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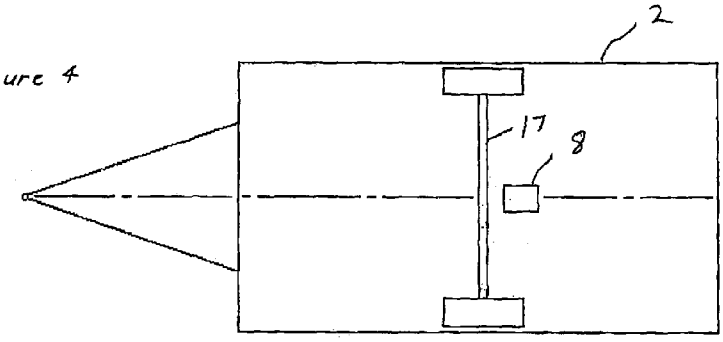
(54) **Title**: AN ELECTRIC STABILITY CONTROL SYSTEM AND DEVICE FOR CONTROLLING SWAY STABILITY OF A CARAVAN OR TRAILER AND THE LIKE.

Figure 4



(57) **Abstract**: A system for substantially minimising sway of a towed vehicle, fitted with electric brakes, hitched to a towing vehicle, the system including an electric stability control (ESC) device adapted for mounting to a portion of the towed vehicle, the ESC device being operably connected to the electric brakes by cable means, the ESC including a sway detecting means for measuring lateral acceleration of the towed vehicle; an actuator means for activating the electric brakes of the towed vehicle, the actuator means being operatively connected to the sway detecting means whereby the sway detecting means activates the actuator means to apply a voltage to the brakes for a period of time when the sway detecting means detects a predetermined lateral acceleration of the towed vehicle relative to the towing vehicle. The system can also be used for controlling dangerous sway and instability of a towed vehicle.

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Title: An electric stability control system and device for controlling sway stability of a caravan or trailer and the like.

Field of the Invention

The present invention relates to a system and device for improving stability control of a towed vehicle such as a caravan or trailer or the like being towed by a towing vehicle such as a car, truck or the like. More particularly, the present invention relates to an electric stability control device which is adapted to control dangerous and excessive swaying of a towed vehicle independent of the towing vehicle, which could otherwise lead to complete loss of control.

Background of the Invention

It is known that when a vehicle such as a caravan or camper trailer or the like is being towed by a towing vehicle such as a car or truck or the like, the towed vehicle has an inherent tendency to become unstable by swaying or fishtailing, which creates a hazardous condition for driving. The tendency of the towed vehicle to sway is initiated and amplified by uneven weight distribution and driving conditions including speed, braking, prevailing wind and rain, and even passing or being passed by other vehicles on the road.

There have been many reported accidents and roll-overs as a result of loss of control of the towing vehicle steering due to uncontrollable sway of the caravan or trailer. One way of trying to minimise swaying of a towed vehicle when towing, has been to use a friction sway control device. The sway control device includes a metal plate, on which is a small ball mount, that can be bolted onto the a frame or draw bar of a caravan or trailer. The hitch receiver can be modified by welding on a small ball mount for the other end of the sway control bar to attach. While this type of sway control device is practical for correcting minor sway of a towed vehicle by varying weight distribution when towing, further improvements or alternative means are required to address potential loss of control arising from dangerous and/or excessive sway.

National towing regulations exist in many jurisdictions now which make it mandatory for all towed vehicles such as caravans, camper trailers and the like with an aggregate trailer

mass (including load) over 750kg to have an effective braking system fitted. It is not unusual for caravans exceeding 1000kgs to be fitted with electric brakes.

In order to operate electric trailer brakes, an electric brake controller is installed in the towing vehicle. In a towing condition, power is supplied from the towing vehicle battery to the electric brake controller, and the controller is also wired to the towing vehicle's stop light circuit through the towed vehicle's plug and socket. This allows the towed vehicle's brakes to come on automatically when the towing vehicle brakes are applied so that when a towing vehicle slows down under braking, the electric brakes on the caravan can be applied in proportion to reduce the effect of the (weight of the) caravan pushing the towing vehicle.

One problem with this is that while an electric brake controller can assist to minimise the effect of a towed vehicle mass on the operation of a towing vehicle under braking conditions, there is a need to provide a system which can operate the towed vehicle's brakes independent from the towing vehicle's brakes so as to manage an unstable conditions caused by swaying of the towed vehicle.

Some electric brake controllers have included a manual over ride systems which allow a driver to manually adjust the level of power to the electric brakes. One practical problem with this however is that a driver first has to identify an unstable towing condition and then operate the controller to apply an effective braking force. This has the potential to increase instability while braking, and in practice there is usually a delay which may allow an unstable condition to worsen.

While electric brake controllers have gone some way toward addressing problems associated with proportional pushing forces exerted by a towed vehicle on a towing vehicle during braking, there still remains the practical issues of swaying and oscillation caused by road conditions such as wind, slippery road surfaces or even pressure variations when passing another vehicle, which could have catastrophic consequences.

Further, electric brake controllers are usually fitted under a dash board element of a towing vehicle so as to be within reach of a driver. A problem with electric brake controllers is that most newly manufactured vehicles now include knee airbags to protect the knees of the driver, and the location of controllers will interfere with the normal operation of the knee airbag.

It is therefore an object of the present invention to address one or more of the foregoing problems. In particular an object of the invention is to provide an alternate device or system for improving sway stability of a towed vehicle when being towed substantially independently of the towing vehicle.

Summary of the Invention

In the present invention there is disclosed a system for substantially minimising sway of a towed vehicle, fitted with electric brakes, hitched to a towing vehicle, the system including:

an electric stability control (ESC) device adapted for mounting to a portion of the towed vehicle, the ESC device being operably connected to the electric brakes by cable means, the ESC including:

a sway detecting means for measuring lateral acceleration of the towed vehicle;

an actuator means for activating the electric brakes of the towed vehicle, the actuator means being operatively connected to the sway detecting means whereby the sway detecting means activates the actuator means to apply a voltage to the brakes for a period of time when the sway detecting means detects a predetermined lateral acceleration of the towed vehicle relative to the towing vehicle;

a power source on the towing vehicle or towed vehicle interconnected to the ESC for providing power to the device;

whereby the actuator means controls the electric brakes by providing an effective predetermined voltage input to the electric brakes dependent on the extent of swaying detected and towing load so that the towed vehicle can be substantially stabilised.

The system of the invention is found to improve on road stability of a towed vehicle compared to the prior art because any critical sway detected by the sway detecting means initiates actuation of the electric brakes of the towed vehicle independent of the towing vehicle to stabilise rate of sway where braking of the towing vehicle may in fact

exacerbate sway acceleration. In particular, the system including the electric stability control device is able to detect dangerous incidents of sway and instability of the towed vehicle and by early intervention avoid a dangerous situation or preventing an accident.

The actuator means can be adapted for maintaining an effective voltage input to the electric brakes of the towed vehicle for a predetermined period after the sway detector means has determined rate of sway having returned to predetermined safe levels.

The actuator means can be configured for maintaining the effective voltage input to the electric brakes of the towed vehicle for a predetermined period after the sway detector means has determined rate of sway having returned to a predetermined safe level.

The amount of voltage output of the actuator means and the duration of braking can be varied dependent on a number of factors including the extent of lateral acceleration, i.e. high lateral acceleration will cause immediate activation of the brakes of the towed vehicle. Alternatively, if a small lateral sway is detected, the electric brakes will be activated when the extent of lateral acceleration is detected above a predetermined amount for a set number of cycles.

The actuator means can receive a signal input from the sway detecting means such that when the sway detecting means senses a predetermined lateral acceleration for about four (4) cycles, the sway detection means activates the actuator means.

When certain critical conditions of lateral acceleration are detected, the actuator means of the ESC transmits a voltage input to the electric brakes of the towed vehicle. The electric brakes are thus energised resulting in braking forces which tend to slow the towed vehicle having the effect of stopping sway movement of the towed vehicle and aligning the towing vehicle and the towed vehicle.

The ESC operates to activate the brakes in two situations. A large swerve causing high lateral acceleration of the towed vehicle activates the brakes immediately. A smaller swaying of the towed vehicle can activate the brakes if the lateral acceleration stays above a set amount for approximately 2 cycles.

In one embodiment, the actuator means is activated to apply a predetermined input voltage to the electric brakes when the sway detector means detects lateral acceleration exceeding about 0.4g, wherein the actuator means can remain in an operating mode until the lateral acceleration detected by the sway detection means is reduced to about 0.15g or less.

