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CONTROL APPARATUS FOR VEHICLE

Abstract

A control apparatus including a processor configured to control a drive power of a towed vehicle which has a drive power source which is towed through a coupler by a towing vehicle. When the towing vehicle is running while towing the towed vehicle, the processor is configured to limit the drive power of the towed vehicle such that the towed vehicle does not push the towing vehicle through the coupler. Preferably, the processor is configured to calculate, based on a drive power of the towing vehicle, an upper limit value of an allowable range of the drive power of the towed vehicle in which the towed vehicle does not push the towing vehicle, and to limit the drive power of the towed vehicle by the upper limit value.

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Background/Summary

[0001] This application claims priority from Japanese Patent Application No. 2024-024104 filed on Feb. 20, 2024, the disclosure of which is herein incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to a control apparatus for controlling a drive power of a towed vehicle.

BACKGROUND OF THE INVENTION

[0003] There is well known a control apparatus that includes a drive control portion that controls a drive power of a towed vehicle which is towed by a towing vehicle through a coupler and which has a drive power source. For example, a control apparatus for an articulated vehicle described in Patent Document 1 is such a control apparatus. Patent Document 1 discloses a towing vehicle equipped with a first motor that can be driven by a first battery, and a towed vehicle equipped with a second motor that can be driven by a second battery.

PRIOR ART DOCUMENT

Patent Document

[0004] [Patent Document 1] [0005] Japanese Patent Application Laid-Open No. 2013-184584

SUMMARY OF THE INVENTION

[0006] A responsiveness of the drive power of the vehicle varies depending on the type or combination of the drive power sources, and varies among engine and electric vehicles. On the other hand, where the towed vehicle as well as the towing vehicle is adapted to generate the drive power, it is possible to increase an acceleration performance in a towing running state in which the towing vehicle runs the towed vehicle. However, if the responsiveness of the drive power varies among vehicles, a situation may occur in which the drive power of the towed vehicle is larger than necessary. Under such a situation, there is a concern that behavior of the towing vehicle may be disturbed or a driver of the towing vehicle may feel discomfort. If the drive power of the towed vehicle is greatly reduced, the above-described situation is unlikely to occur, but benefit of increasing the acceleration performance is unlikely to be obtained.

[0007] The present invention has been made in view of the above circumstances, and an object of the present invention is to provide a control apparatus capable of stabilizing behavior of a towing vehicle while enjoying an increase in acceleration performance by a drive power of a towed vehicle.

[0008] The present invention provides a control apparatus comprising a processor configured to control a drive power of a towed vehicle which has a drive power source which is towed through a coupler by a towing vehicle. When the towing vehicle is running while towing the towed vehicle, the processor is configured to limit the drive power of the towed vehicle such that the towed vehicle does not push the towing vehicle through the coupler.

[0009] In the control apparatus according to the present invention, when the towing vehicle is in the towing running state in which the towing vehicle is running while towing the towed vehicle, the drive power of the towed vehicle is limited such that the towed vehicle having the drive power source does not push the towing vehicle through the coupler. Thus, the towed vehicle generates the drive power, and thus, drive assistance in the towing running state can be performed. For example, improvement of acceleration performance and hill climbing performance, enlargement of towing capacity, extension of cruising distance and the like can be expected. Further, response of the drive power of the towed vehicle is controlled, and thus the towed vehicle is prevented or suppressed from pushing the towing vehicle. Therefore, it is possible to stabilize behavior of the towing vehicle while enjoying the improvement of the acceleration performance by the drive power of the towed vehicle.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a view showing a schematic configuration of a articulated vehicle to which the present invention is applied, and is a view showing control functions and main parts of a control system for various controls in the articulated vehicle.

[0011] FIGS. **2**A and **2**B are views showing an example of a towing running state in which a towing vehicle runs while towing a trailer as a towed vehicle.

[0012] FIG. **3** is a flowchart for explaining a main part of a control operation of a vehicle control apparatus, and is a flowchart for explaining a control operation for stabilizing behavior of the towing vehicle while enjoying an increase in acceleration performance by a drive power of the trailer.

