined as the maximum of the tilt angles at which the vehicle 1 will not be overturned even in the "hydraulic suspension operating state". In other words, when the tilt angle exceeds the maximum tolerable tilt angle $\theta$ m, there is the possibility of the vehicle 1 being overturned, unless the vehicle 1 is in the "hydraulic suspension locked state".

**[0050]** At the step 102, when it has been determined that the current tilt angle $\theta$ for the body 2 is equal to or smaller than the maximum tolerable tilt angle $\theta$ m, an ON control signal i for shifting the control valve 40 to the connecting position 40a is generated to give the "hydraulic suspension operating state" (at step 103), and this ON control signal i is applied to the electromagnetic solenoid 40c in the control valve 40. As a result, the control valve 40 is shifted to the connecting position 40a, thus the "hydraulic suspension operating state" being given (at step 104). On the other hand, at the step 102, when it has been determined that the current tilt angle $\theta$ for the body 2 exceeds the maximum tolerable tilt angle $\theta$ m, an OFF control signal i for shifting the control valve 40 to the disconnecting position 40b is generated to give the "hydraulic suspension locked state" (at step 105), and this OFF control signal i is applied to the electromagnetic solenoid 40c in the control valve 40. As a result, the control valve 40 is shifted to the disconnecting position 40b, thus the "hydraulic suspension locked state" being given (at step 104).

**[0051]** With the configuration describe above, provided that the current tilt angle 0 for the body 2 is equal to or smaller than the maximum tolerable tilt angle θ m, the hydraulic oil for the hydraulic suspension cylinders 21 to 24 for the wheels 11 to 14 flows freely. Therefore, as long as the vehicle 1 travels on a road having an inclination angle equal to or smaller than the maximum tolerable tilt angle θ m, the shock imposed on the vehicle 1 by the irregularities of the road surface can be effectively absorbed while the vehicle 1 being prevented from being overturned. On the other hand, when the current tilt angle θ for the body 2 exceeds the maximum tolerable tilt angle θ m, the inflow and outflow of the hydraulic oil for the hydraulic suspension cylinders 21 to 24 for the wheels 11 to 14 is locked. Therefore, as long as the vehicle 1 travels on a road which inclination angle is at least equal to or smaller than the maximum tilt angle, which is larger than the maximum tolerable tilt angle θ m, the vehicle 1 can be prevented from being overturned. Thus, according to the present embodiment, overturning of the vehicle 1 on the inclined road having an inclination angle equal to or smaller than the maximum tilt angle can be prevented without the function of the hydraulic suspensions being impaired.

**[0052]** In the embodiment 1, the maximum tolerable tilt angle 0 m is fixed regardless of whether the vehicle 1 is traveling or standing, and therefore a vehicle speed sensor 4 is not necessarily required.

EMBODIMENT 2

**[0053]** In the embodiment 1, a maximum tolerable tilt angle θ m is fixed regardless of whether the vehicle 1 is traveling or standing. In the embodiment 2, on the other hand, the value of the maximum tolerable tilt angle θ m is changed with a change in vehicle speed. When the vehicle 1 is traveling, the body 2 will jolt due to shocks imposed on the vehicle 1 by the irregularities of the road surface or the like, resulting in that the position of the center of gravity of the vehicle 1 is likely to be changed. As a result, the vehicle 1 can more easily be overturned. In addition, as the vehicle speed V becomes higher, the change in the amount of the position of the center of gravity becomes greater, resulting in that the vehicle 1 can be overturned more easily. Therefore, it is preferable that the maximum tolerable tilt angle θ m be set at a smaller value as the vehicle speed V is increased.

**[0054]** To obtain the maximum tolerable tilt angle θ m at a particular vehicle speed V, the maximum tolerable tilt angle θ m1 when the vehicle 1 is standing (the vehicle speed V is 0) and the maximum tolerable tilt angle θ m2 (< θ m1) when the vehicle 1 is at a maximum speed (the vehicle speed V is at Vm) are previously determined. Then, these values are used to calculated the maximum tolerable tilt angle θ m at a particular vehicle speed V by proportional distribution from the following equation (1).

$$\theta m = \theta m1 - V \cdot (\theta m1 - \theta m2)/(Vm - 0) \qquad (1)$$

**[0055]** FIG. 5 illustrates the procedure for processing in the embodiment 2 that is carried out by the controller 5.

**[0056]** Referring to FIG. 5, detection signals from the tilt angle sensor 3 and from the vehicle speed sensor 4 are inputted into the controller 5 (at step 201), and the maximum tolerable tilt angle θ m for the current vehicle speed V is set based on the equation (1) (at step 202). Then, it is determined whether or not the current tilt angle θ for the body 2 is equal to or smaller than the maximum tolerable tilt angle θ m (at step 203).

**[0057]** At the step 203, when it has been determined that the current tilt angle θ for the body 2 is equal to or smaller than the maximum tolerable tilt angle θ m, an ON control signal i for shifting the control valve 40 to the connecting position 40a to give the "hydraulic suspension operating state" is generated (at step 204), and this ON control signal i is applied to the electromagnetic solenoid 40c in the control valve 40. As a result of this, the control valve 40 is shifted to the connecting position 40a, thus the "hydraulic suspension operating state" being given (at step 205). On the other hand, at the step 203, when it has been determined that the current tilt angle θ for the body 2 exceeds the maximum tolerable tilt angle θ m, an OFF control signal i for shifting the control valve 40 to the disconnecting position 40b to give the "hydraulic suspension locked state" is generated (at step 206), and this OFF control signal i is applied to the electromagnetic solenoid 40c in the control valve 40. As a result of this, the control valve 40 is shifted to the disconnecting position 40b, thus the "hydraulic suspension locked state" being given (at step 205).

**[0058]** According to the embodiment 2, the same effects as those according to the embodiment 1 can be obtained. In addition, because the maximum tolerable tilt angle θ m changes according to the vehicle speed V, the range of maximum tolerable tilt angle when the vehicle is standing or travels at low speed becomes wider than that in the embodiment 1. As a result, the chance of the function of the hydraulic suspensions being impaired can be minimized.

EMBODIMENT 3

**[0059]** In the embodiment 1, the "hydraulic suspension operating state" is given even when the vehicle 1 is standing, provided that the tilt angle is equal to or smaller than the maximum tolerable tilt angle θ m. In the embodiment 3, on the other hand, the "hydraulic suspension locked state" is given regardless of the tilt angle when the vehicle 1 is standing. If the vehicle is a construction machine, it is normally left standing while the work machine 6 is being operated for carrying out the work. During the work, the rotating superstructure 2b is turned or the work machine 6 is operated, which can result in the body 2 being jolted. Thus, when the vehicle 1 is positioned on an inclined road, there arises the possibility of being overturned due to the change in the position of the center of gravity of the vehicle 1. Thus, when the vehicle 1 is standing, it is preferable that the hydraulic suspensions be kept locked to prevent the overturning caused by the jolt as a result of the work.

**[0060]** FIG. 6 illustrates the procedure for processing in the embodiment 3 that is carried out by the controller 5.

**[0061]** First, the procedure which does not perform the processing enclosed by a dotted line box in Fig. 6 will be described.

**[0062]** Referring to FIG. 6, a detection signal from the tilt angle sensor 3 is inputted into the controller 5 (at step 301), and it is determined whether or not the current tilt angle θ for the body 2 is equal to or smaller than the maximum tolerable tilt angle θ m (at step 302). At the step 302, when it has been determined that the current tilt angle θ for the body 2 exceeds the maximum tolerable tilt angle θ m, an OFF control signal i for shifting the control valve 40 to the disconnecting position 40b to give the "hydraulic suspension locked state" is generated (at step 303), and this OFF control signal i is applied to the electromagnetic solenoid 40c in the control valve 40. As a result of this, the control valve 40 is shifted to the disconnecting position 40b, the "hydraulic suspension locked state" being given (at step 304).

**[0063]** At the step 302, when it has been determined that the current tilt angle θ for the body 2 is equal to or smaller than the maximum tolerable tilt angle θ m, information about whether the vehicle 1 is traveling, i.e., a detection signal from the vehicle speed sensor 4 is inputted into the controller 5 (at step 305), and based on the result of detection by the vehicle speed sensor 4, it is determined whether the vehicle 1 is traveling or standing (at step 307).

**[0064]** At the step 307, when it has been determined that the vehicle 1 is currently standing, the program proceeds to the step 303, the "hydraulic suspension locked state" being given (at step 303, 304).

**[0065]** At the step 307, when it has been determined that the vehicle 1 is currently traveling, an ON control signal i for shifting the control valve 40 to the connecting position 40a to give the "hydraulic suspension operating state" is generated (at step 308), and this ON control signal i is applied to the electromagnetic solenoid 40c in the control valve 40. As a result of this, the control valve 40 is shifted to the connecting position 40a, the "hydraulic suspension operating state" being given (at step 304).