In a related embodiment, the actuator means is activated to apply a predetermined input voltage to the electric brakes when the sway detector means detects lateral acceleration exceeding about 0.2g for two cycles, wherein the actuator means can remain in an operating mode until the lateral acceleration detected by the sway detection means is reduced to about 0.15g or less.

The input voltage for controlling electric brakes of a towed vehicle (such as a caravan or trailer) can range between 4 to 12 volts depending on load, brake size, tyre radius and weight of towed vehicle. The actuator means can include optimal voltage input ranges for specific trailer/caravan weight as per the examples.

In a related aspect of the present invention there is disclosed an electric stability control device for controlling electric brakes of a towed vehicle so as to substantially minimise effects of lateral acceleration during a tow condition, the device including:

a sway detecting means for measuring lateral acceleration of the towed vehicle;

an actuator means connectable to the electric brakes for activating the electric brakes of the towed vehicle, the actuator means being operatively connected to the sway detecting means whereby the sway detecting means activates the actuator means when the sway detecting means detects a predetermined lateral acceleration of the towed vehicle;

wherein in an operating condition, a power source is provided to power the ESC, and the actuator means provides an effective predetermined voltage input to the electric brakes dependent on the extent of swaying detected and towing load and for a period of time effective to substantially stabilise the towed vehicle independent of the towing vehicle.

The ESC device represents a significant improvement over the prior art because an unstable amount of sway of a towed vehicle, which could otherwise lead to a catastrophic event, can be detected early and substantially minimised by supplying a predetermined

input voltage to the electric brakes for a period of time until lateral acceleration has returned to a predetermined safe level.

The actuator means can be configured for maintaining the effective voltage input to the electric brakes of the towed vehicle for a predetermined period after the sway detector means has determined rate of sway having returned to a predetermined safe level.

The actuator means is activated to apply a predetermined input voltage to the electric brakes when the sway detector means detects lateral acceleration exceeding about 0.4g, wherein the actuator means can remain in an operating mode until the lateral acceleration detected by the sway detection means is reduced to about 0.15g or less.

In a related embodiment, the actuator means is activated to apply a predetermined input voltage to the electric brakes when the sway detector means detects lateral acceleration exceeding about 0.2g for two cycles, wherein the actuator means can remain in an operating mode until the lateral acceleration detected by the sway detection means is reduced to about 0.15g or less.

In a related aspect, the present invention provides a sway control unit for a towed vehicle, the towed vehicle comprising electrically actuated brakes, the sway control unit:

being mountable to the towed vehicle;

comprising an accelerometer which is adapted to sense lateral acceleration of the towed vehicle; and

operating to apply an actuating voltage to the electrically controlled brakes when the lateral acceleration of the towed vehicle meets specified, criteria, the actuating voltage being:

where the towed vehicle is a single axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

in the range of 4 volts to 6 volts for a load between 500kg and 750kg;

in the range of 5 volts to 7 volts for a load between 750kg and 1,000kg; and

in the range of 6 volts to 8 volts for a load between 1000kg to 1250kg; and

in the range of 8 to 10 volts for a load between 1250kg and 1750kg; and

where the towed vehicle is a tandem axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

in the range of 8 volts to 10 volts for a load between 1,500kg and 2,000kg; and

in the range of 10 volts to 12 volts for a load between 2,000kg and 2,500kg; and

where the towed vehicle is a single axle vehicle with brakes substantially 12 inches in diameter and having brake pads substantially 52mm inches wide:

in the range of 6 to 8 volts for a load between 1500kg and 1750kg;

in the range of 7 to 9 volts for a load between 1750kg and 2000kg;

in the range of 8 to 10 volts for a load between 2000kg and 2250kg; and

in the range of 9 to 11 volts for a load between 2250kg and 2500kg.

It is preferred that the actuating voltage is:

where the towed vehicle is a single axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

in the range of 4.5 to 5.5 volts for a load between 500kg and 750kg;

in the range of 5.5 to 6.5 volts for a load between 750kg and 1,000kg; and

in the range of 6.5 to 7.5 volts for a load between 1000kg to 1250kg; and

in the range of 8.5 to 9.5 volts for a load between 1250kg and 1750kg; and

where the towed vehicle is a tandem axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

in the range of 8.5 to 9.5 volts for a load between 1,500kg and 2,000kg; and

in the range of 10.5 volts to 11.5 volts for a load between 2,000kg and 2,500kg;

where the towed vehicle is a single axle vehicle with brakes substantially 12 inches in diameter and having brake pads substantially 52mm inches wide:

in the range of 6.5 to 7.5 volts for a load between 1500kg and 1750kg;

in the range of 7.5 to 8.5 volts for a load between 1750kg and 2000kg;

in the range of 8.5 to 9.5 volts for a load between 2000kg and 2250kg; and

in the range of 9.5 to 10.5 volts for a load between 2250kg and 2500kg.

It is preferred that the actuating voltage is:

where the towed vehicle is a single axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

5 volts for a load between 500kg and 750kg;

6 volts for a load between 750kg and 1,000kg;

7 volts for a load between 1000kg to 1250kg;

9 volts for a load between 1250kg and 1750kg; and

where the towed vehicle is a tandem axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

9 volts for a load between 1,500kg and 2,000kg; and

11 volts for a load between 2,000kg and 2,500kg.

where the towed vehicle is a single axle vehicle with brakes substantially 12 inches in diameter and having brake pads substantially 52mm inches wide:

7 volts for a load between 1500kg and 1750kg;

8 volts for a load between 1750kg and 2000kg;

9 volts for a load between 2000kg and 2250kg; and

10 volts for a load between 2250kg and 2500kg.

Brief description of the drawings

For a better understanding of the invention, and to show how it may be carried into effect, embodiments of it are shown, by way of non-limiting example only, in the accompanying drawings. In the drawings:

figure 1 is a plan view illustrating the problem of sway of a towed vehicle;

figure 2 is standard ISO swerve and recovery track (ISO standard number 3888)

figure 3 illustrates an aspect of operation of an embodiment of the present invention;

figure 4 is a plan view, showing hidden detail, of an embodiment of the present invention;

figure 5 is a plan view, showing hidden detail, of an embodiment of the present invention;

figure 6 is a schematic representation of apparatus according to an embodiment of the present invention;

figure 7 is a graph illustrating an aspect of the operation of an embodiment of the present invention;

figures 8 and 10 are a set of graphs which summarize test and other data; and

figure 9 illustrates an aspect of operation of an embodiment of the present invention.

Description of preferred embodiments of the invention

Construction

Figure 6 illustrates apparatus according to a preferred embodiment of the present invention. In figure 6, a towing vehicle is represented at 1 and a towed vehicle is represented at 2. The towing vehicle and the towed vehicle are joined by a tow-bar which is not illustrated in the drawing.

The towing vehicle 1 comprises a battery 4, an ignition switch 6 and an electric brake controller 7. The towed vehicle 4 comprises an electric sway control (ESC) unit 8, electric brakes 9 and a LED-light 11. Power cables 12 supply power from the battery 4 to the ESC unit 8 through cables which join through a connector (which is not illustrated in the drawings) at the tow-bar. The electric brake controller 7 in the towing vehicle 1 is connected to the electric brakes 9 in the towed vehicle 2 by electric cables 13.

The ESC unit 8 comprises a circuit board mounted in a plastic box which is centrally mounted under the towed vehicle. A LED-light 11 is mounted on the drawbar and is connected by cables 14 to the ESC unit 8. An accelerometer (which is not illustrated in the drawings) is also mounted within the ESC unit 8. In the case of a single axle towed vehicle, the ESC unit 8 is mounted directly behind the axle 17 so that the accelerometer is approximately 100mm from the longitudinal axis of the axle. Figure 5 illustrates an alternative preferred form of the invention, in which the towed vehicle has tandem axles 17. In the case of such a tandem-axle towed vehicle, the ESC unit 8 is mounted so that the accelerometer is approximately equidistant between the two axles 17.

Operation

The application of the brakes of the towing vehicle 1 by the driver in the normal course of driving operates the electric brake controller 7, which in turn operates to energize the electric brakes 9 on the towed vehicle 2.

The ESC unit 8 uses the output of the accelerometer to constantly measure the lateral (that is, side-to-side) acceleration of the towed vehicle 2 at a frequency of 100Hz. When certain critical conditions (described below) of lateral acceleration are detected, the ESC unit 8 energizes the electric brakes 9 of the towed vehicle. As is illustrated in figure 3, the energization of the brakes 9 result in braking forces 18 which tend to slow the towed vehicle 2 independently of the towing vehicle 1. As is illustrated in figure 9, this braking of the towed vehicle 2, independently of the towing vehicle 1, has the effect of stopping sway movement of the towed vehicle 2 and aligning the towing vehicle and the towed vehicle. The ESC unit 8 operates automatically to operate the brakes 9 enough to provide firm braking without skidding. The brakes are applied until the ESC unit 8 detects that the sway is no longer critical.