[0013] FIG. **4** is a view showing an example of a time chart in a case where the control operation shown in the flowchart of FIG. **3** is executed.

[0014] FIG. **5** is a flowchart for explaining a main part of a control operation of the vehicle control apparatus, and is a flowchart for explaining a control operation for stabilizing behavior of the towing vehicle while enjoying an increase in acceleration performance by the drive power of the trailer, and is an embodiment different from FIG. **3**.

[0015] FIG. **6** is a flowchart for explaining a main portion of a control operation of an electronic control device of the trailer, which is a flowchart for explaining a control operation for stabilizing behavior of the towing vehicle while enjoying an increase in acceleration performance by the drive power of the trailer, and is an embodiment different from FIGS. **3** and **5**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0016] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings.

First Embodiment

[0017] FIG. **1** is a view showing a schematic configuration of a articulated vehicle to which the present invention is applied, and is a view showing control functions and main parts of a control system for various controls in the articulated vehicle **10**. In FIG. **1**, the articulated vehicle **10** is a combination of a towing vehicle **20** and a trailer **60**.

[0018] The towing vehicle **20** is, for example, a known automobile, and includes an engine **22**, a transmission **24**, a differential gear device **26**, a drive shaft **28** and drive wheels **30**. The engine **22** functions as a drive power source of the towing vehicle **20**. An engine torque Te, which is a torque of the engine **22**, is controlled by an electronic control device **50**. In the towing vehicle **20**, a power of the engine **22** is transmitted to the drive wheels **30** sequentially via the transmission **24**, the differential gear device **26**, the pair of drive shafts **28** and the like.

[0019] The trailer **60** is a towed vehicle towed by the towing vehicle **20**. The trailer **60** includes an electric motor **62**, a differential gear device **64**, a drive shaft **66** and drive wheels **68**. The electric motor **62** functions as a drive power source of the trailer **60**. The electric motor **62** is controlled by an electronic control device **80**, to generate an electric motor torque Tm. In the trailer **60**, a power of the electric motor **62** is transmitted to the drive wheels **68** sequentially via the differential gear device **64**, the pair of drive shafts **66** and the like. A regenerative torque, which is a negative torque of the electric motor torque Tm, may be transmitted to the drive wheels **68** as a braking torque.

[0020] FIGS. **2**A and **2**B are views showing an example of a towing running state of the articulated vehicle **10** in which the towing vehicle **20** is running while towing the trailer **60**. FIG. **2**A is a side view as viewed from a left side of the articulated vehicle **10**. FIG. **2**B is a plan view as viewed from an upper side of articulated vehicle **10**. In FIGS. **2**A and **2**B, the trailer **60** is towed by the towing vehicle **20** through a coupler **90**. The coupler **90** includes, for example, a trailer hitch member **92** and a towing-vehicle hitch member **94**. The trailer hitch member **92** is attached to a front end portion of the trailer **60**. The towing-vehicle hitch member **94** is attached to a rear end portion of the towing vehicle **20**. The trailer hitch member **92** and the towing-vehicle hitch member **94** are connected through a coupling portion **96**. The coupling portion **96** is a coupling portion of the trailer **60** coupled to the towing vehicle **20**, and is a distal end portion of the trailer hitch member **92** on a side of the towing vehicle **20**. The coupling portion **96** corresponds to a coupling portion between the towing vehicle **20** and the trailer **60**. The trailer **60** is towed by the towing vehicle **20** such that the coupler **90** prevents the towing vehicle **20** and the trailer **60** from approaching and separating from each other by the coupling portion **96** being coupled to the towing-vehicle hitch member **94**.

[0021] Referring back to FIG. **1**, the towing vehicle **20** further includes the electronic control device **50** as a controller related to controls of the engine **22** and the like. The electronic control device **50** includes a so-called microcomputer or processor including, for example, a CPU, a RAM, a ROM and an input/output interface. The CPU performs various controls of the towing vehicle **20** by performing signal processing according to a program stored in the ROM in advance while using a temporary storage function of the RAM, for example.