**[0066]** Thus, according to the present embodiment, when the vehicle 1 is standing, the "hydraulic suspension locked state" is given regardless of the tilt angle; when the vehicle 1 is traveling, and the tilt angle is equal to or smaller than the maximum tolerable tilt angle θ m, the "hydraulic suspension operating state" is given; and when the vehicle I is traveling, and the tilt angle exceeds the maximum tolerable tilt angle θ m, the "hydraulic suspension locked state" is given.

**[0067]** The processing enclosed by the dotted line box in FIG. 6 may be performed as required.

**[0068]** In the case where the processing is added, at the step 305, in addition to information about whether the vehicle 1 is traveling (i.e., a detection signal from the vehicle speed sensor 4), information about whether the vehicle 1 is working is inputted into the controller 5 (at step 305). Here, the information about whether the vehicle 1 is working can be acquired as, for example, a detection value given by the sensor which detects the operating position of the lever for operating the work machine 6, or a detection value given by the sensor which detects the hydraulic pressure in the hydraulic circuit for driving the work machine 6.

**[0069]** Between the step 305 and the step 307, whether the vehicle 1 is working is determined based on the detection signal from the sensor (at step 306).

**[0070]** At the step 306, when it has been determined that the vehicle 1 is currently working, the program proceeds to the step 303, the "hydraulic suspension locked state" being given (at step 303, 304), and when it has been determined that the vehicle 1 is currently not working, whether the vehicle 1 is traveling is then determined (at step 307).

**[0071]** Thus, according to the present embodiment which adds determination of whether the vehicle 1 is working, when the vehicle 1 is standing or working, the "hydraulic suspension locked state" is given regardless of the tilt angle; when the vehicle 1 is traveling, and the tilt angle is equal to or smaller than the maximum tolerable tilt angle θ m, the "hydraulic suspension operating state" is given; and when the vehicle 1 is traveling, and the tilt angle exceeds the maximum tolerable tilt angle θ m, the "hydraulic suspension locked state" is given.

**[0072]** As described above, according to the embodiment 4, overturning of the vehicle when traveling on an inclined road can be prevented without the function of the hydraulic suspensions being impaired. In addition, when the vehicle is either standing or working, the "hydraulic suspension locked state" is given, thus the overturning caused by the jolt as a result of the work can be prevented.

## EMBODIMENT 4

**[0073]** In the above-described embodiment 3, the maximum tolerable tilt angle θ m is fixed regardless of whether the vehicle 1 is traveling or standing. However, as with the embodiment 2, the value of the maximum tolerable tilt angle θ m may be changed with a change in vehicle speed.

**[0074]** FIG. 7 illustrates the procedure for processing in the embodiment 4 that is carried out by the controller 5.

**[0075]** Referring to FIG. 7, detection signals from the tilt angle sensor 3 and that from the vehicle speed sensor 4 are inputted into the controller 5 (at step 401), and the maximum tolerable tilt angle θ m for the current vehicle speed V is set based on the equation (1) (at step

409).

**[0076]** In the subsequent steps 402 to 408, the same processings as those at the steps 302 to 308 are carried out.

**[0077]** Therefore, according to the present embodiment 4, the same effects as those according to the embodiment 3 can be obtained, and in addition, because the maximum tolerable tilt angle θ m is set according to the value of vehicle speed V, the range of maximum tolerable tilt angle when the vehicle is traveling at low speed is wider than that for the embodiment 3, and the chance of the function of the hydraulic suspensions being impaired can be minimized.

**[0078]** At the step 305 in FIG. 6, and the step 405 in FIG. 7, in order to acquire information about whether the vehicle 1 is working, a detection signal from the vehicle speed sensor 4 is used. However, in order to acquire information about whether the vehicle 1 is working, a detection signal from the vehicle speed sensor 4 need not always be used. For example, a detection value given by the sensor which detects the operating position of the lever for traveling the vehicle, or a detection value given by the sensor which detects the hydraulic pressure in the hydraulic circuit for driving the base carrier (for instance, the delivery pressure for the hydraulic motor for traveling) may be used as information about whether the vehicle is traveling.

**[0079]** FIG. 8 shows a hydraulic circuit having a configuration which is different from that as shown in FIG. 3. As with FIG. 3, FIG. 8 shows a hydraulic circuit which controls the inflow and outflow of the hydraulic oil for hydraulic suspension cylinders 21, 22 for left-hand and right-hand front wheels 11, 12.

**[0080]** Referring to FIG. 8, a pipe line 33 comprising pipe lines 33A, 33B, 33P, 33Q, 33R and 33T, an accumulator 34, directional flow control valves 51, 52, and a hydraulic pressure source control valve 55 constitute vehicle height adjusting means. The vehicle height adjusting means adjusts the height of the vehicle 1. The same components as those in FIG. 3 are provided with the same signs and the description will be appropriately omitted.

**[0081]** The hydraulic suspension cylinder 21 for the wheel 11 comprises a hydraulic oil chamber 32A, 32B which is partitioned by a piston 31a. The hydraulic oil chamber 32A is connected to a port A of the directional flow control valve 51 through the pipe line 33A, while the hydraulic oil chamber 32B is connected to a port B of the directional flow control valve 51 through the pipe line 33B.

**[0082]** A port P of the directional flow control valve 51 is connected to an output port D of the hydraulic pressure source control valve 55. An input port Q of the hydraulic pressure source control valve 55 is connected to the delivery port of a hydraulic pump 7 through the pipe line 33Q. An input port R of the hydraulic pressure source control valve 55 is connected to a hydraulic chamber 35 of an accumulator 34 through the pipe line 33R.

**[0083]** A reservoir 39 is connected to a port T of the directional flow control valve 51 through the pipe line 33T.

**[0084]** For the other hydraulic suspension cylinder 22, a similar directional flow control valve 52 is provided.

**[0085]** The pipe line 33P is connected to the port P for the other hydraulic suspension cylinder 22, and the pipe line 33T is connected to the port T for the other hydraulic suspension cylinder 22.

**[0086]** The directional flow control valve 51 has a vehicle-height increasing adjustment position 51a and a vehicle-height decreasing adjustment position 51b, being operated according to a control signal i which is applied to an electromagnetic solenoid 51d. To the electromagnetic solenoid 51d of the directional flow control valve 51, a control signal i is applied by a controller 5.

**[0087]** The hydraulic pressure source control valve 55 comprises a hydraulic pump selecting position 55b, an accumulator selecting position 55a, and a hydraulic pressure source disconnecting,position 55c, and operates according to a control signal j which is applied to an electromagnetic solenoid 55d. To the electromagnetic solenoid 55d of the hydraulic pressure source control valve 55, a control signal j is applied by a controller 5.

**[0088]** When the directional flow control valve 51 is in the vehicle-height increasing adjustment position 51a, and the hydraulic pressure source control valve 55 is in the hydraulic pump selecting position 55b, the hydraulic oil chamber 32A of the hydraulic suspension cylinder 21 is connected to the delivery port of the hydraulic pump 7, and the hydraulic oil chamber 32B of the hydraulic suspension cylinder 21 is connected to the reservoir 39. Therefore, the hydraulic oil is supplied to the hydraulic oil chamber 32A of the hydraulic suspension cylinder 21, and the hydraulic oil is discharged from the hydraulic oil chamber 32B to the reservoir 39, a rod 31b being moved upward in the drawing (extended) to increase the height of the body on the wheel 11 side (vehicle-height increasing adjustment).

**[0089]** On the other hand, when the directional flow control valve 51 is in the vehicle-height decreasing adjustment position 51b, and the hydraulic pressure source control valve 55 is in the hydraulic pump selecting position 55b, the hydraulic oil chamber 32B of the hydraulic suspension cylinder 21 is connected to the delivery port of the hydraulic pump 7, and the hydraulic oil chamber 32A of the hydraulic suspension cylinder 21 is connected to the reservoir 39. Therefore, the hydraulic oil is supplied to the hydraulic oil chamber 32B of the hydraulic suspension cylinder 21, and the hydraulic oil is discharged from the hydraulic oil chamber 32A to the reservoir 39, the rod 31b being moved downward in the drawing (retracted) to decrease the height of the body on the wheel 11 side (vehicle-height decreasing adjustment).

**[0090]** When the directional flow control valve 51 is in the vehicle-height increasing adjustment position 51a, and the hydraulic pressure source control valve 55 is in the accumulator selecting position 55a, the hydraulic oil chamber 32A of the hydraulic suspension cylinder 21 is connected to the hydraulic oil chamber 35 of the accumulator 34, and the hydraulic oil chamber 32B is connected to the reservoir 39. Therefore, a change in the pressure in the hydraulic oil chamber 32A of the hydraulic suspension cylinder 21 causes the pressure in the hydraulic oil chamber 35 of the accumulator 34 to change due to the mutual connection between the hydraulic oil chambers 32A, 35, thus, with an increase in the pressure in the hydraulic oil chamber 32A, the high-pressure gas in the gas chamber 36 is compressed, generating a repulsive force due to the elasticity of the gas. Therefore, as the load imposed on the wheel 11 is changed, the hydraulic suspension cylinder 21 is retracted or extended ("hydraulic suspension operating state").