The ESC unit 8 operates to activate the brakes 9 in two types of situation. A large swerve causing high lateral acceleration of the towed vehicle 2 will cause the ESC unit 8 to activate the brakes 9 immediately. A smaller swaying of the towed vehicle 2 will cause the ESC unit 8 to activate the brakes 9 if the lateral acceleration stays above a set amount for approximately 4 cycles. In both situations the ESC unit 8 continues to apply the brakes of the towed vehicle and holds them on for a short period after the lateral acceleration has returned to a safe level. When ESC unit 8 activates, the driver will feel the vehicle being slowed down by the soft braking of the towed vehicle.

As is illustrated in figure 7, when lateral acceleration 19 exceeds about 0.4g then braking force 21 is applied by the brakes 9 under control of the ESC unit 8 until lateral acceleration reduces to 0.15g or less.

Braking force 21 is also applied by the brakes 9 under the control of the ESC unit where lateral acceleration exceeds 0.2g for 2 cycles, and the brakes 9 are held on until lateral acceleration reduces to 0.15g or less.

The LED light provides feedback of the current status of the ESC unit 8 and warns of any errors that may have occurred.

LED Display	Condition	What to Do
Green	Active	
Green Flashing	Active Self start up test incomplete	Drive forward so that the ESC unit detects movement, the start up test should complete and the light will change to constant green.
Red	Inactive	Check the connectors and reconnect. If the light remains red the number of errors detected has exceeded the allowable number set. The caravan is safe to tow but the ESC unit is inactive and should be analysed using the software and reset.
Red Flashing	Fault detected	Check the connectors and reconnect. If LED continues to flash red, disconnect the ESC unit before driving. The ESC unit requires analysis and repair.
LED not working	No power or LED faulty	Check the power supply, connectors and reconnect. Replace LED if required.

Calibration with 10-inch brakes

Testing was carried out on a standard ISO swerve and recovery track such as is illustrated in figure 2. In this testing, the towed vehicles were caravans of various weight, suspension type and wheel size. The purpose of this testing was to determine the suitable input voltage to the brakes 9 over a representative complete range of caravans. This testing was also conducted on a wet surface to ensure that the settings would be suitable in all conditions for each weight range.

ESC units 8 were fitted to two single axle caravans and a tandem axle caravan then swerve tested at various loads to determine the acceptable voltage setting for each weight. The caravans were loaded to the weight required then tested for a range of voltage settings. Single axle caravans were tested from 1000kg to 1750kg in 250kg steps. The tandem axle caravan was tested from 1600kg to 2500kg.

After initial trials it was determined that the vehicle speed did not dramatically affect the response or effectiveness of the ESC unit 8. The tow vehicle and caravan entered the course at 80km/hr for each test. After the dry track testing had been completed, the tests were repeated on a wet surface. The track was watered down and remained wet from soaker hoses which were left running along the side of the test track.

The tandem axle caravan was towed by a Mitsubishi Pajero 4WD. A 960kg single axle caravan was towed by a Mercedes 380 sedan. A 1750kg single axle caravan was towed by both a Holden Commodore sedan and a Mitsubishi Pajero.

Each caravan was fitted with new tyres which were inflated to the pressure recommended by the manufacturer for the load and with new 10-inch electric brakes. (That is, the brakes were 10-inch diameter and had brake pads of 2.25 inches wide.) The caravans were loaded with sandbags to achieve the required weight for each test. Care was taken to locate the weight from the sandbags centrally over the axles.

The location of the ESC unit 8 when mounted to the underside of a caravan/trailer was also tested and evaluated.

Figure 8 summarizes the results of testing, and also illustrates extrapolation of the test data.

The graph 22 illustrates the performance of a single axle caravan in dry conditions and the graph 23 illustrates the performance of a single axle caravan in wet conditions. From this observed performance, it is concluded that for a single axle towed vehicle, of a weight from 1250kg to 1750kg,, in either dry or wet conditions, a 9-volt input to the electric brakes would be selected for commercial products. It is similarly concluded that for a single axle towed vehicle, of a weight from 1000kg to 1250kg,, in either dry or wet conditions, a 7-volt input to the electric brakes would be selected for commercial products. From these conclusions, it is extrapolated that, in wet or dry conditions, the following voltage settings could be used for a single axle vehicle:

in the range of 4 volts to 6 volts for a load between 500kg and 750kg;
in the range of 5 volts to 7volts for a load between 750kg and 1,000kg;
in the range of 6 volts to 8 volts for a load between 1000kg to 1250kg; and
in the range of 8 to 10 volts for a load between 1250kg and 1750kg.

The graph 24 illustrates performance of a tandem axle caravan in dry conditions and the graph 26 illustrates the performance of a tandem axle caravan in wet conditions. (The figures relating to weights in the range 1,600kg to 2,500kg were determined by trial, the figures for weights from 1,500kg to 1,600kg were determined by extrapolation.) It is

concluded that, for a tandem axle towed load, in wet or dry conditions, the following voltage settings could be used:

in the range of 8 volts to 10 volts for a load between 1,500kg and 2,000kg; and

in the range of 10 volts to 12 volts for a load between 2,000kg and 2,500kg.

Calibration with 12-inch brakes

Testing was similarly carried out on single axle caravans which were fitted with 12-inch brakes. (That is, the brakes were 12-inch in diameter and had brake pades of 52mm wide.) The results of the testing are illustrated in figure 9. From that testing, it is extrapolated that, in wet or dry conditions, the following voltage settings could be used:

in the range of 6 to 8 volts for a load between 1500kg and 1750kg;

in the range of 7 to 9 volts for a load between 1750kg and 2000kg;

in the range of 8 to 10 volts for a load between 2000kg and 2250kg; and

in the range of 9 to 11 volts for a load between 2250kg and 2500kg

While the present invention has been described with reference to a few specific embodiments, the description is illustrative of the invention and is not to be construed as limiting the invention. Various modifications may occur to those skilled in the art without departing from the true spirit and scope of the invention as defined by the appended claims.

Throughout this specification, the words "comprise", "comprising", and "comprises" are to be taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

In the claims, each dependent claim is to be read as being within the scope of its parent claim or claims, in the sense that a dependent claim is not to be interpreted as infringed unless its parent claims are also infringed.

The claims defining the invention are as follows:

1. A system for substantially stabilising dangerous and excessive sway of a towed vehicle, fitted with electric brakes, hitched to a towing vehicle, the system including:

an electric stability control (ESC) device adapted for mounting to a portion of the towed vehicle, the ESC device being operably connected to the electric brakes by cable means, the ESC including:

a sway detecting means for measuring lateral acceleration of the towed vehicle;

an actuator means for activating the electric brakes of the towed vehicle, the actuator means being operatively connected to the sway detecting means whereby the sway detecting means activates the actuator means to apply a voltage to the brakes for a period of time when the sway detecting means detects a predetermined lateral acceleration of the towed vehicle relative to the towing vehicle;

a power source on the towing vehicle or towed vehicle interconnected to the ESC for providing power to the device;

whereby the actuator means controls the electric brakes by providing an effective predetermined voltage input to the electric brakes dependent on the extent of swaying detected and towing load so that the towed vehicle can be substantially stabilised.

2. A system for substantially minimising sway of a towed vehicle wherein the actuator means is adapted for maintaining an effective voltage input to the electric brakes of the towed vehicle for a predetermined period after the sway detector means has determined rate of sway having returned to predetermined safe levels.

3. A system for substantially minimising sway of a towed vehicle wherein the actuator means can be configured for maintaining the effective voltage input to the electric brakes of the towed vehicle for a predetermined period after the sway detector means has determined rate of sway having returned to a predetermined safe level.

4. A system for substantially minimising sway of a towed vehicle wherein the amount of voltage output of the actuator means and the duration of braking can be varied

dependent on a number of factors including the extent of lateral acceleration, i.e. high lateral acceleration will cause immediate activation of the brakes of the towed vehicle. Alternatively, if a small lateral sway is detected, the electric brakes will be activated when the extent of lateral acceleration is detected above a predetermined amount for a set number of cycles.

5. A system for substantially minimising sway of a towed vehicle wherein the actuator means can receive a signal input from the sway detecting means such that when the sway detecting means senses a predetermined lateral acceleration for about two (2) cycles, the sway detection means activates the actuator means.