[0022] Various signals and the like based on values detected by various sensors and the like provided in the towing vehicle **20** are supplied to the electronic control device **50**. The various sensors and the like provided in the towing vehicle **20** are, for example, an engine speed sensor **32**, a vehicle running-speed sensor **34**, an accelerator opening sensor **36**, a throttle-valve opening sensor **38**, a steering sensor **40** and the like. The various signals include, for example, an engine rotational speed Ne, a vehicle running speed Vv, an accelerator opening degree θacc, a throttle-valve opening degree θth, a steering angle θsw and a steering direction Dsw. The engine rotational speed Ne is a rotational speed of the engine **22**. The vehicle running speed Vv is a running speed of the towing vehicle **20**. The accelerator opening degree θacc is a signal corresponding to an acceleration request amount indicating a magnitude of an acceleration operation made by a driver of the towing vehicle **20**, and is an accelerator operation amount by the driver. The throttle-valve opening degree θth is the opening degree of the electronic throttle valve. The steering angle θsw is a steering angle of a steering wheel of the towing vehicle **20**. The steering direction Dsw is a steering direction of the steering wheel.

[0023] Various command signals and the like are outputted from the electronic control device **50** to various devices and the like provided in the towing vehicle **20**. The various devices provided in the towing vehicle **20** include the engine **22**, for example. The various command signals include an engine control command signal Se for controlling the engine **22**, for example.

[0024] The trailer **60** further includes the electronic control device **80** as a controller related to control of the electric motor **62** and the like. The electronic control device **80** includes a so-called microcomputer or processor including, for example, a CPU, a RAM, a ROM and an input/output interface. The CPU executes various controls of the trailer **60** by performing signal processing in accordance with a program stored in the ROM in advance while using a temporary storage function of the RAM, for example.

[0025] Various signals and the like based on values detected by various sensors and the like provided in the trailer **60** are supplied to the electronic control device **80**. The various sensors and the like provided in the trailer **60** are, for example, an electric-motor speed sensor **70**, a vehicle running-speed sensor **72**, a load sensor **74** and the like. The load sensor **74** is a sensor provided in the coupler **90**, particularly, in the coupling portion **96** (see FIGS. **2**A and **2**B), and is, for example, a strain gauge. The various signals include an electric-motor rotational speed Nm, a trailer running speed Vt and a hitch load Fx. The electric-motor rotational speed Nm is a rotational speed of the electric motor **62**. The trailer running speed Vt is a running speed of the trailer **60**. The hitch load

Fx is a load applied to the coupler **90**, particularly, to the coupling portion **96**, and corresponds to a difference between a vehicle drive power Fv and a trailer drive power Ft in consideration of, for example, the steering angle θsw, a weight of the towing vehicle **20**, a weight of the trailer **60** and the like (see FIGS. **2**A and **2**B). The vehicle drive power Fv is a drive power of the towing vehicle **20**. The trailer drive power Ft is a drive power of the trailer **60**. The hitch load Fx corresponds to a magnitude obtained by subtracting the vehicle drive power Fv from the trailer drive power Ft. When the hitch load Fx is a positive value (Fx>0), a direction of the hitch load Fx is a direction in which the trailer **60** pushes the towing vehicle **20**. When the hitch load Fx is a negative value (Fx<0), the trailer **60** does not push the towing vehicle **20**, that is, the towing vehicle **20** pulls the trailer **60**.

[0026] Various command signals and the like are outputted from the electronic control device **80** to various devices and the like provided in the trailer **60**. The various devices provided in the trailer **60** include the electric motor **62**, for example. The various command signals include a motor control command signal Sm for controlling the electric motor **62**, for example.

[0027] The electronic control device **50** and the electronic control device **80** are connected to each other in a wired or wireless manner so as to be able to communicate with each other. The electronic control device **50** and the electronic control device **80** cooperate with each other to constitute a vehicle control apparatus **100** that performs a drive control, for example.