**[0091]** Although the above description has been given about the hydraulic suspension cylinder 21 provided for the wheel 11, the same description is applicable to the hydraulic suspension cylinder 22 provided for the wheel 12, the hydraulic suspension cylinder 22 being provided with a directional flow control valve 52.

**[0092]** Also, the same description can be applied to the hydraulic suspension cylinders 23, 24 provided for the wheels 13, 14, respectively, the hydraulic suspension cylinders 23, 24 being provided with directional flow control valves 53, 54, respectively.

**[0093]** Next, the embodiments 5 and 6 which are based on the configuration as shown in FIG. 8 will be described.

EMBODIMENT 5

**[0094]** FIG. 9 illustrates the procedure for processing in the embodiment 5 that is carried out by the controller 5.

**[0095]** Referring to FIG. 9, a detection signal from the tilt angle sensor 3 is inputted into the controller 5 (at step 501), and it is determined whether the body 2 is tilted with respect to the level (at step 502).

**[0096]** At the step 502, when it has been determined that the body 2 is tilted, the target vehicle height for bringing the current tilt angle θ to zero is calculated. For example, when the vehicle 1 is traveling on an inclined road 90 as shown in FIG. 1A with the right-hand wheels 12, 14 being on the higher side of the road and the left-hand wheels 11, 13 being on the lower side of the road, the body 2 can be leveled by increasing the vehicle height on the side of the left-hand wheels 11, 13 and decreasing the vehicle height on the side of the right-hand wheels 12, 14. Then, the target vehicle height on the side of the left-hand wheels 11, 13, and the target vehicle height on the side of the right-hand wheels 12, 14 that are required for making the body 2 level are calculated based on the detected tilt angle θ, and a control signal i according to the target height and a control signal j for selecting the hydraulic pressure source are generated (at step 503), this control signal i being applied to the respective electromagnetic solenoids 51d to 54d of the directional flow control valves 51 to 54, and the control signal j being applied to the electromagnetic solenoid 55d of the hydraulic pressure source control valve 55. As a result of this, for example, the directional flow control valves 51, 53 for the left-hand wheels 11, 13 are shifted to the vehicle-height increasing adjustment positions 51a, 53a, the vehicle height on the side of the left-hand wheels 11, 13 being adjusted for an increased height. In addition, the directional flow control valves 52, 54 for the right-hand wheels 12, 14 are shifted to the vehicle-height decreasing adjustment positions 51b, 54b, the vehicle height on the side of the right-hand wheels 12, 14 being adjusted for a decreased height. Further, the hydraulic pressure source control valve 55 is shifted to the hydraulic pump selecting position 55b, the delivery port of the hydraulic pump 7 being connected to the respective hydraulic oil chambers of the hydraulic suspension cylinders 21 to 24 (at step 504). When the target vehicle height is reached, resulting in the body 2 being leveled, the tilt angle θ is brought to zero (NO at step 502), thus the hydraulic pressure source control valve 55 is shifted from the hydraulic pump selecting position 55b to the accumulator selecting position 55a, thus the "hydraulic suspension operating state" being given (at step 505, 504).

**[0097]** When the vehicle 1 is traveling on a level road with no inclination, the tilt angle θ is determined to be zero (NO at step 502) and therefore, the directional flow control valves 51 to 54 are shifted to the connecting positions 51c to 54c, respectively. Thus, the "hydraulic suspension operating state" is given (at step 505, 504).

**[0098]** As described above, according to the embodiment 5, because the body 2 can always be leveled, whereby the overturning can be prevented. In addition, after the target vehicle height has been reached, the "hydraulic suspension operating state" is given, whereby the function of the hydraulic suspensions will not be impaired.

EMBODIMENT 6

**[0099]** If the vehicle is a construction machine, it is normally left standing while the work machine 6 is being operated for carrying out the work. During the work, the rotating superstructure 2b is turned or the work machine 6 is operated, resulting in the body 2 being jolted. Therefore, if the "hydraulic suspension operating state" is given while the vehicle 1 is standing (i.e., working), the body 2 will jolt, and there arises the possibility of the vehicle 1 being overturned due to the change in the position of the center of gravity of the vehicle 1. Thus, when the vehicle 1 is standing (working), it is preferable that the vehicle height adjustment be performed to maintain the levelness of the body 2 for prevention of the overturning caused by the jolt as a result of the work.

[0100] FIG. 10 illustrates the procedure for processing in the embodiment 6 that is carried out by the controller 5.

[0101] First, the procedure which does not perform the processing enclosed by a dotted line box in FIG. 10 will be described.

[0102] Referring to FIG. 10, a detection signal from the tilt angle sensor 3 is inputted into the controller 5 (at step 601), and it is determined whether the body 2 is currently tilted (at step 602). At the step 602, when it has been determined that the body 2 is currently tilted, the vehicle height adjustment is performed in the same manner as that in the step 503, 504 in FIG. 9 to level the posture of the body 2 (at step 603, 604).

[0103] At the step 602, when it has been determined that the body 2 is currently not tilted, information about whether the vehicle 1 is traveling, i.e., a detection signal from the vehicle speed sensor 4, is inputted into the controller 5 (at step 605), and based on the result of detection by the vehicle speed sensor 4, it is determined whether the vehicle 1 is traveling or standing (at step 607).

[0104] At the step 607, it has been determined that the vehicle 1 is currently standing, the program proceeds to the step 603, and the vehicle height adjustment is performed to level the posture of the body 2 (at step 603, 604).

[0105] At the step 607, when it has been determined that the vehicle 1 is currently traveling, a control signal j for shifting the hydraulic pressure source control valve 55 to the accumulator selecting position 55a is generated to give the "hydraulic suspension operating state" (at step 608), and this control signal j is applied to the electromagnetic solenoid 55d of the hydraulic pressure source control valve 55. As a result of this, the hydraulic pressure source control valve 55 is shifted to the accumulator selecting position 55a, thereby the "hydraulic suspension operating state" being given (at step 604).

[0106] As described above, according to the present embodiment, when the vehicle 1 is standing, the vehicle height adjustment is performed to maintain the levelness of the body 2, whereby the overturning caused by the jolt as a result of the work can be prevented.

[0107] The processing enclosed by the dotted line box in FIG. 10 may be added as required.

[0108] In the case where the processing is added, at the step 605, in addition to information about whether the vehicle 1 is traveling (i.e., a detection signal from the vehicle speed sensor 4), information about whether the vehicle 1 is working is inputted into the controller 5 (at step 605). Here, the information about whether the vehicle 1 is working can be acquired as, for example, a detection value given by the sensor which detects the operating position of the lever for operating the work machine 6, or a detection value given by the sensor which detects the hydraulic pressure in the hydraulic circuit for driving the work machine 6.

[0109] Between the step 605 and the step 607, whether the vehicle 1 is working is determined based on the detection signal from the sensor (at step 606).

[0110] At the step 606, when it has been determined that the vehicle 1 is currently working, the program proceeds to the step 603 and the vehicle height adjustment is performed to level the posture of the body 2 (at step 603, 604). When it has been determined that the vehicle 1 is currently not working, whether the vehicle 1 is traveling is then determined (at step 607).

[0111] As described above, according to the present embodiment which adds determination process of whether the vehicle 1 is working, when the vehicle 1 is standing or working, the vehicle height adjustment is performed to maintain the levelness of the body 2, thus the overturning caused by the jolt as a result of the work can be prevented.

[0112] At the step 605 in FIG. 10, in order to acquire information about whether or not the vehicle 1 is traveling, a detection signal from the vehicle speed sensor 4 is used. However, in order to acquire information simply about whether or not the vehicle 1 is traveling, it is not necessary to use a detection signal from the vehicle speed sensor 4. For example, a detection value given by the sensor which detects the operating position of the lever for traveling the vehicle, or a detection value given by the sensor which detects the hydraulic pressure in the hydraulic circuit for driving the base carrier (for instance, the delivery pressure for the hydraulic motor for traveling) may be used as information about whether or not the vehicle is traveling.

[0113] In the embodiments 5 and 6, when the body 2 is tilted, the vehicle height is adjusted such that the posture of the body 2 is matched to the horizontal posture (the tilt angle being zero degree). However, it is not always required to match the posture of the body 2 exactly to the horizontal posture (the tilt angle being zero). Instead, the posture of the body 2 may be brought closer to the horizontal posture for matching the posture of the body to a substantially horizontal posture. For example, when the body 2 is tilted by 15 degree from the level, the posture of the body 2 may be brought to a posture (a tilt angle of 5 degree, for example) close to the exact horizontal posture to be matched to a substantially horizontal posture.