6. A system for substantially minimising sway of a towed vehicle wherein the actuator means is activated to apply a predetermined input voltage to the electric brakes when the sway detector means detects lateral acceleration exceeding about 0.4g, wherein the actuator means can remain in an operating mode until the lateral acceleration detected by the sway detection means is reduced to about 0.15g or less.

7. A system for substantially minimising sway of a towed vehicle wherein the actuator means is activated to apply a predetermined input voltage to the electric brakes when the sway detector means detects lateral acceleration exceeding about 0.2g for two cycles, wherein the actuator means can remain in an operating mode until the lateral acceleration detected by the sway detection means is reduced to about 0.15g or less.

8. A system for substantially minimising sway of a towed vehicle wherein the input voltage for controlling electric brakes of a towed vehicle (such as a caravan or trailer) can range between 4 to 12 volts depending on load, brake size, tyre radius and weight of towed vehicle. The actuator means can include optimal voltage input ranges for specific trailer/caravan weight as per the examples.

9. An electric stability control device for controlling electric brakes of a towed vehicle so as to substantially minimise effects of lateral acceleration during as tow condition, the device including:

a sway detecting means for measuring lateral acceleration of the towed vehicle;

an actuator means connectable to the electric brakes for activating the electric brakes of the towed vehicle, the actuator means being operatively connected to the sway detecting means whereby the sway detecting means activates the actuator means when the sway detecting means detects a predetermined lateral acceleration of the towed vehicle;

wherein in an operating condition, a power source is provided to power the ESC, and the actuator means provides an effective predetermined voltage input to the electric brakes dependent on the extent of swaying detected and towing load and for a period of time effective to substantially stabilise the towed vehicle independent of the towing vehicle.

10. An electric stability control device for controlling electric brakes of a towed vehicle in accordance with claim 9 wherein the actuator means can be configured for maintaining the effective voltage input to the electric brakes of the towed vehicle for a predetermined period after the sway detector means has determined rate of sway having returned to a predetermined safe level.

11. An electric stability control device for controlling electric brakes of a towed vehicle in accordance with claim 9 wherein the actuator means is activated to apply a predetermined input voltage to the electric brakes when the sway detector means detects lateral acceleration exceeding about 0.4g, wherein the actuator means can remain in an operating mode until the lateral acceleration detected by the sway detection means is reduced to about 0.15g or less.

12. An electric stability control device for controlling electric brakes of a towed vehicle in accordance with claim 9 wherein the actuator means is activated to apply a predetermined input voltage to the electric brakes when the sway detector means detects lateral acceleration exceeding about 0.2g for two cycles, wherein the actuator means can remain in an operating mode until the lateral acceleration detected by the sway detection means is reduced to about 0.15g or less.

13. A sway control unit for a towed vehicle, the towed vehicle comprising electrically actuated brakes, the electronic sway control unit:

being mountable to the towed vehicle;

comprising an accelerometer which is adapted to sense lateral acceleration of the towed vehicle; and

operating to apply an actuating voltage to the electrically controlled brakes when the lateral acceleration of the towed vehicle meets specified, criteria, the actuating voltage being:

where the towed vehicle is a single axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

in the range of 4 volts to 6 volts for a load between 500kg and 750kg;

in the range of 5 volts to 7 volts for a load between 750kg and 1,000kg; and

in the range of 6 volts to 8 volts for a load between 1000kg to 1250kg; and

in the range of 8 to 10 volts for a load between 1250kg and 1750kg; and

where the towed vehicle is a tandem axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

in the range of 8 volts to 10 volts for a load between 1,500kg and 2,000kg; and

in the range of 10 volts to 12 volts for a load between 2,000kg and 2,500kg; and

where the towed vehicle is a single axle vehicle with brakes substantially 12 inches in diameter and having brake pads substantially 52mm inches wide:

in the range of 6 to 8 volts for a load between 1500kg and 1750kg;

in the range of 7 to 9 volts for a load between 1750kg and 2000kg;

in the range of 8 to 10 volts for a load between 2000kg and 2250kg; and

in the range of 9 to 11 volts for a load between 2250kg and 2500kg.

14. A sway control unit for a towed vehicle as claimed in claim 13, the actuating voltage being:

where the towed vehicle is a single axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

in the range of 4.5 to 5.5 volts for a load between 500kg and 750kg;

in the range of 5.5 to 6.5 volts for a load between 750kg and 1,000kg; and

in the range of 6.5 to 7.5 volts for a load between 1000kg to 1250kg; and

in the range of 8.5 to 9.5 volts for a load between 1250kg and 1750kg; and

where the towed vehicle is a tandem axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

in the range of 8.5 to 9.5 volts for a load between 1,500kg and 2,000kg; and

in the range of 10.5 volts to 11.5 volts for a load between 2,000kg and 2,500kg; and

where the towed vehicle is a single axle vehicle with brakes substantially 12 inches in diameter and having brake pads substantially 52mm inches wide:

in the range of 6.5 to 7.5 volts for a load between 1500kg and 1750kg;

in the range of 7.5 to 8.5 volts for a load between 1750kg and 2000kg;

in the range of 8.5 to 9.5 volts for a load between 2000kg and 2250kg; and

in the range of 9.5 to 10.5 volts for a load between 2250kg and 2500kg.

15. A sway control unit for a towed vehicle as claimed in claim 14, the actuating voltage being:

where the towed vehicle is a single axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

5 volts for a load between 500kg and 750kg;

6 volts for a load between 750kg and 1,000kg;

7 volts for a load between 1000kg to 1250kg;and

9 volts for a load between 1250kg and 1750kg; and

where the towed vehicle is a tandem axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

9 volts for a load between 1,500kg and 2,000kg; and

11 volts for a load between 2,000kg and 2,500kg; and

where the towed vehicle is a single axle vehicle with brakes substantially 12 inches in diameter and having brake pads substantially 52mm inches wide:

7 volts for a load between 1500kg and 1750kg;

8 volts for a load between 1750kg and 2000kg;

9 volts for a load between 2000kg and 2250kg; and

10 volts for a load between 2250kg and 2500kg.

16. An sway control unit for a towed vehicle as claimed in any one of the preceding claims, substantially as described with reference to the drawings.

AMENDED CLAIMS
received by the International Bureau on 02 August 2012 (02.08.2012)

The claims defining the invention are as follows:

1. A system for substantially stabilising dangerous and excessive sway of a towed vehicle, fitted with electric brakes, hitched to a towing vehicle, the system including:

an electric stability control (ESC) device adapted for mounting to a portion of the towed vehicle, the ESC device being operably connected to the electric brakes by cable means, the ESC including:

a sway detecting means for measuring lateral acceleration of the towed vehicle;

an actuator means for activating the electric brakes of the towed vehicle, the actuator means being operatively connected to the sway detecting means whereby the sway detecting means activates the actuator means to apply a voltage to the brakes for a period of time when the sway detecting means detects a predetermined lateral acceleration of the towed vehicle relative to the towing vehicle;

a power source on the towing vehicle or towed vehicle interconnected to the ESC for providing power to the device;

whereby the actuator means controls the electric brakes by providing an effective predetermined voltage input to the electric brakes dependent on the extent of swaying detected and towing load so that the towed vehicle can be substantially stabilised.

2. A system for substantially minimising sway of a towed vehicle according to claim 1 wherein the actuator means is adapted for maintaining an effective voltage input to the electric brakes of the towed vehicle for a predetermined period after the sway detector means has determined rate of sway having returned to predetermined safe levels.

3. A system for substantially minimising sway of a towed vehicle according to claim 1 wherein the actuator means is configured for maintaining the effective voltage input to the electric brakes of the towed vehicle for a predetermined period after the sway detector means has determined rate of sway having returned to a predetermined safe level.

4. A system for substantially minimising sway of a towed vehicle according to claim 1 wherein the amount of voltage output of the actuator means and the duration of braking

is varied dependent on a number of factors including the extent of lateral acceleration, whereby a high lateral acceleration will cause immediate activation of the brakes of the towed vehicle, and whereby when a small lateral sway is detected, the electric brakes will be activated when the extent of lateral acceleration is detected above a predetermined amount for a set number of cycles.

5. A system for substantially minimising sway of a towed vehicle according to claim 1 wherein the actuator means ~~can~~ receives a signal input from the sway detecting means such that when the sway detecting means senses a predetermined lateral acceleration for about two (2) cycles, the sway detection means activates the actuator means.

6. A system for substantially minimising sway of a towed vehicle according to claim 1 wherein the actuator means is activated to apply a predetermined input voltage to the electric brakes when the sway detector means detects lateral acceleration exceeding about 0.4g, wherein the actuator means can remain in an operating mode until the lateral acceleration detected by the sway detection means is reduced to about 0.15g or less.