[0028] The electronic control device **50** includes an engine control portion **52** that controls the engine **22** in order to realize various controls in the towing vehicle **20**. The engine control portion **52** calculates a requested vehicle drive amount Qvdem, which is a requested drive amount for the towing vehicles **20**, by applying the accelerator operation amount θacc and the vehicle running speed Vv to a requested vehicle drive amount map MAPv, for example. The requested vehicle drive amount map MAPv is a relationship for obtaining the requested vehicle drive amount Qvdem, which is obtained and stored in advance, for example, experimentally or by design, that is, which is determined in advance. The requested vehicle drive amount Qvdem is, for example, the vehicle drive power Fv requested for the towing vehicle **20**, that is, a requested vehicle drive power Fvdem in the drive wheels **30**. The engine control portion **52** calculates a requested engine torque Tedem that is a requested value of the engine torque Te for realizing the requested vehicle drive amount Qvdem, in consideration of, for example, a transmission loss, an auxiliary load, a gear ratio of the transmission **24** and the like. The engine control portion **52** outputs an engine control command signal Se for controlling the engine **22** so as to obtain the requested engine torque Tedem.

[0029] The electronic control device **80** includes an electric-motor control portion **82** that controls the electric motor **62** in order to realize various controls in the trailer **60**. The electric-motor control portion **82** calculates a trailer drive request amount Qtdem, which is a drive request amount for the trailer **60**, by applying the accelerator opening degree θacc and the trailer running speed Vt to a requested trailer drive amount map MAPt, for example. The requested trailer drive amount map MAPt is a relationship for obtaining a predetermined trailer drive request amount Qtdem, for example. The trailer drive request amount Qtdem is, for example, a trailer drive power Ft requested for the trailer **60**, that is, a requested trailer drive power Ftdem in the drive wheel **68**. The motor control portion **82** calculates a requested motor torque Tmdem, which is a requested value of the motor torque Tm for realizing the trailer drive request amount Qtdem, in consideration of, for example, a transmission loss. The electric-motor control portion **82** outputs an electric-motor control command signal Sm for controlling the electric motor **62** so as to obtain the requested motor torque Tmdem. In this way, the electric-motor control portion **82** functions as a drive control portion that controls the trailer drive power Ft.

[0030] By the way, in consideration of output characteristics of the engine **22** and the electric motor **62**, a responsiveness of the vehicle drive power Fv to the requested vehicle drive power Fvdem may be inferior to a responsiveness of the trailer drive power Ft to the requested trailer drive power Ftdem. Therefore, during acceleration such as when the accelerator is turned on or when the accelerator is increased, the trailer drive power Ft temporarily becomes larger than the vehicle drive power Fv, and there is a possibility that the trailer **60** would push the towing vehicle **20** at one point from the connection portion **96** through the coupler **90**. In this case, there is a concern that behavior of the towing vehicle **20** could be disturbed. Unless otherwise specified, the vehicle drive power Fv is synonymous with an actual vehicle drive power Fvr which is an actual value of the vehicle drive power Fv, and the trailer drive power Ft is synonymous with an actual trailer drive power Ftr which is an actual value of the trailer drive power Ft.

[0031] Therefore, the electric-motor control portion **82** controls the response of the trailer drive power Ft in order to avoid the trailer **60** from pushing the towing vehicle **20** through the coupler **90**. For example, the electric-motor control portion **82** limits the trailer drive power Ft such that the trailer **60** does not push the towing vehicle through the coupler **90** when the towing vehicle **20** is in the towing running state in which the towing vehicle **20** is running while towing the trailer **60** through the coupler **90**.

[0032] FIG. **3** is a flowchart showing a main part of the control operation of the vehicle control apparatus **100**, and is a flowchart showing a control routine for stabilizing the behavior of the towing vehicle **20** while enjoying the improvement of the acceleration performance by the trailer drive power Ft. This control routine is repeatedly executed, for example.