[0114] As described above, by carrying out the control which brings the posture of the body 2 to the exact horizontal posture or to a substantially horizontal posture, it is possible to prevent the tilt angle $\theta$ of the body 2 from being increased so as to exceed the maximum tolerable tilt angle $\theta$ m.

EMBODIMENT 7

[0115] In the embodiments 5 and 6, by adjusting the vehicle height, the posture of the body 2 is matched to the horizontal posture or to a substantially horizontal posture. However, in order to prevent the overturning, it is not always necessary to set the target vehicle height at a vehicle height corresponding to the horizontal posture or to a substantially horizontal posture. Instead, the target vehicle height may be set at a vehicle height corresponding to a certain tilt angle not exceeding the maximum tolerable tilt angle θ m so as to hold the tilt angle θ of the body 2 below the maximum tolerable tilt angle θ m.

**[0116]** FIG. 11 illustrates the procedure for processing in the embodiment 7 that is carried out by the controller 5.

**[0117]** Referring to FIG. 11, a detection signal from the tilt angle sensor 3 is inputted into the controller 5 (at step 701), and it is determined that the current tilt angle θ for the body 2 is equal to or smaller than the maximum tolerable tilt angle θ m (at step 702). At the step 702, when it has been determined that the current tilt angle θ for the body 2 exceeds the maximum tolerable tilt angle θ m (NO at step 702), the vehicle height adjustment is performed in the same manner as that in the step 503, 504 in FIG. 9 (or the step 603, 604 in FIG. 10) to bring the posture of the body 2 closer to the horizontal posture (at step 703, 704).

**[0118]** At the step 702, when it has been determined that the current tilt angle θ for the body 2 is equal to or smaller than the maximum tolerable tilt angle θ m (YES at step 702), a control signal j for shifting the hydraulic pressure source control valve 55 to the accumulator selecting position 55a to give the "hydraulic suspension operating state" is generated in the same manner as that in the step 505, 504 in FIG. 9 (or the step 608, 604 in FIG. 10) (at step 705). This control signal j is applied to the electromagnetic solenoid 55d of the hydraulic pressure source control valve 55. As a result of this, the hydraulic pressure source control valve 55 is shifted to the accumulator selecting position 55a, thereby the "hydraulic suspension operating state" being given (at step 704).

**[0119]** According to the embodiment 7, when the body 2 is tilted to exceed the maximum tolerable tilt angle θ m, the vehicle height is adjusted to bring the posture of the body 2 to a posture closer to the horizontal posture, and when the current tilt angle reaches a certain tilt angle equal to or smaller than the maximum tolerable tilt angle θ m (i.e., when the target vehicle height is reached), the vehicle height adjustment is terminated, thereby the "hydraulic suspension operating state" being given. In this manner, the tilt angle for the body 2 is held to be equal to or smaller than the maximum tolerable tilt angle θ m, and thus the overturning can be prevented. Moreover, once the vehicle height reaches the target value, and the tilt angle for the body 2 is held to be equal to or smaller than the maximum tolerable tilt angle θ m, the "hydraulic suspension operating state" is given. As a result, the function of the hydraulic suspensions will not be impaired.

**[0120]** In the above-described embodiments, the vehicle height adjusting means is constituted by a pipe line 33, an accumulator 34, directional flow control valves 51, 52, and a hydraulic pressure source control valve 55. However, the present invention is not limited to the vehicle height adjusting means of the above-described configuration. The vehicle height adjusting means of any other configurations may be employed as long as the vehicle height adjusting means includes an oil-gas pressure spring which comprises a gas chamber, an oil chamber, a spring member and a damper member, and performs the compression of the gas in the gas chamber via oil. Also, the vehicle height adjusting means may be configured so that it includes a gas spring (an air spring) that utilizes the restitution of the compressed gas such as air, nitrogen gas, etc.

**[0121]** The present invention has been described above based on the embodiments of the invention. Any other embodiments obtained by persons having ordinary skill in the art to which the present invention pertains from the disclosure of this application are contained in the scope of the present invention.

**[0122]** In the above-described embodiments, description has been made on the assumption that the present invention is applied to a construction machine, such as a wheel-type excavator. However, the present invention is not limited to being applicable to construction machines, but the present invention can be applied to general vehicles, such as passenger cars and cargo trucks.

**Claims**

1. A wheel-type construction machine (1) having a body (2) that is connected to wheels (11, 12) through hydraulic suspension cylinders (21, 22), comprising:

    a tilt angle sensor (3) for detecting a tilt angle in rolling directions of the body (2);
    a vehicle speed sensor (4) for detecting a vehicle speed; and
    a controller (5) for performing a control of shutting off inflow and outflow of a hydraulic oil for the hydraulic suspension cylinders (21, 22) when the tilt angle detected by the tilt angle sensor (3) exceeds a maximum tolerable tilt angle based on detection values given by the tilt angle sensor (3) and the vehicle speed sensor (4),

2. The wheel-type construction machine of claim 1, wherein the maximum tolerable tilt angle is determined according to a vehicle speed detected by the vehicle speed sensor (4).

3. A wheel-type construction machine (1) having a body (2) that is connected to wheels (11, 12) through hydraulic suspension cylinders (21, 22), comprising:

a tilt angle sensor (3) for detecting a tilt angle in rolling directions of the body (2);
vehicle height adjusting means (33, 34, 51, 52, 55) for adjusting a vehicle height by controlling inflow and outflow of a hydraulic oil for the hydraulic suspension cylinders (21, 22); and
controlling means (5) for controlling the vehicle height adjusting means (33, 34, 51, 52, 55) to bring the tilt angle of the body (2) to being equal to or smaller than the maximum tolerable tilt angle when the tilt angle detected by the tilt angle sensor (3) exceeds a maximum tolerable tilt angle.

**4.** A wheel-type construction machine (1) with which a body (2) is connected to wheels (11, 12) through hydraulic suspension cylinders (21, 22), comprising:

a tilt angle sensor (3) for detecting a tilt angle in the rolling directions of the body (2);
vehicle height adjusting means (33, 34, 51, 52, 55) for adjusting a vehicle height by controlling inflow and outflow of a hydraulic oil for the hydraulic suspension cylinders (21,22); and
controlling means (5) for controlling the vehicle height adjusting means (33, 34, 51, 52, 55) to bring the body (2) close to the horizontal posture according to the tilt angle detected by the tilt angle sensor (3).

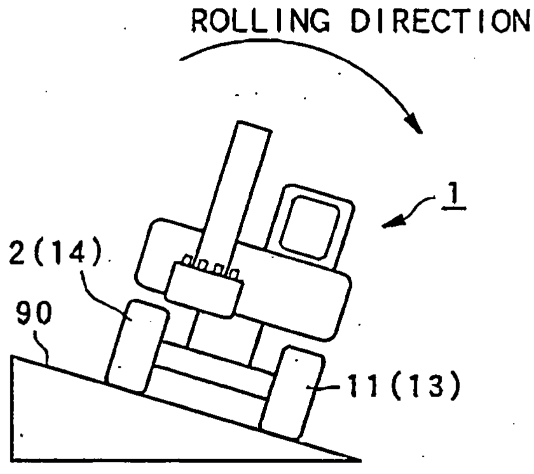


FIG. 1A

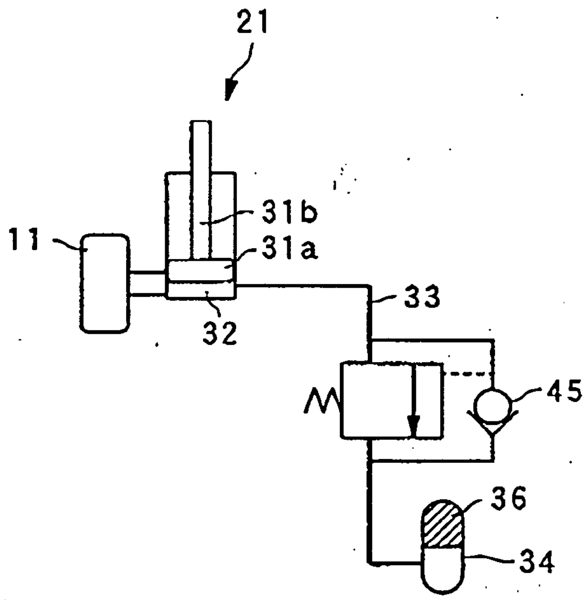


FIG. 1B (PRIOR ART)