7. A system for substantially minimising sway of a towed vehicle according to claim 1 wherein the actuator means is activated to apply a predetermined input voltage to the electric brakes when the sway detector means detects lateral acceleration exceeding about 0.2g for two cycles, wherein the actuator means can remain in an operating mode until the lateral acceleration detected by the sway detection means is reduced to about 0.15g or less.

8. A system for substantially minimising sway of a towed vehicle according to claim 1 wherein the input voltage for controlling electric brakes of a towed vehicle (such as a caravan or trailer) ranges between 4 to 12 volts depending on load, brake size, tyre radius and weight of towed vehicle.

9. An electric stability control device for controlling electric brakes of a towed vehicle so as to substantially minimise effects of lateral acceleration during as tow condition, the device including:

a sway detecting means for measuring lateral acceleration of the towed vehicle;

an actuator means connectable to the electric brakes for activating the electric brakes of the towed vehicle, the actuator means being operatively connected to the sway

detecting means whereby the sway detecting means activates the actuator means when the sway detecting means detects a predetermined lateral acceleration of the towed vehicle;

wherein in an operating condition, a power source is provided to power the ESC, and the actuator means provides an effective predetermined voltage input to the electric brakes dependent on the extent of swaying detected and towing load and for a period of time effective to substantially stabilise the towed vehicle independent of the towing vehicle.

10. An electric stability control device for controlling electric brakes of a towed vehicle in accordance with claim 9 wherein the actuator means can be configured for maintaining the effective voltage input to the electric brakes of the towed vehicle for a predetermined period after the sway detector means has determined rate of sway having returned to a predetermined safe level.

11. An electric stability control device for controlling electric brakes of a towed vehicle in accordance with claim 9 wherein the actuator means is activated to apply a predetermined input voltage to the electric brakes when the sway detector means detects lateral acceleration exceeding about 0.4g, wherein the actuator means can remain in an operating mode until the lateral acceleration detected by the sway detection means is reduced to about 0.15g or less.

12. An electric stability control device for controlling electric brakes of a towed vehicle in accordance with claim 9 wherein the actuator means is activated to apply a predetermined input voltage to the electric brakes when the sway detector means detects lateral acceleration exceeding about 0.2g for two cycles, wherein the actuator means can remain in an operating mode until the lateral acceleration detected by the sway detection means is reduced to about 0.15g or less.

13. A sway control unit for a towed vehicle, the towed vehicle comprising electrically actuated brakes, the electronic sway control unit:

being mountable to the towed vehicle;

comprising an accelerometer which is adapted to sense lateral acceleration of the towed vehicle; and

operating to apply an actuating voltage to the electrically controlled brakes when the lateral acceleration of the towed vehicle meets specified, criteria, the actuating voltage being:

where the towed vehicle is a single axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

in the range of 4 volts to 6 volts for a load between 500kg and 750kg;

in the range of 5 volts to 7 volts for a load between 750kg and 1,000kg; and

in the range of 6 volts to 8 volts for a load between 1000kg to 1250kg; and

in the range of 8 to 10 volts for a load between 1250kg and 1750kg; and

where the towed vehicle is a tandem axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

in the range of 8 volts to 10 volts for a load between 1,500kg and 2,000kg; and

in the range of 10 volts to 12 volts for a load between 2,000kg and 2,500kg; and

where the towed vehicle is a single axle vehicle with brakes substantially 12 inches in diameter and having brake pads substantially 52mm inches wide:

in the range of 6 to 8 volts for a load between 1500kg and 1750kg;

in the range of 7 to 9 volts for a load between 1750kg and 2000kg;

in the range of 8 to 10 volts for a load between 2000kg and 2250kg; and

in the range of 9 to 11 volts for a load between 2250kg and 2500kg.

14. A sway control unit for a towed vehicle as claimed in claim 13, the actuating voltage being:

where the towed vehicle is a single axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

in the range of 4.5 to 5.5 volts for a load between 500kg and 750kg;

in the range of 5.5 to 6.5 volts for a load between 750kg and 1,000kg; and

in the range of 6.5 to 7.5 volts for a load between 1000kg to 1250kg; and

in the range of 8.5 to 9.5 volts for a load between 1250kg and 1750kg; and

where the towed vehicle is a tandem axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

in the range of 8.5 to 9.5 volts for a load between 1,500kg and 2,000kg; and

in the range of 10.5 volts to 11.5 volts for a load between 2,000kg and 2,500kg; and

where the towed vehicle is a single axle vehicle with brakes substantially 12 inches in diameter and having brake pads substantially 52mm inches wide:

in the range of 6.5 to 7.5 volts for a load between 1500kg and 1750kg;

in the range of 7.5 to 8.5 volts for a load between 1750kg and 2000kg;

in the range of 8.5 to 9.5 volts for a load between 2000kg and 2250kg; and

in the range of 9.5 to 10.5 volts for a load between 2250kg and 2500kg.

15. A sway control unit for a towed vehicle as claimed in claim 14, the actuating voltage being:

where the towed vehicle is a single axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

5 volts for a load between 500kg and 750kg;

6 volts for a load between 750kg and 1,000kg;

7 volts for a load between 1000kg to 1250kg;and

9 volts for a load between 1250kg and 1750kg; and

where the towed vehicle is a tandem axle vehicle with brakes substantially 10 inches in diameter and having brake pads substantially 2.25 inches wide:

9 volts for a load between 1,500kg and 2,000kg; and

11 volts for a load between 2,000kg and 2,500kg; and

where the towed vehicle is a single axle vehicle with brakes substantially 12 inches in diameter and having brake pads substantially 52mm inches wide:

7 volts for a load between 1500kg and 1750kg;

8 volts for a load between 1750kg and 2000kg;

9 volts for a load between 2000kg and 2250kg; and

10 volts for a load between 2250kg and 2500kg.

16. An sway control unit for a towed vehicle as claimed in any one of the preceding claims, substantially as described with reference to the drawings.