[0033] In FIG. **3**, first, at step S**10***a* corresponding to function of the electronic control device **50**, information such as the accelerator opening degree θacc, the steering angle θsw and the steering direction Dsw is obtained. Next, at step S**20***a* corresponding to functions of the engine control portion **52** and the motor control portion **82**, the requested vehicle drive power Fvdem and the requested trailer drive power Ftdem are calculated. Next, at step S**30***a* corresponding to functions of the engine control portion **52** and the motor control portion **82**, an estimated value of the vehicle drive power Fv and an estimated value of the trailer drive power Ft are calculated. For example, the estimated value of the vehicle drive power Fv is calculated by a predetermined approximate expression in which a response delay with respect to the requested vehicle drive power Fvdem is taken into consideration. Alternatively, the estimated value of the vehicle drive power Fv is calculated based on the actual engine torque Te. In this instance, the steering angle θsw, the steering direction Dsw, the braking power by wheel brakes and the like may be considered. Further, for example, the estimated value of the trailer drive power Ft is calculated by a predetermined approximate expression in which a response delay with respect to the requested trailer drive power Ftdem is taken into consideration. Alternatively, the estimated value of the trailer drive power Ft is calculated based on the actual electric motor torque Tm. Next, at step S**40***a* corresponding to function of the motor control portion **82**, a trailer drive power limit Ftlim, which is an upper limit value of the trailer drive power Ft at which the trailer **60** does not push the towing vehicle **20** through the coupler **90**, is calculated based on the estimated value of the vehicle drive power Fv. For example, the trailer drive power limit Ftlim, which is an upper limit value of an allowable range of the trailer drive power Ft in which the hitch load Fx becomes a negative value in calculation, is calculated based on the estimated value of the trailer drive power Fv. Next, at step S**50***a* corresponding to function of the motor control portion **82**, the requested trailer drive power Ftdem is limited or upper-guarded to the trailer drive power limit Ftlim. That is, when the requested trailer drive power Ftdem exceeds the trailer drive power limit Ftlim, the requested trailer drive power Ftdem is set to the trailer drive power limit Ftlim. Next, at step S**60***a* corresponding to function of the electric-motor control portion **82**, the electric motor **62** is controlled using the requested trailer drive power Ftdem whose upper limit is guarded by the trailer drive power limit Ftlim, and the trailer **60** is driven. That is, the requested trailer drive power Ftdem, whose upper limit is guarded by the trailer drive power limit Ftlim, is reflected in the trailer drive power Ft.

[0034] In this way, the electric-motor control portion **82** calculates the trailer drive power limit Ftlim, which is the upper limit of the allowable range of the trailer drive power Ft in which the trailer **60** does not push the towing vehicle **20**, based on the vehicle drive power Fv, and then limits the trailer drive power Ft by the trailer drive power limit Ftlim. The trailer drive power limit Ftlim is the upper limit of the allowable range of the trailer drive power Ft in which the hitch load Fx is less than a load value by which the towing vehicle **20** is pushed by the trailer **60**, namely, in which the hitch load Fx does not act in a direction by which the towing vehicle **20** is pushed by the trailer **60**. That is, the trailer drive power limit Ftlim is determined such that the trailer **60** does not push the towing vehicle **20**.

[0035] FIG. **4** is a view showing an example of a time chart in a case where the control routine shown in the flowchart of FIG. **3** is executed. FIG. **4** shows an example of the case of starting or accelerating. In FIG. **4**, a time point t**1** indicates a time point at which the accelerator is turned on or a time point at which the accelerator is operated to increase the acceleration. In a comparative example indicated by a broken line, the trailer drive power Ft is generated with better responsiveness than the vehicle drive power Fv. In such a situation, the trailer **60** pushes the towing vehicle **20**. In contrast, in the present embodiment indicated by two dot chain line, the trailer drive power Ft is limited by the trailer drive power limit Ftlim, and thus a situation in which the trailer **60** pushes the towing vehicle **20** is avoided or suppressed.

[0036] As described above, according to the present embodiment, the trailer **60** includes the electric motor **62** as the drive power source. Accordingly, the trailer **60** generates the trailer drive power Ft, and thus, drive assistance can be performed in the towing running state in which the towing vehicle **20** is running while towing the trailer **60**, and for example, improvement of acceleration performance or hill climbing performance, increase of towing capacity and extension of running distance can be expected. In addition, when the towing vehicle **20** is in the towing running state, the trailer drive power Ft is limited such that the trailer **60** does not push the towing vehicle through the coupler **90**. Accordingly, the response of the trailer drive power Ft is controlled, and thus the trailer **60** is prevented or suppressed from pushing the towing vehicle **20**. Therefore, it is possible to stabilize the behavior of the towing vehicle **20** while enjoying the improvement of the acceleration performance by the trailer drive power Ft.