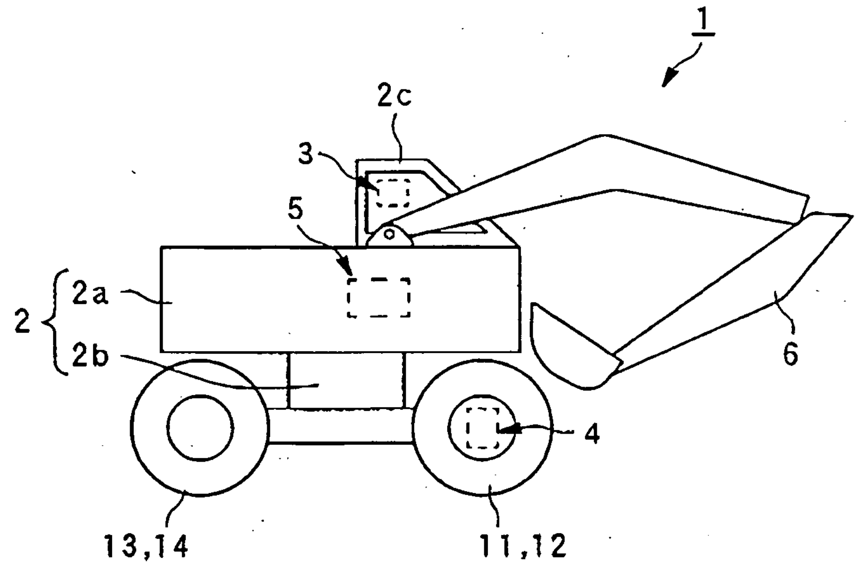
1
2c
3
5
2a
2
2b
6
4
13,14
11,12

FIG. 2

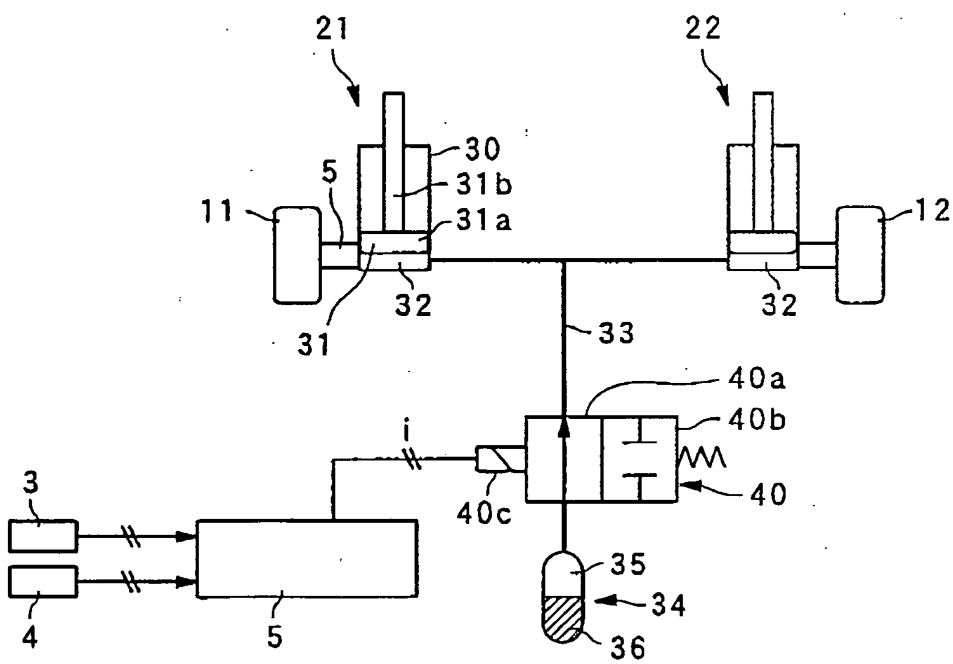
21
22
30
31b
31a
5
11
12
32
31
32
33
40a
40b
i
40
40c
3
35
34
36
4
5

FIG. 3

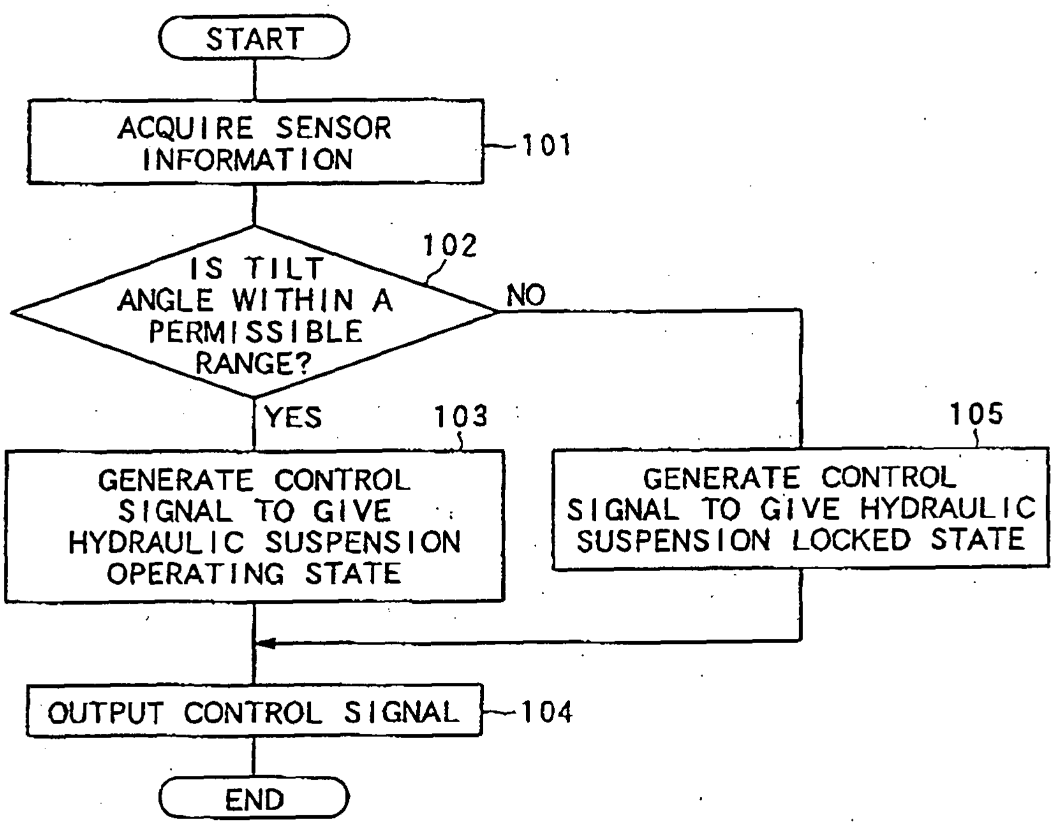
START
ACQUIRE SENSOR INFORMATION
101
IS TILT ANGLE WITHIN A PERMISSIBLE RANGE?
102
NO
YES
103
GENERATE CONTROL SIGNAL TO GIVE HYDRAULIC SUSPENSION OPERATING STATE
105
GENERATE CONTROL SIGNAL TO GIVE HYDRAULIC SUSPENSION LOCKED STATE
OUTPUT CONTROL SIGNAL
104
END