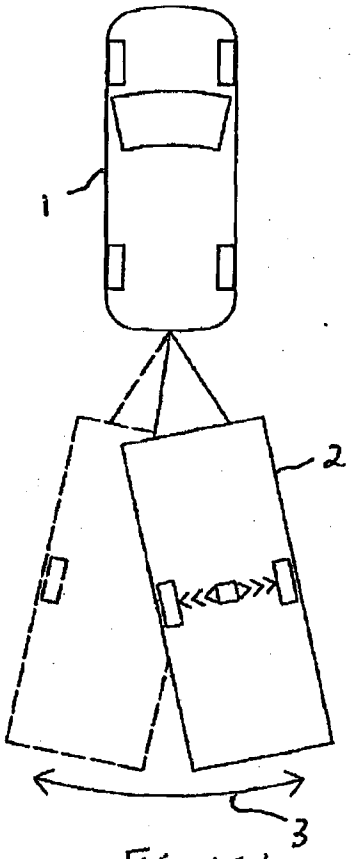

FIGURE 1

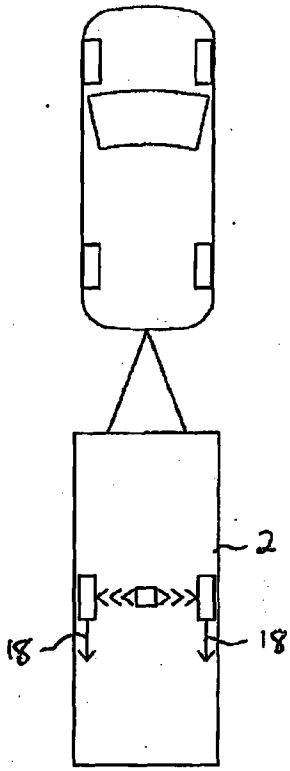

FIGURE 3

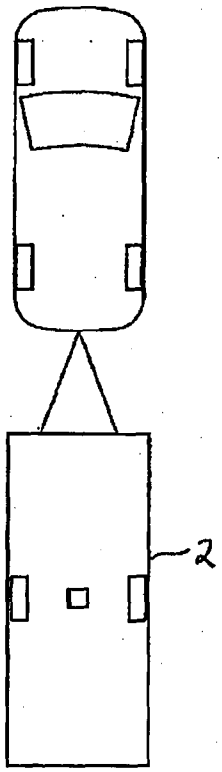

FIGURE 9

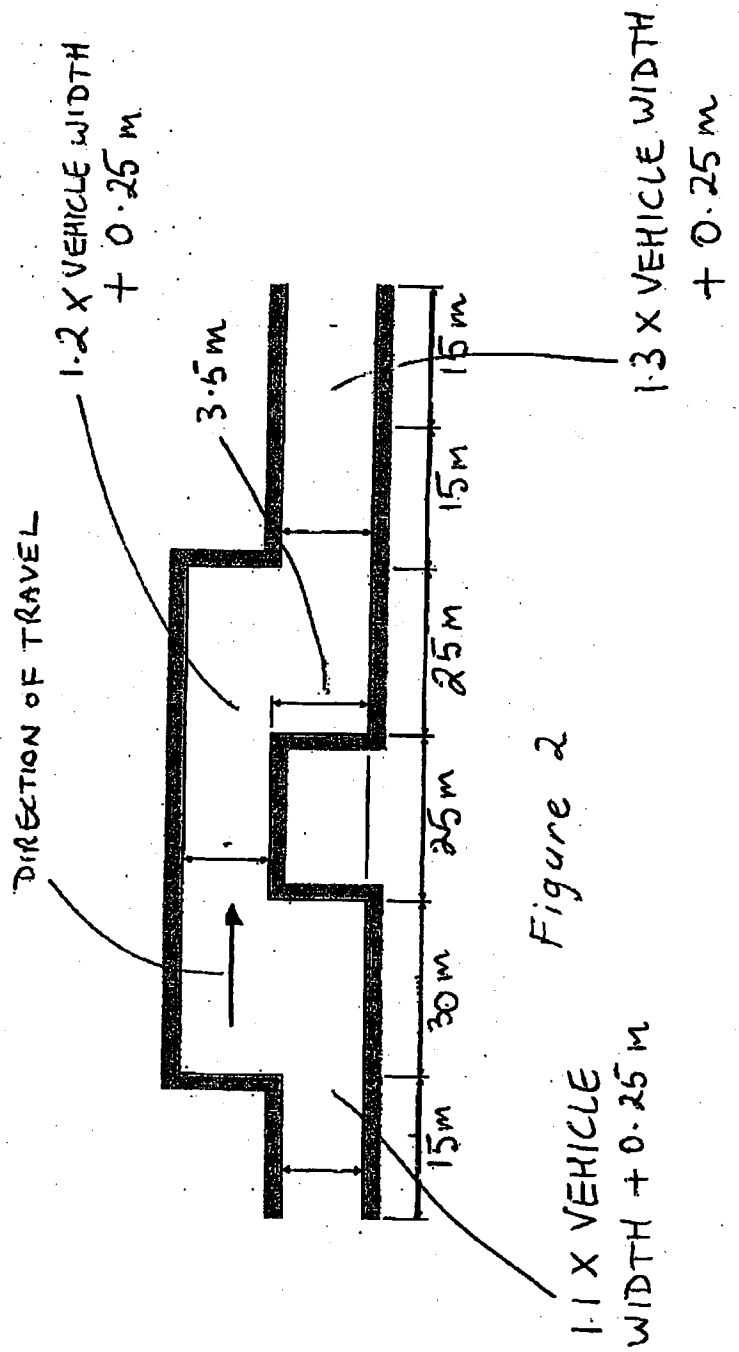
1.2 X VEHICLE WIDTH + 0.25 m
3.5 m
DIRECTION OF TRAVEL
1.3 X VEHICLE WIDTH + 0.25 m
15m
15m
25m
25m
30m
15m
1.1 X VEHICLE WIDTH + 0.25 m