[0037] Further, according to the present embodiment, the trailer drive power limit Ftlim is calculated based on the vehicle drive power Fv, and the trailer drive power Ft is limited by the trailer drive power limit Ftlim. The trailer drive power limit Ftlim is the upper limit of the allowable range of the trailer drive power Ft in which the hitch load Fx is less than a load value by which the towing vehicle **20** is pushed by the towed vehicle **60**, namely, in which the hitch load Fx does not act in a direction by which the towing vehicle **20** is pushed by the trailer **60**. Thus, the trailer drive power Ft is appropriately limited such that the trailer **60** does not push the towing vehicle **20** in the towing running state.

[0038] Next, other embodiments of the present invention will be described. In the following description, the same reference numerals are given to the same parts as those in the first embodiment, and the description thereof will be omitted.

Second Embodiment

[0039] In the first embodiment, the trailer drive power Ft is limited by calculating the trailer drive power limit Ftlim. In this embodiment, the trailer drive power Ft is limited by the direction of the hitch load Fx.

[0040] FIG. **5** is a flowchart showing a main part of the control operation of the vehicle control device **100**, and is a flowchart showing a control routine for stabilizing the behavior of the towing vehicle **20** while enjoying the improvement of the acceleration performance by the trailer drive power Ft, and is repeatedly executed, for example. The flow chart of FIG. **5** shows the control routine, which is executed in this second embodiment and which is different from the control routine shown in the flowchart of FIG. **3**.

[0041] In FIG. **5**, steps S**10***b*, S**20***b* and S**30***b* are the same as steps S**10***a*, S**20***a* and S**30***a* in FIG. **3**, and therefore, the description thereof is omitted. Step S**30***b* is followed by step S**40***b* corresponding to function of the electric-motor control portion **82**, which is implemented to calculate the hitch load Fx by using the steering angle θsw, the steering direction Dsw, the estimated value of the vehicle drive power Fv, the estimated value of the trailer drive power Ft and the like, and to obtain the direction of the hitch load Fx. Then, it is determined whether or not the direction of the hitch load Fx corresponds to a direction in which the trailer **60** pushes the towing vehicle **20**. At this step S**40***b*, a detection signal of the load sensor **74** indicative of the hitch load Fx may be used. When an affirmative determination is made at this step S**40***b*, the requested trailer drive power Ftdem is subtracted or reduced at S**50***b* corresponding to function of the electric-motor control portion **82**. For example, the requested trailer drive power Ftdem is reduced in a feedback control such that the hitch load Fx is less than a load value by which the towing vehicle **20** is pushed by the trailer **60**, namely, in which the hitch load Fx does not act in a direction by which the towing vehicle **20** is pushed by the trailer **60**. Alternatively, the requested trailer drive power Ftdem is subtracted or reduced depending on the hitch load Fx such that the requested trailer drive power Ftdem is reduced by a magnitude that is increased as the hitch load Fx is increased. When a negative determination is made at this step S**40***b*, or after implementation of step S**50***b*, step S**60***b* corresponding to function of the motor control portion **82** is implemented to control the motor **62** by using the requested trailer drive power Ftdem, and to drive the trailer **60**. Further, at step S**60***b*, the requested trailer drive power Ftdem calculated at step S**20***b* is used as it is, and is reflected in the trailer drive power Ft. When an affirmative determination is made at step S**40***b*, the requested trailer drive power Ftdem reduced at step S**50***b* is used and is reflected in the trailer drive power Ft.

[0042] In this way, the electric motor control portion **82** obtains the direction of the hitch load Fx and limits the trailer drive power Ft such that the direction of the hitch load Fx becomes a direction in which the trailer **60** does not push the towing vehicle **20**.

[0043] As described above, according to the present second embodiment, similarly to the first embodiment described above, it is possible to achieve the behavior stabilization of the towing vehicle **20** while enjoying the improvement of the acceleration performance by the trailer drive power Ft.

[0044] Further, according to the present second embodiment, the direction of the hitch load Fx is obtained, and the trailer drive power Ft is limited such that the direction of the hitch load Fx becomes a direction in which the trailer **60** does not push the towing vehicle **20**. Thus, the trailer drive power Ft is appropriately limited such that the trailer **60** does not push the towing vehicle **20** in the towing running state.

Third Embodiment

[0045] In the first and second embodiments, the electronic control device **50** and the electronic control device **80** cooperate with each other to constitute the vehicle control device **100** that performs the drive control of the articulated vehicle **10**. In the present third embodiment, the electronic control device **80** limits the trailer drive power Ft independently without cooperating with the electronic control device **50**. Therefore, in the present third embodiment, the trailer drive power Ft is limited by using the hitch load Fx which is the signal supplied from the load sensor **74**.

[0046] FIG. **6** is a flowchart showing a main part of the control operation of the electronic control device **80**, and is a flowchart showing a control routine for stabilizing the behavior of the towing vehicle **20** while enjoying the improvement of the acceleration performance by the trailer drive power Ft, and is repeatedly executed, for example. The flow chart of FIG. **6** shows the control routine, which is executed in this third embodiment and which is different from the control routines shown in the flowcharts of FIGS. **3** and **5**. The control routine shown in the flow chart of FIG. **6** can be completed only by the electronic control device **80**.

[0047] In FIG. **6**, each step of the control routine corresponds to function of the electric motor control portion **82**. At step S**10***c*, the requested trailer drive power Ftdem is calculated. At this step S**10***c*, the accelerator opening θacc is not used, and the requested trailer drive power Ftdem for resisting a running resistance of the trailer **60** is calculated based on the trailer running speed Vt, for example. Next, at step S**20***c*, information of the hitch load Fx which is the signal supplied from the load sensor **74** is obtained. Next, at step S**30***c*, it is determined whether or not the direction of the hitch load Fx is a direction in which the trailer **60** pushes the towing vehicle **20**. When an affirmative determination is made at step S**30***c*, step S**40***c* is implemented. Since this step S**40***c* is the same as step S**50***b* in FIG. **5**, and therefore, the description thereof is omitted. When a negative determination is made at step S**30***c*, or after implementation of step S**40***c*, step S**50***c* is implemented to control the electric motor **62** by using the requested trailer drive power Ftdem, and to drive the trailer **60**. Further, when the negative determination is made at step S**30***c*, the requested trailer drive power Ftdem calculated at step S**10***c* is used as it is, and is reflected in the trailer drive power Ft. When an affirmative determination is made at step S**30***c*, the requested trailer drive power Ftdem reduced at step S**40***c* is used and reflected in the trailer drive power Ft.

[0048] In this way, the electric-motor control portion **82** obtains the magnitude and the direction of the hitch load Fx by the load sensor **74**, and limits the trailer drive power Ft when the direction of the hitch load Fx is the direction in which the trailer **60** pushes the towing vehicle **20**. When limiting the trailer drive power Ft, the electric motor control portion **82** increases the magnitude of reduction in the trailer drive power Ft as the magnitude of the hitch load Fx is increased.

[0049] As described above, according to the present third embodiment, similarly to the first and second embodiments described above, it is possible to achieve the behavior stabilization of the towing vehicle **20** while enjoying the improvement of the acceleration performance by the trailer drive power Ft.

[0050] According to the present third embodiment, the magnitude and the direction of the hitch load Fx are obtained by the load sensor **74**, and the trailer drive power Ft is limited when the direction of the hitch load Fx is the direction in which the trailer **60** pushes the towing vehicle **20**. When the trailer drive power Ft is limited, the magnitude of reduction in the trailer drive power Ft is increased as the magnitude of the hitch load Fx is increased. Thus, the trailer drive power Ft is appropriately limited such that the trailer **60** does not push the towing vehicle **20** in the towing running state. Further, the trailer drive power Ft can be limited by the trailer **60** alone such that the trailer **60** does not push the towing vehicle **20**.

[0051] Although the embodiments of the present invention have been described in detail with reference to the drawings, the present invention is also applicable to other aspects.

[0052] For example, in the first to third embodiments described above, the strain gauge is used as an example of the load sensor **74**, but the present invention is not limited to the detail. For example, the sensor provided in the coupling portion **96** may be a sensor capable of detecting the magnitude and the direction of the hitch load Fx, and may be a load cell, a displacement sensor or the like that are different from the strain gauge. The displacement sensor calculates the magnitude and the direction of the hitch load Fx by a displacement amount, for example. In the first and second embodiments described above, the trailer drive power Ft can be limited without using the hitch load Fx which is the detection signal of the load sensor **74**, and thus the load sensor **74** may not be provided.

[0053] In the first to third embodiments, for example, an electric motor may be used as the power source of the towing vehicle **20** instead of or in addition to the engine **22**. The transmission **24** is, for example, a known planetary gear type automatic transmission, a known belt type continuously variable transmission, a known synchronous meshing type parallel two shaft automatic transmission, a known electric continuously variable transmission, a known synchronous meshing type parallel two shaft manual transmission or the like. In a case where the power source included in the towing vehicle **20** is an electric motor, the towing vehicle **20** may not include the transmission **24**.

[0054] In the first to third embodiments, when the articulated vehicle **10** turns, an assist power from the trailer **60** is applied in a direction slightly deviated from a longitudinal direction of the towing vehicle **20**, and thus the assist power may act in an unintended direction (see FIG. **2**B). Therefore, the present invention is particularly useful when the articulated vehicle **10** turns.

[0055] In the third embodiment, a way (degree) of being pulled in the towing running state may be estimated based on the trailer speed Vt with respect to the trailer drive power Ft, and the magnitude and the direction of the hitch load Fx may be estimated by the way of being pulled. In this case, the load sensor **74** may not be provided.
[0056] In the third embodiment, since the trailer **60** can limit the trailer drive power Ft by itself, the vehicle control apparatus **100** may include at least the electronic control device **80**. Further, the electronic control device **50** and the electronic control device **80** may not be connected to each other for communication with each other.
[0057] The above description is merely one embodiment, and the present invention can be implemented in a mode in which various modifications and improvements are added based on the knowledge of those skilled in the art.
NOMENCLATURE OF ELEMENTS
[0058] **20**: towing vehicle [0059] **50**: electronic control device [0060] **60**: trailer (towed vehicle) [0061] **62**: electric motor (drive power source) [0062] **74**: load sensor (sensor) [0063] **80**: electronic control device [0064] **82**: electric-motor control portion (drive control portion) [0065] **90**: coupler [0066] **100**: vehicle control apparatus (control apparatus)

Claims

1. A control apparatus comprising a processor configured to control a drive power of a towed vehicle which has a drive power source which is towed through a coupler by a towing vehicle, wherein, when the towing vehicle is running while towing the towed vehicle, the processor is configured to limit the drive power of the towed vehicle such that the towed vehicle does not push the towing vehicle through the coupler.
2. The control apparatus according to claim 1, wherein the processor is configured to calculate, based on a drive power of the towing vehicle, an upper limit value of an allowable range of the drive power of the towed vehicle in which the towed vehicle does not push the towing vehicle, and to limit the drive power of the towed vehicle by the upper limit value.
3. The control apparatus according to claim 2, wherein the allowable range of the drive power of the towed vehicle is a range in which a load applied to the coupler is less than a load value by which the towing vehicle is pushed by the towed vehicle.
4. The control apparatus according to claim 1, wherein the processor is configured to obtain a direction of a load applied to the coupler, and to limit the drive power of the towed vehicle such that the direction of the load becomes a direction in which the towed vehicle does not push the towing vehicle.
5. The control apparatus according to claim 1, wherein the processor is configured to obtain a magnitude and a direction of a load applied to the coupler, by a sensor provided in the coupler, and wherein the processor is configured, when the direction of the load is a direction in which the towed vehicle pushes the towing vehicle, to limit the drive power of the towed vehicle, and to reduce the drive power of the towed vehicle by a magnitude that is increased as the magnitude of the load applied to the coupler is increased.