FIG. 4

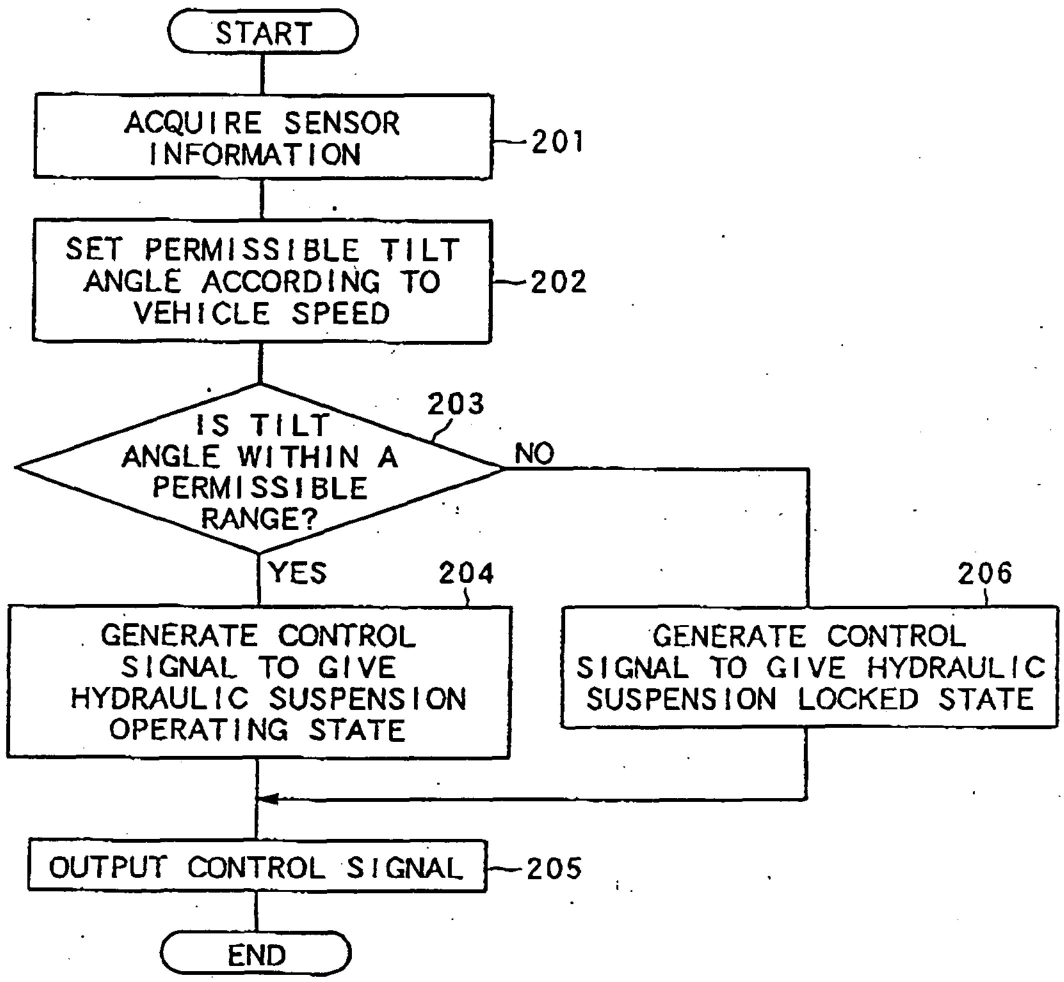
START
ACQUIRE SENSOR INFORMATION
201
SET PERMISSIBLE TILT ANGLE ACCORDING TO VEHICLE SPEED
202
203
IS TILT ANGLE WITHIN A PERMISSIBLE RANGE?
NO
YES
204
GENERATE CONTROL SIGNAL TO GIVE HYDRAULIC SUSPENSION OPERATING STATE
206
GENERATE CONTROL SIGNAL TO GIVE HYDRAULIC SUSPENSION LOCKED STATE
OUTPUT CONTROL SIGNAL
205
END

FIG. 5

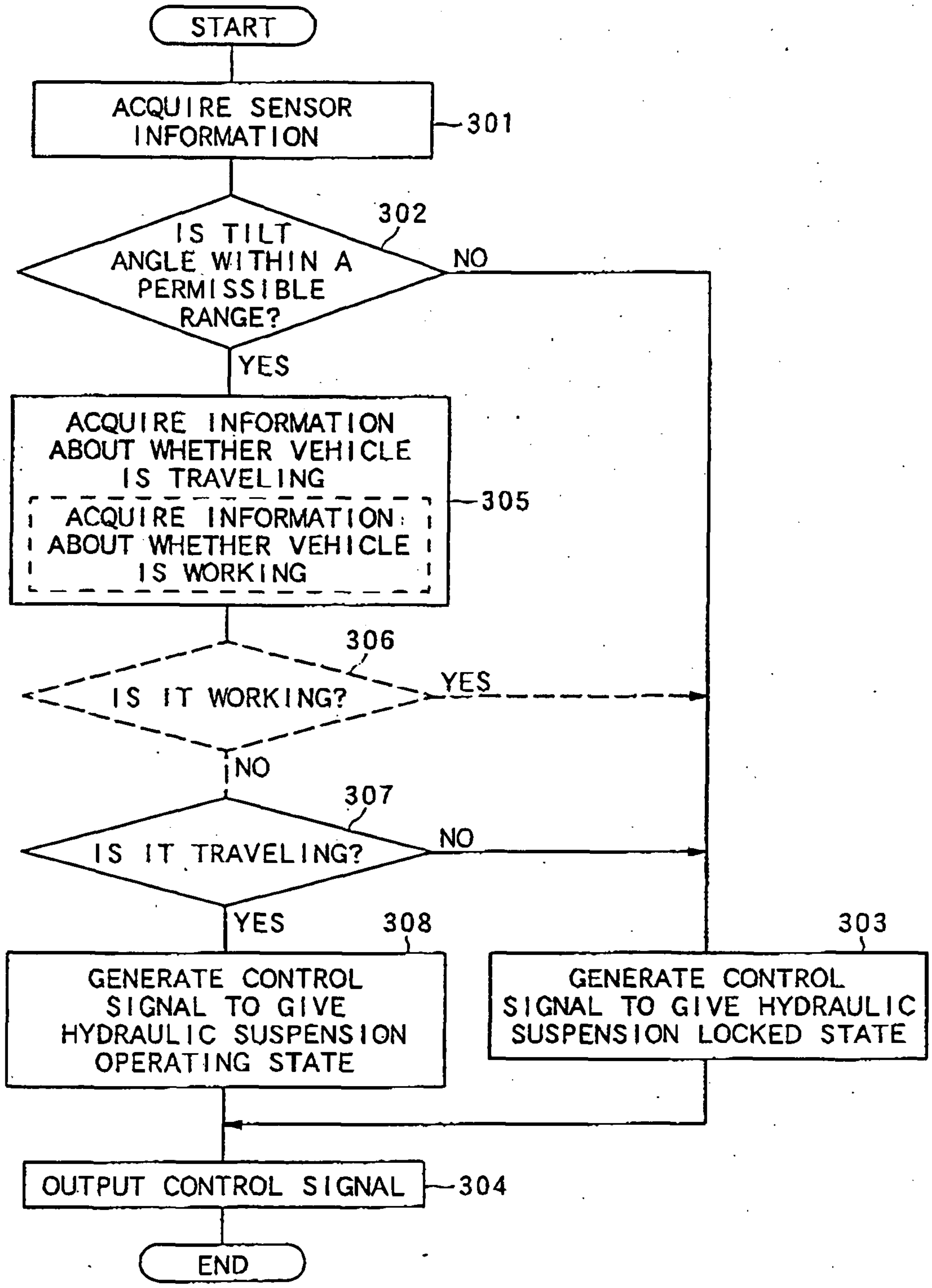
START
ACQUIRE SENSOR INFORMATION
301
IS TILT ANGLE WITHIN A PERMISSIBLE RANGE?
302
NO
YES
ACQUIRE INFORMATION ABOUT WHETHER VEHICLE IS TRAVELING
ACQUIRE INFORMATION ABOUT WHETHER VEHICLE IS WORKING
305
IS IT WORKING?
306
YES
NO
IS IT TRAVELING?
307
NO
YES
308
GENERATE CONTROL SIGNAL TO GIVE HYDRAULIC SUSPENSION OPERATING STATE
303
GENERATE CONTROL SIGNAL TO GIVE HYDRAULIC SUSPENSION LOCKED STATE
OUTPUT CONTROL SIGNAL
304
END

FIG. 6

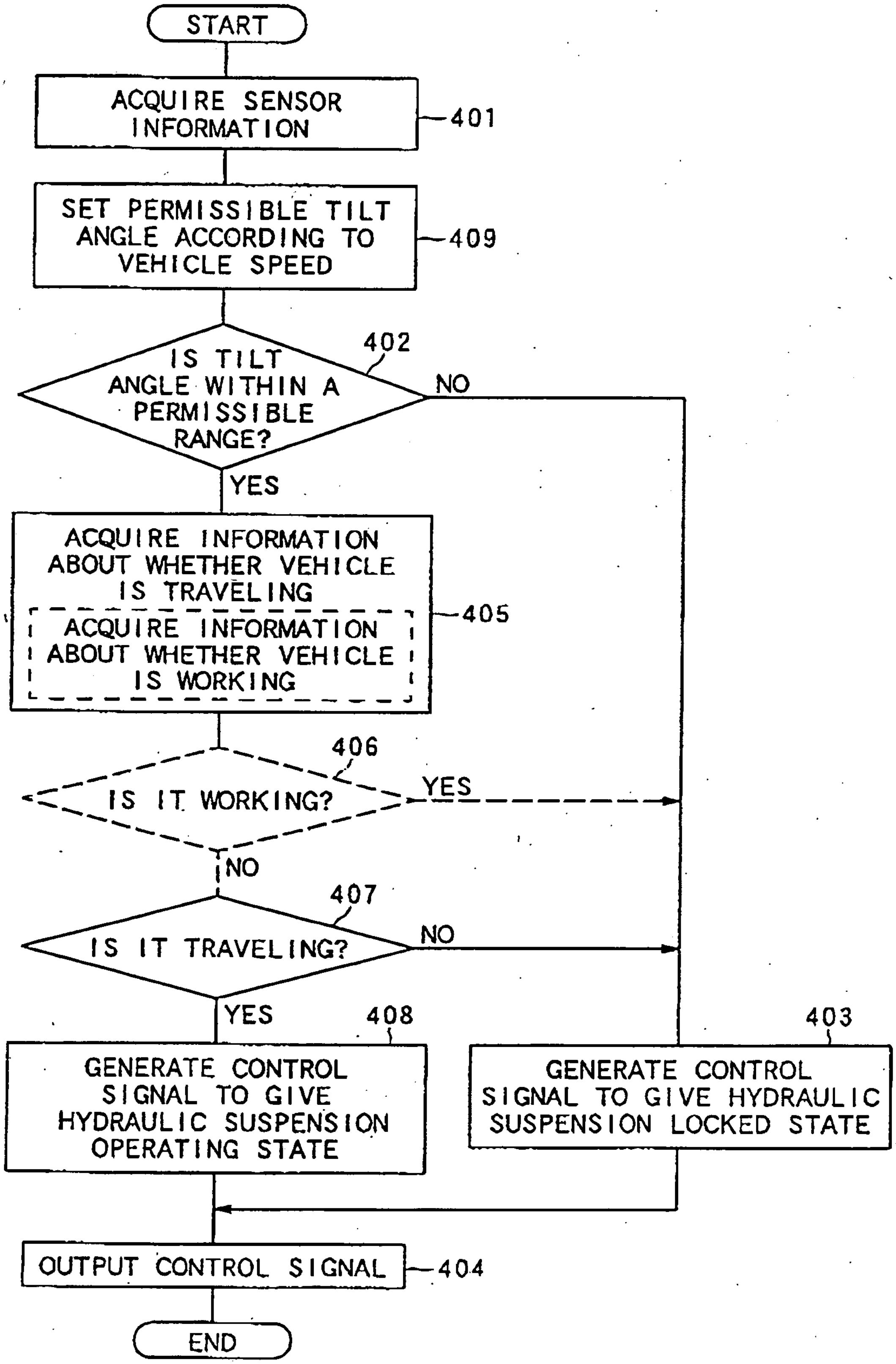
START
ACQUIRE SENSOR INFORMATION
401
SET PERMISSIBLE TILT ANGLE ACCORDING TO VEHICLE SPEED
409
IS TILT ANGLE WITHIN A PERMISSIBLE RANGE?
402
NO
YES
ACQUIRE INFORMATION ABOUT WHETHER VEHICLE IS TRAVELING
ACQUIRE INFORMATION ABOUT WHETHER VEHICLE IS WORKING
405
IS IT WORKING?
406
YES
NO
IS IT TRAVELING?
407
NO
YES
408
GENERATE CONTROL SIGNAL TO GIVE HYDRAULIC SUSPENSION OPERATING STATE
403
GENERATE CONTROL SIGNAL TO GIVE HYDRAULIC SUSPENSION LOCKED STATE
OUTPUT CONTROL SIGNAL
404
END

FIG. 7

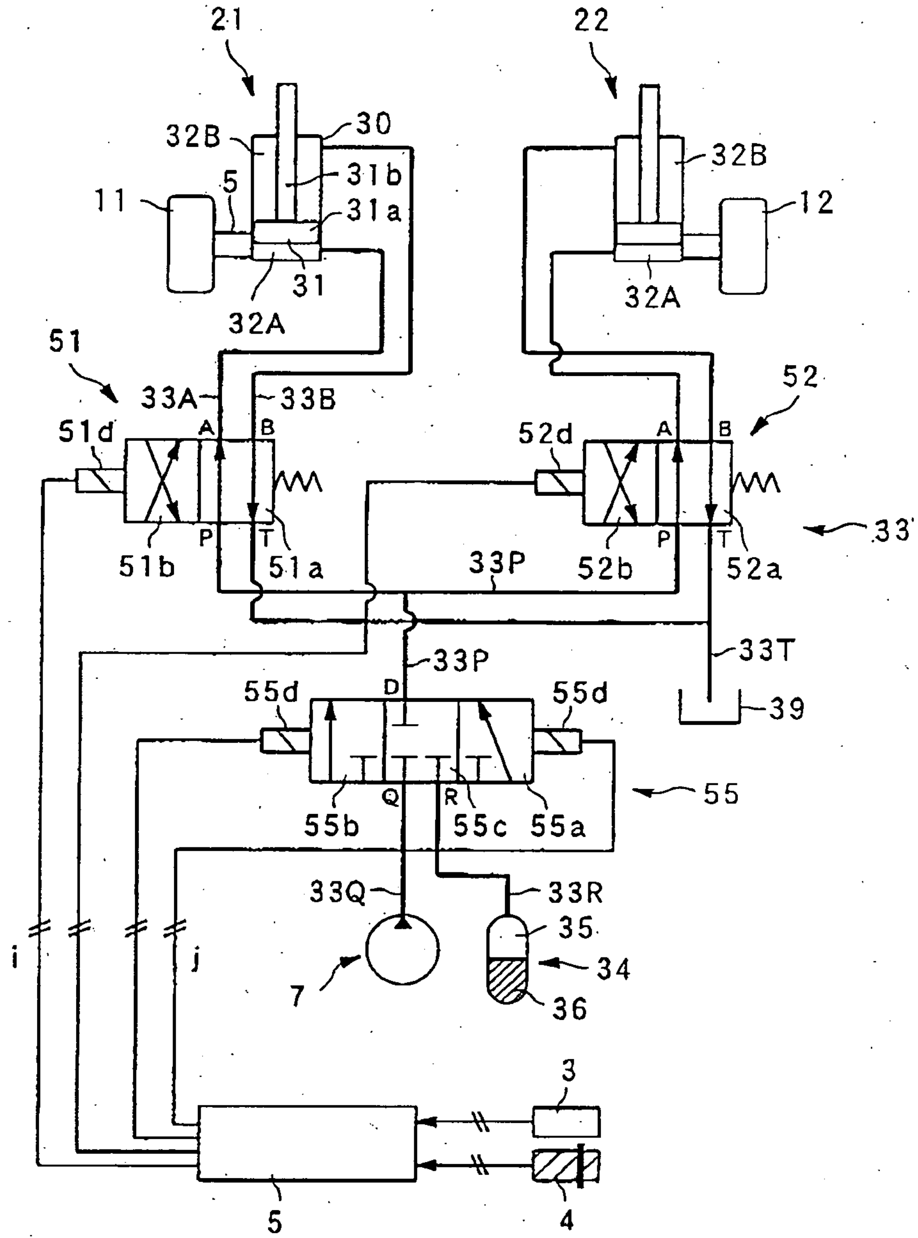
21
22
32B
30
31b
5
11
31a
31
32A
32B
12
32A
51
33A
33B
52
51d
A
B
52d
A
B
33
P
T
51b
51a
33P
52b
52a
33T
33P
D
55d
55d
39
Q
R
55
55b
55c
55a
33Q
33R
35
i
j
34
7
36
3
5
4

FIG. 8

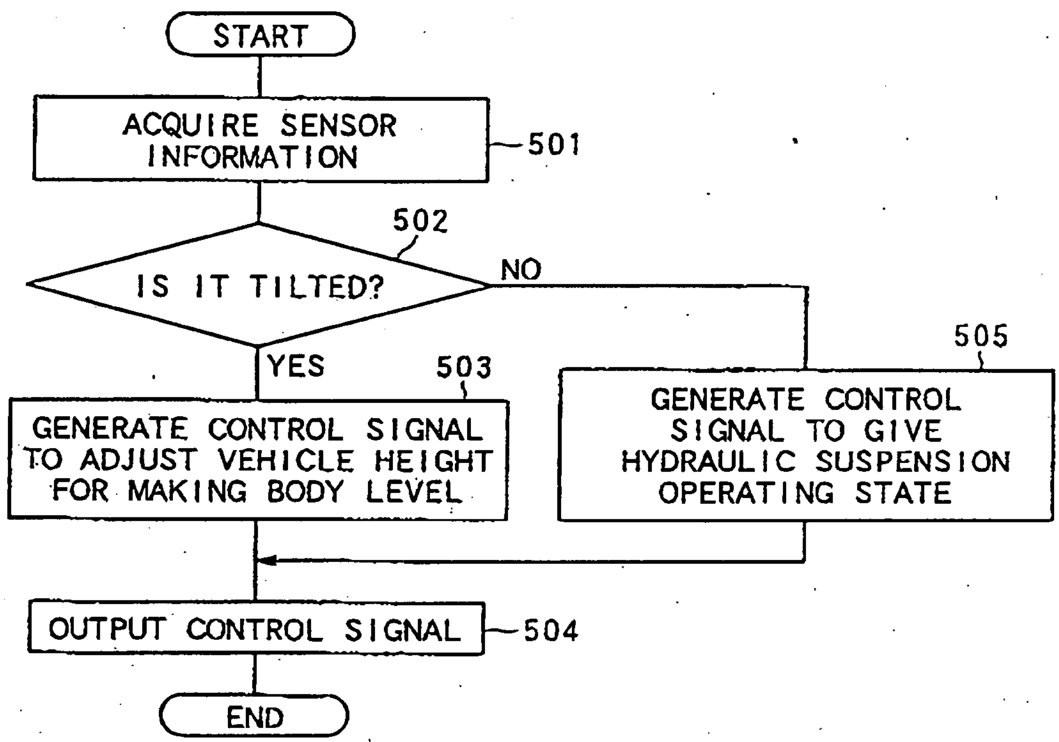
START
ACQUIRE SENSOR INFORMATION
501
502
IS IT TILTED?
NO
YES
503
505
GENERATE CONTROL SIGNAL TO ADJUST VEHICLE HEIGHT FOR MAKING BODY LEVEL
GENERATE CONTROL SIGNAL TO GIVE HYDRAULIC SUSPENSION OPERATING STATE
OUTPUT CONTROL SIGNAL
504
END

FIG. 9

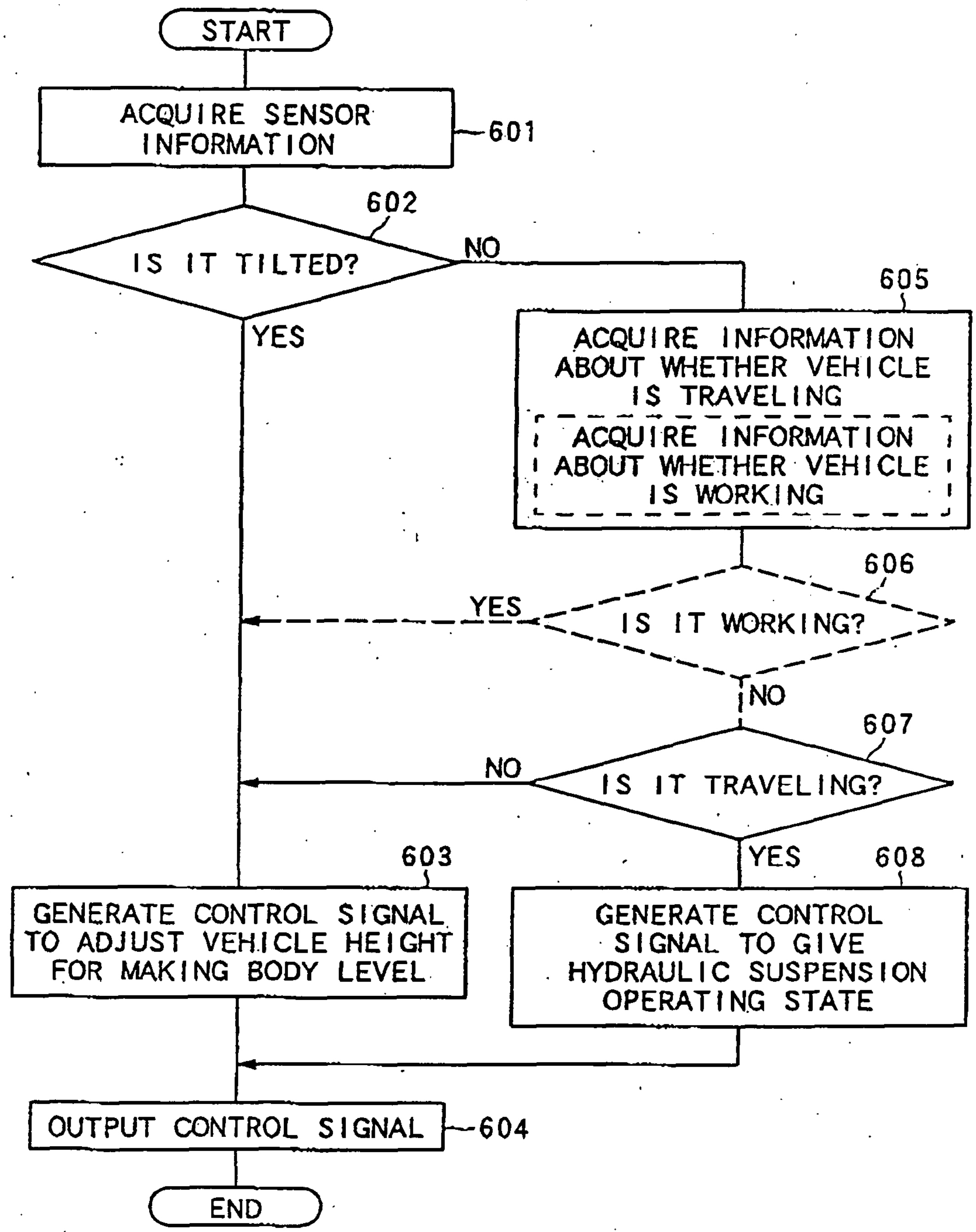
START
ACQUIRE SENSOR INFORMATION
601
602
IS IT TILTED?
NO
YES
605
ACQUIRE INFORMATION ABOUT WHETHER VEHICLE IS TRAVELING
ACQUIRE INFORMATION ABOUT WHETHER VEHICLE IS WORKING
606
YES
IS IT WORKING?
NO
607
NO
IS IT TRAVELING?
603
YES
608
GENERATE CONTROL SIGNAL TO ADJUST VEHICLE HEIGHT FOR MAKING BODY LEVEL
GENERATE CONTROL SIGNAL TO GIVE HYDRAULIC SUSPENSION OPERATING STATE
OUTPUT CONTROL SIGNAL
604
END

FIG.10

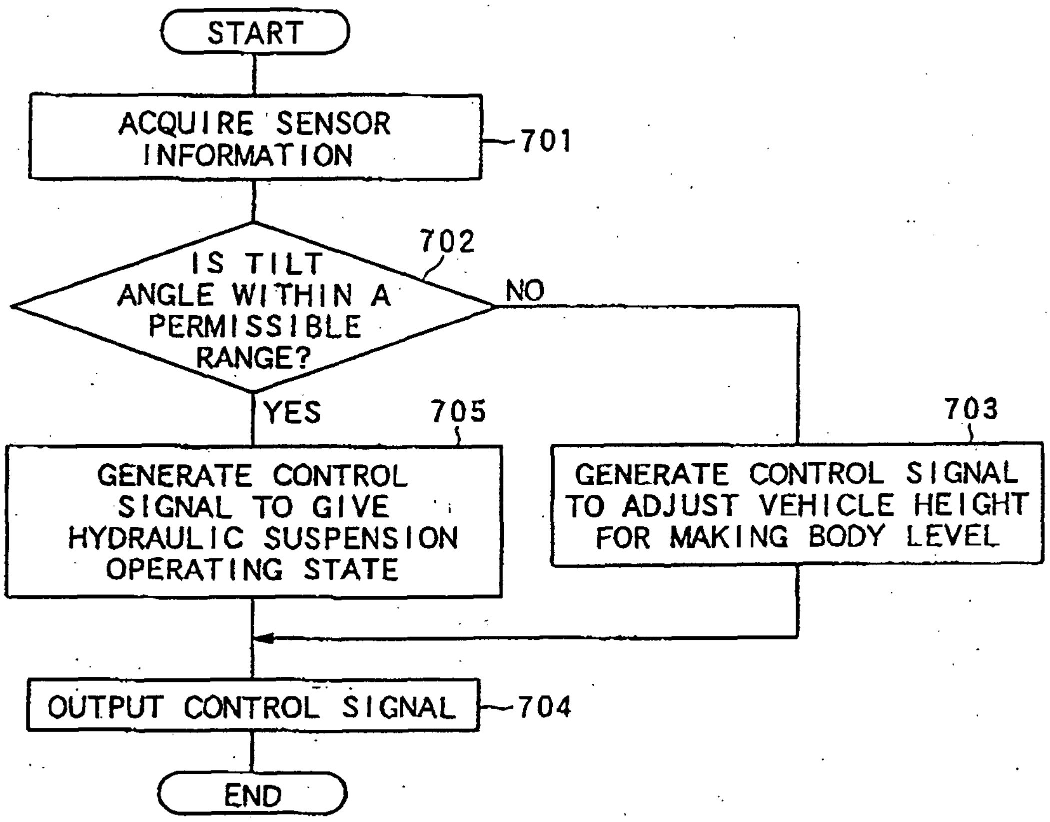
START
ACQUIRE SENSOR INFORMATION
701
IS TILT ANGLE WITHIN A PERMISSIBLE RANGE?
702
NO
YES
705
GENERATE CONTROL SIGNAL TO GIVE HYDRAULIC SUSPENSION OPERATING STATE
703
GENERATE CONTROL SIGNAL TO ADJUST VEHICLE HEIGHT FOR MAKING BODY LEVEL
OUTPUT CONTROL SIGNAL
704
END

FIG.11