Figure 2

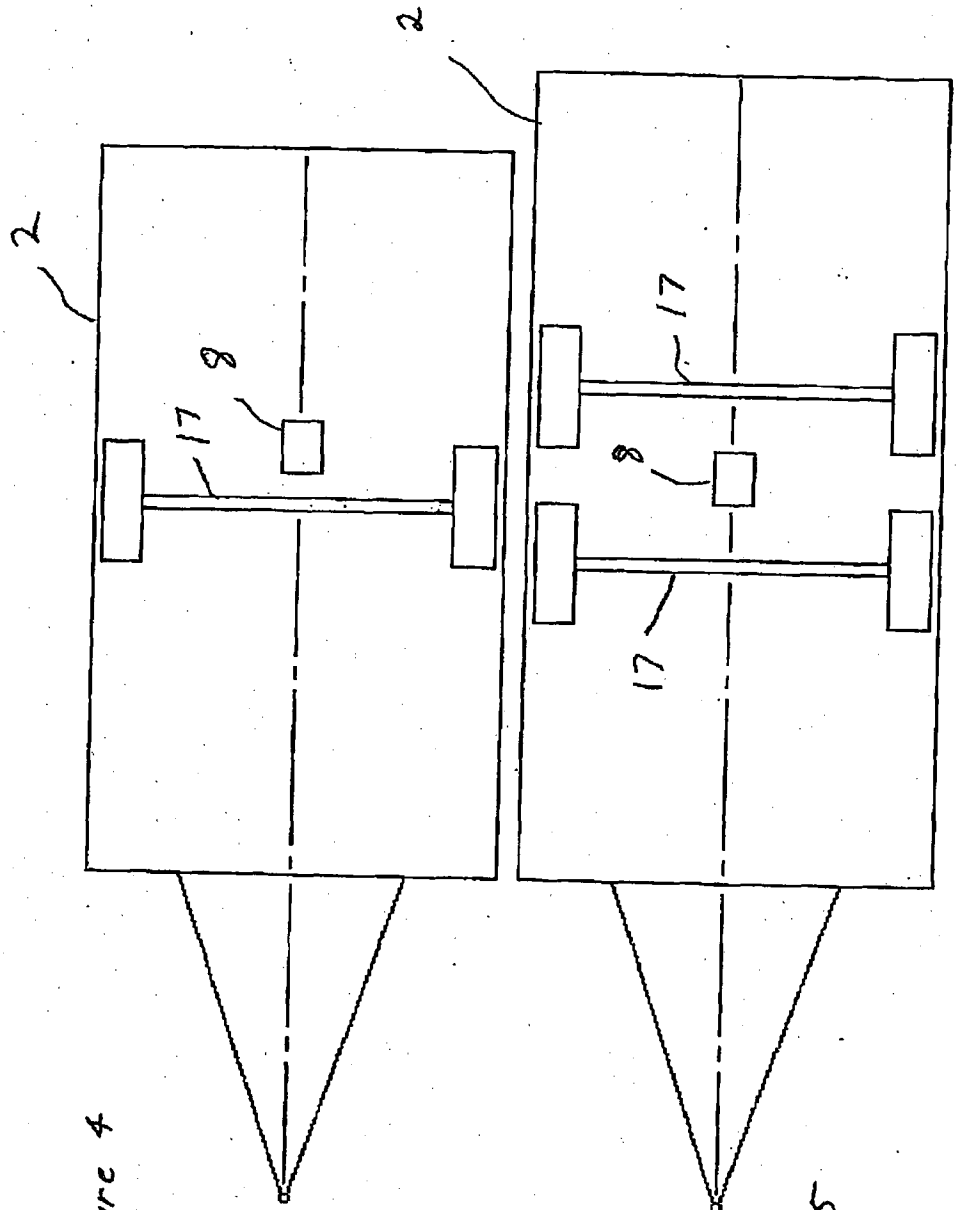

Figure 4

Figure 5

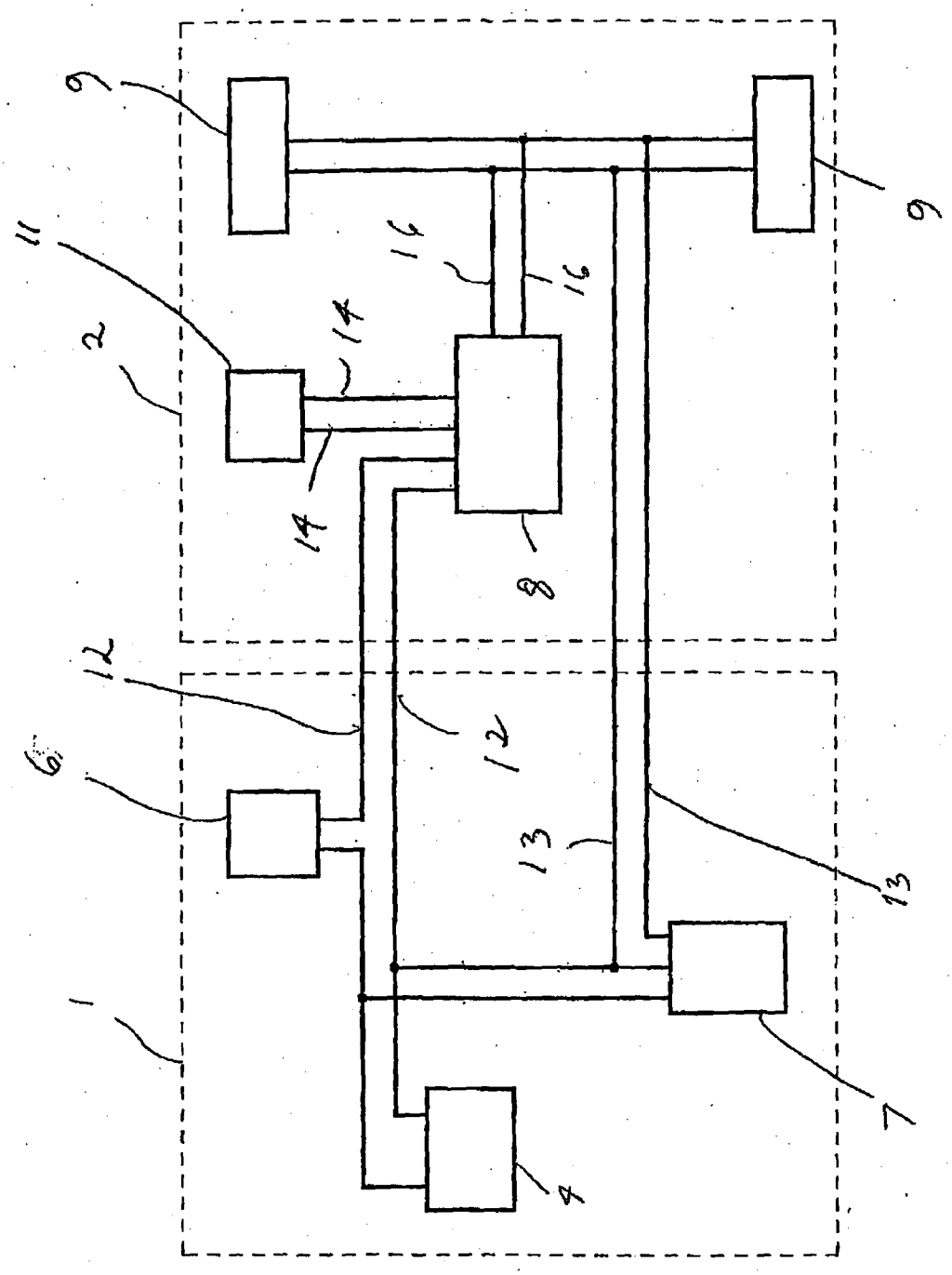

Figure 6

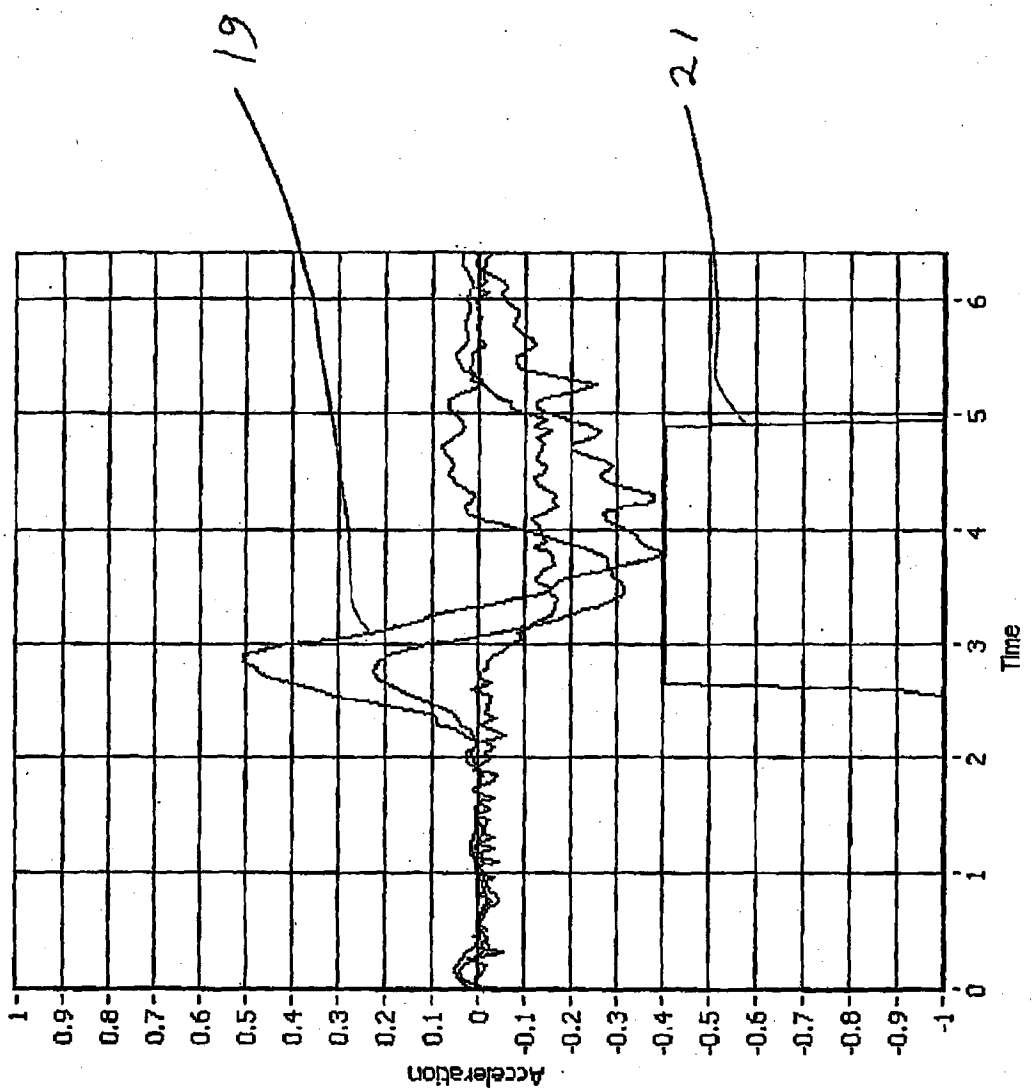
19
21
Acceleration
Time
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
0
1
2
3
4
5
6

Figure 7

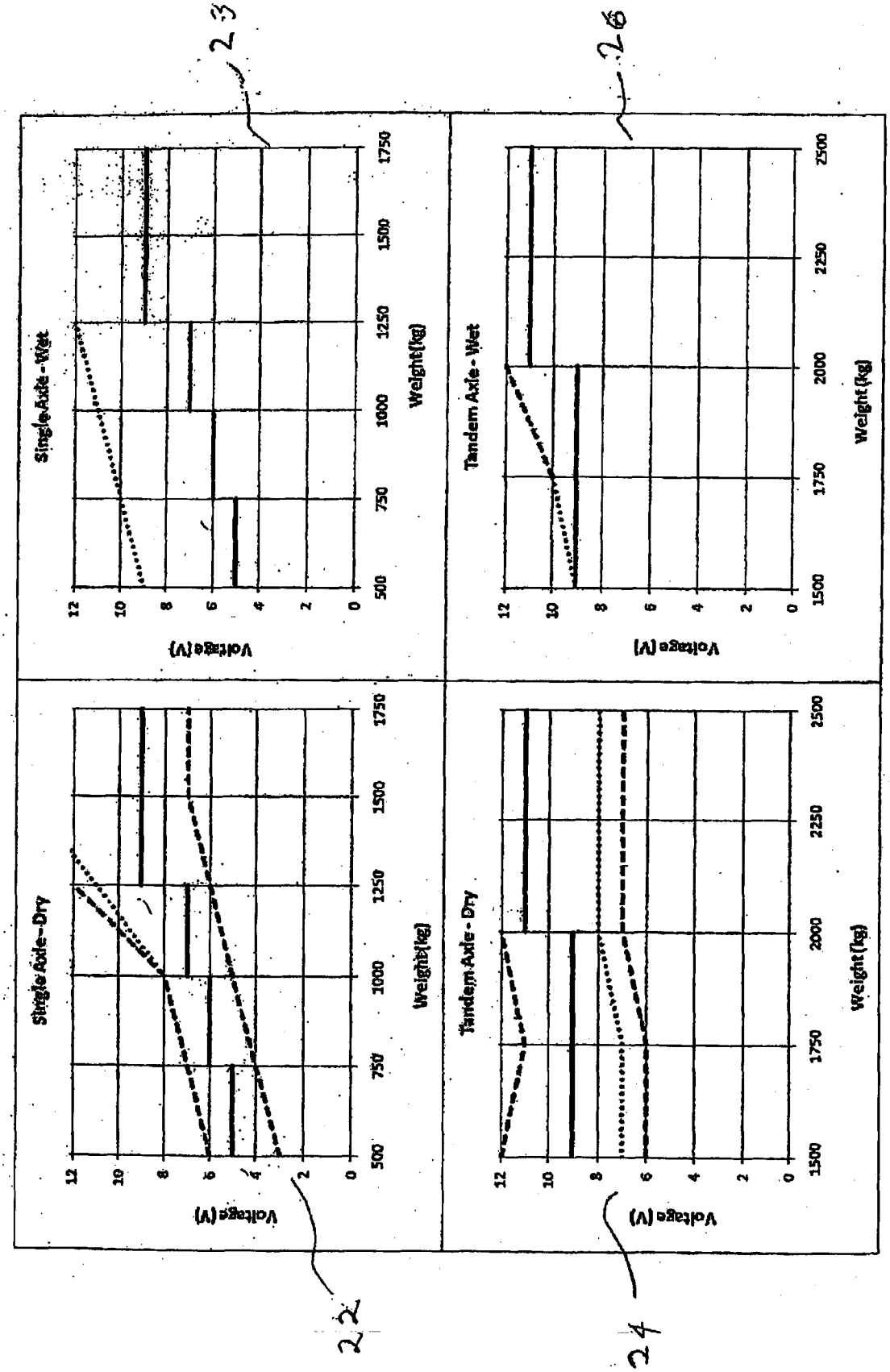
Single Axle - Dry
Single Axle - Wet
Tandem Axle - Dry
Tandem Axle - Wet
Voltage (V)
Weight (kg)
22
23
24
26
EBS Setting Compromise Brake Input Voltage
Reduced Performance
Maximum / Minimum

Figure 8

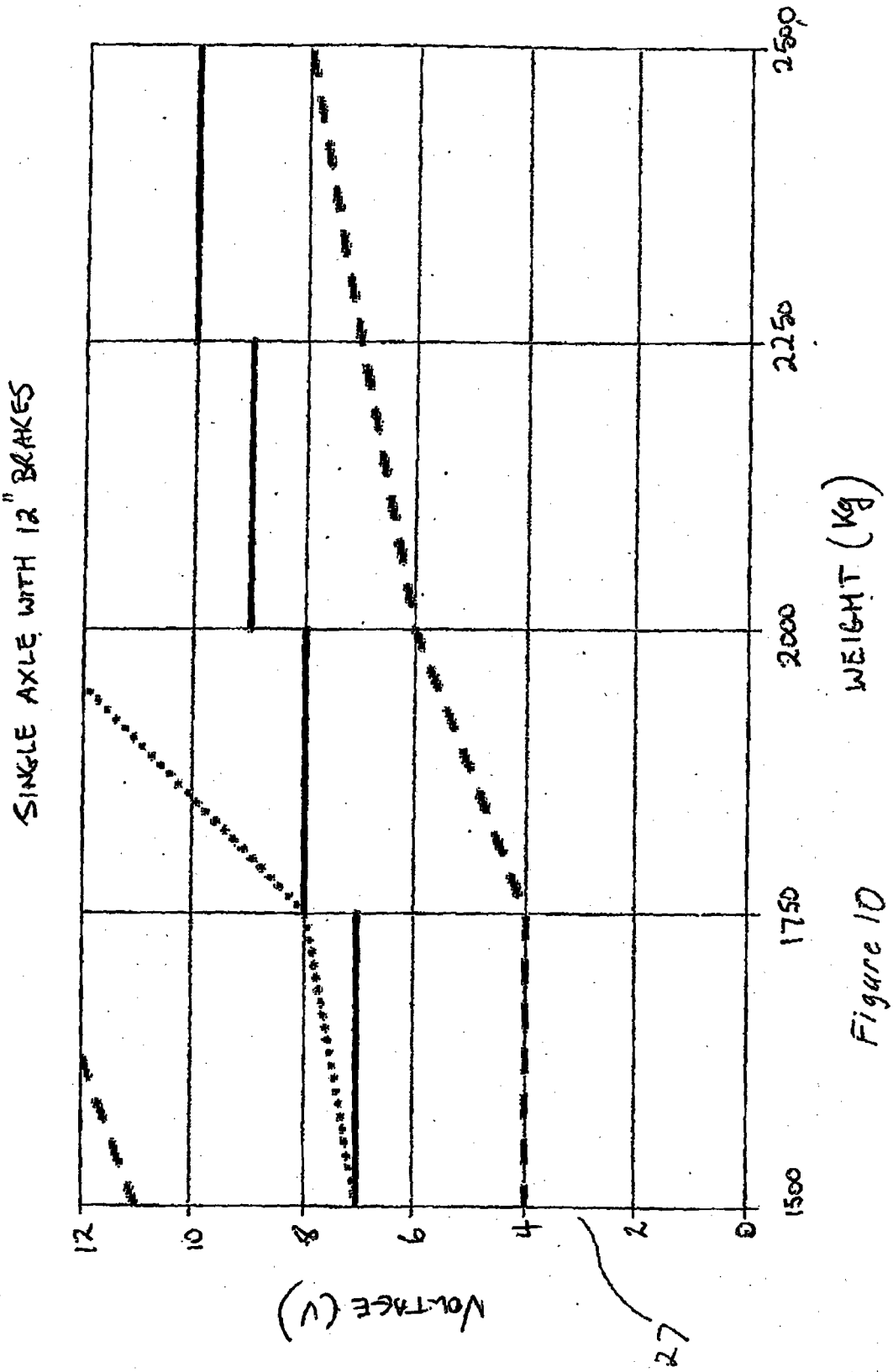
SINGLE AXLE WITH 12" BRAKES
Voltage (V)
12
10
8
6
4
2
0
1500
1750
2000
2250
2500
WEIGHT (Kg)
27

Figure 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2012/000239

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

B60T 7/20 (2006.01)	***B60T 8/1755*** (2006.01)	***B62D 65/12*** (2006.01)
B60D 1/30 (2006.01)	***B62D 59/02*** (2006.01)	***B62D 105/00*** (2006.01)
B60T 7/12 (2006.01)	***B62D 63/08*** (2006.01)	***B62D 111/00*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

1. WPI, EPODOC: IPC, ECLA B60T 7/20, B60T 7/12, B60T 13/74, B60T 8/1755, B60D 1/30, B62D 111/00, B62D 105/00, B62D 59/02, B62D 63/08, B62D 65/12 and keywords (trailer, electrical, electro-mechanical, electro-magnetic, brake, sway, control) and like terms
2. WPI, EPODOC: Keywords (electrical, brake, stability, trailer, sway) and like terms
3. WPI, EPODOC: Keywords (trailer, electrical, sway, sensor, control) and like terms
4. USPTO & ESPACENET: (Keywords (trailer, sway, brake, electrical) and like terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	US 4040507 A (REISE) 9 August 1977	
X	Figures 1-8; column 2, lines 52-53; column 2, line 63- column 3, line 7	2, 3, 6, 7
Y	column 2, lines 52-53; column 2, line 63- column 3, line 7	5, 10, 13-15
	US 3758165 A (SAVELLI) 11 September 1973	
X	Figures 1, 2; column 4, lines 58-63; column 1, lines 42-44; column 5, lines 4-14	1, 4, 6, 7, 9, 11, 12
Y	Figures 1, 2	5, 10, 13-15

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 May 2012	25 May 2012

Name and mailing address of the ISA/AU

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2012/000239

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: **8, 16**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
The claims do not comply with Rule 6.2(a) because they rely on references to the description and/or drawings.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2012/000239

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2007/0260385 A1 (TANDY, JR. et al.) 8 November 2007 Paragraph [0042]	5, 13-15
A	US 3948544 A (PRESLEY et al.) 6 April 1976 Whole document	
A	DE 10215617 A1 (CONTINENTAL TEVES & CO OHG AG) 20 November 2003. English abstract retrieved from EPODOC	
A	GB 1514965 A (MOTOR WHEEL CORPORATION) 21 June 1978 Whole document	
	For Y indications: For claim 10, US 4040507 and US 3758165 are combined. For claims 5, 13-15, US 4040507 or US 3758165 is combined with US 2007/0260385	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2012/000239

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	4040507	NONE					
US	3758165	NONE					
US	2007260385	US	7798263				
US	3948544	AR	207495	ES	445480	JP	51108419
DE	10215617	NONE					
GB	1514965	CA	1047625	DE	2522878	FR	2271963
		JP	51002124				

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX