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(54) Title: VEHICLE WINCH CONTROL SYSTEM AND METHOD OF CONTROLLING A WINCH

(57) Abstract: Embodiments of the
present invention provide a winch control
system for a vehicle operable in use
to control a winch having an electric
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one selected from a substantially con-
stant prescribed winch line tension and a
substantially constant prescribed winch
drum torque.

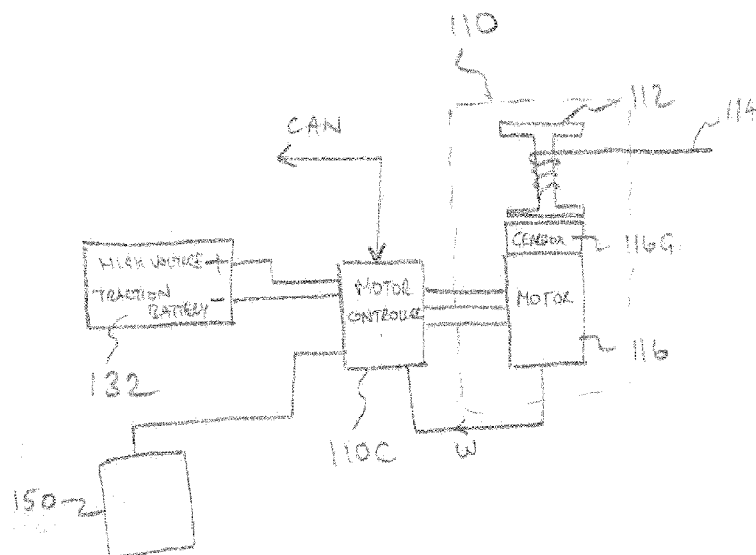


FIGURE 2

VEHICLE WINCH CONTROL SYSTEM AND METHOD OF CONTROLLING A WINCH

FIELD OF THE INVENTION

5 The present invention relates to a vehicle winch control system and method of controlling a winch. Particularly, but not exclusively, embodiments of the invention relate to a winch apparatus for mounting to a motor vehicle for assisting movement of the vehicle or other objects. Aspects of the invention relate to an apparatus, to a system, to a unit, to a module, to a vehicle and to a method.

10

BACKGROUND

It is known to attach a winch to a motor vehicle at a front, rear or mid-point of the vehicle. Winches are typically used for three main purposes – self recovery, third party
15 vehicle recovery and the lifting of heavy or remote objects.

In a self-recovery scenario, a winch may be employed for example to recover the vehicle to which the winch is attached if the vehicle becomes stranded in muddy terrain. Typically, a winch cable is unwound from a winch drum and tethered to a fixed object
20 ahead of the vehicle. The cable is then rewound onto the drum, dragging the vehicle towards the fixed object. Typically, the vehicle is driven under its own power as the cable is rewound. Use of a winch is useful in situations where there is insufficient grip, excessive gradient or where it is desirable to minimise surface damage due to excessive wheel spin.

25

In a third party vehicle recovery scenario, the winch cable is attached to the third party vehicle to be recovered whilst the host vehicle to which the winch is fitted is stationary. The host vehicle may be restrained from moving, for example by being secured to a fixed object. The winch cable is then rewound, dragging the third party vehicle towards
30 the host vehicle.

In a third scenario a winch may be used to move heavy or remote objects, for example to erect a pylon, move an obstruction such as a fallen tree, or winch personnel in a cliff rescue situation. Use of a winch may provide a more powerful and more controlled pull
35 than could be achieved for example with a tow rope.

In the case of self-recovery, the driver of the vehicle must ensure that the speed at which the vehicle is driven corresponds closely to the speed at which the winch is wound in. This is a non-trivial task and requires considerable expertise. Undulations in surface height or changes in surface grip can cause lurching of the vehicle in a forward direction,
5 resulting in slackening of the winch cable and binding of the winch drum.

Winches for vehicles are typically powered by a 12V or 24V system. Due to the heavy currents involved (around 500A), they are switched by solenoids in either a forward or reverse direction. This can generate a relatively abrupt pulling force which can be a
10 disadvantage in some use situations.

It is desirable to provide an improved winch apparatus.

STATEMENT OF THE INVENTION

15 Embodiments of the invention may be understood with reference to the appended claims.

Aspects of the present invention provide a system, a vehicle and a method.
20

In one aspect of the invention for which protection is sought there is provided a winch control system for a vehicle operable to control a winding speed of a winch having an electric drive motor to have a value that is dependent on a speed of rotation of a powertrain of the vehicle.

25 The speed corresponding to that of the powertrain may be a speed that the vehicle would travel at if the amount of slip between a driven wheel and the driving surface were less than a prescribed value, optionally substantially zero. Thus, by knowing the speed of the powertrain, a corresponding wheel speed may be calculated and the speed of the
30 winch controlled in dependence on the corresponding wheel speed.

Advantageously the system may be operable wherein a winding speed of a winch is controlled in dependence on a powertrain speed whereby a winch cable line speed is proportional to a powertrain speed.
35

The system may be operable wherein a winding speed of a winch is controlled responsive to a speed of rotation of a powertrain such that a speed at which a vehicle is pulled over ground by a winch is substantially equal to a speed at which a vehicle would be driven over ground by a powertrain if an amount of wheel slip were less than a prescribed value.

In another aspect of the invention for which protection is sought there is provided a winch control system for a vehicle operable in use to control a winch having an electric winch drive motor to maintain at least one selected from a prescribed winch line tension and a prescribed winch drum torque.

In another aspect of the invention for which protection is sought there is provided a winch control system for a vehicle operable in use to control a winch having an electric winch drive motor to maintain at least one selected from a substantially constant prescribed winch line tension and a substantially constant prescribed winch drum torque.

Embodiments of the invention have the advantage that the winch line tension or winch drum torque may be controlled directly by the electric drive motor under the control system. In particular, the electric drive motor may be arranged in direct mechanical communication with the winch drum and not via an intermediate clutch or coupling arranged to control the winch drum torque or the winch line tension.

Embodiments of the invention have the advantage that, when a driver of a vehicle having such a control system seeks to drive a vehicle with the assistance of a winch, the driver may concentrate on driving the vehicle whilst the winch drive motor is controlled to maintain a substantially constant winch line tension or winch drum torque. In some embodiments this feature has the advantage that when a vehicle with such a winch control system seeks to pull itself free from a location at which it is immobilised, a risk that a winch cable becomes slack during the winching operation is reduced. This reduces a risk that the winch becomes either snagged or bound.

It is to be understood that in some embodiments the winch control system may control the winding speed of the motor to maintain the constant tension or torque. Accordingly, in some embodiments the winch control system may comprise a user input device operable by a user to select the substantially constant prescribed winch line tension or winch drum torque. By providing a system in which the winding speed of the winch may

be varied, the winch may be controlled to commence winding at a relatively slow speed in order to allow the amount of tension or torque to increase relatively slowly in order to reduce shock on the winch, the vehicle to which it is attached and an object to which a line of the winch is attached. In conventional winch systems the winch speed is set to a relatively slow, constant speed, typically around 3m/minute due to the relatively narrow constant power speed range of the motors employed and the requirement to minimise the shock of initiating the pull. Embodiments of the invention allow higher winch speeds to be obtained by starting at a relatively low speed and increasing the speed over time.

Furthermore, a trend in vehicle design is to reduce vehicle weight in order to reduce emissions of harmful gases such as carbon dioxide. Reducing vehicle weight can result in difficulties when moving other objects when it is required for the vehicle to remain stationary. This is because, due to the reduced weight, when winching is commenced the vehicle may itself be pulled, for example by being dragged over ground. This problem may be ameliorated by reducing the initial line speed at which winching is commenced, before increasing the line speed (if required) once the object being moved has started to move.

It is to be understood that in some embodiments a switched reluctance (SR) motor may be employed. An SR motor may be provided that has a relatively wide range of speeds at which it may be operated with a substantially constant power. This may be achieved at least in part by means of electronic regulation of the motor. This may allow higher speeds to be achieved under lighter loads, for example when spooling in a cable that is not attached to an object.

Advantageously the control system may be operable in use to limit to a prescribed value the winch line tension or winch drum torque.

Thus the amount of tension or torque is not allowed to increase above a prescribed value.

This feature has the advantage that when a winch cable is coupled to an object having a prescribed maximum pulling force thereon, the control system is able to ensure that the maximum pulling force is not exceeded.

It is to be understood that in conventional electrically driven winch systems the winch has a single speed setting, and is either 'on' or 'off'. An impulse imparted to an object when the winch is switched on and suddenly tugs on the object can be severe, resulting in damage to the object, the vehicle, the winch cable or cable couplings. By way of example, if the winch, being mounted to a motor vehicle, is being used to pull another vehicle from a location in which it is stranded, the winch may be attached to a tie-down anchor point of the stranded vehicle. Tie-down anchor points are designed to allow a vehicle to be secured to another vehicle or trailer when being transported thereby. A load limit of around 1kN is imposed on some tie-down anchor points in order to prevent damage to or failure of the tie-down anchor point. If such an anchor point is coupled to a conventional winch, the load limit of 1kN might easily be exceeded when the winch is started or first applies tension to the vehicle.

Conventional winches are generally geared with a relatively high gear ratio in order to maintain a relatively low line speed, thereby reducing the impulse imparted to a vehicle or object (including the vehicle bearing the winch) when the winch cable begins to pull on the object. Embodiments of the present invention have the advantage that the winch may be operated in such a manner as to limit the magnitude of the impulse imparted to an object whilst still allowing relatively high winch cable line speeds to be achieved.

It is to be understood that winch cable line tension may be measured by a variety of different means. In some embodiments control electronics may be arranged to determine line tension responsive to one or more winch motor operating parameters such as an electrical potential across terminals of the motor, an amount of current drawn by the motor or any other suitable parameter.

It is to be understood that in some embodiments the control system may be arranged to maintain up to a given prescribed maximum winch cable tension.

Advantageously the system may be arranged to take into account an increase in diameter of a winch drum as a winch cable is wound or unwound, wherein a speed of rotation of a winch drum is controlled to decrease as a winch drum increases in diameter.

The system may be operable to set a maximum rate at which the winch cable may be wound and/or unwound by the winch drive motor.

Advantageously the system may be operable to allow a user to set a maximum rate at which the winch cable may be wound and/or unwound by the winch drive motor.

- 5 Optionally the system may be operable to allow a user to select the prescribed value of line tension or drum torque to be maintained.

The system may comprise a user input device operable by a user to select the prescribed value of line tension or drum torque to be maintained.

10

The system may be operable to control a winch drive motor of a winch to apply a brake torque to a winch drum.

- 15 This feature has the advantage that a braking force may be applied to the winch line. In some embodiments this feature allows a winch requiring brake means to be provided with a friction brake of a smaller size than would otherwise be required or, in some embodiments, no friction brake at all.

- 20 Advantageously the system may be operable to control a winch drive motor to apply a brake torque to a winch drum to effect regenerative braking.

- 25 It is to be understood that electric power generated by the winch drive motor in these circumstances may be employed to recharge a battery of the vehicle. This has the advantage that charge drained from the battery due to operation of the winch may be replenished at least in part through regenerative braking.

Further advantageously, the system may be operable to limit a rate of increase of the amount of torque applied to a winch drum of a winch to a prescribed value.

- 30 This feature has the advantage that the magnitude of an impulse imparted to an object and a vehicle to which a winch is fitted when winching may be limited.

- 35 This feature may be particularly useful for example when a winching operation is commenced and may be referred to as a 'soft start' function. Control parameters associated with the soft start function such as the maximum allowable rate of increase of torque applied to the winch drum may be pre-set in the control system and/or provided to

the control system from an external source, such as via a directly connected user interface, the CAN bus or any other suitable means.

5 The electric drive motor may be arranged to be supplied with electric power at a potential that is in the range from around 100V to around 5kV, optionally in the range from around 100V to around 1kV, further optionally in the range from around 200V to around 700V.

10 It is to be understood that employment of a motor operating in this range of potentials has the advantage that losses due to the flow of relative high currents (known as 'I²R' losses) may be reduced.

15 In a further aspect of the invention for which protection is sought there is provided an electric or hybrid electric vehicle control system comprising a winch control system according to the preceding aspect.

In a still further aspect of the invention for which protection is sought there is provided a vehicle comprising a system according to a preceding aspect.

20 In one aspect of the invention for which protection is sought there is provided a converter or an inverter unit for an electric or hybrid electric vehicle comprising a system according to a preceding aspect. A converter is typically used where the electric or hybrid vehicle comprises a direct current (DC) traction or propulsion motor, in which case the converter provides a time varying (e.g. pulsed, optionally pulse width, position or phase modulated) direct current for powering the traction motor. In contrast, an inverter is typically used
25 where the electric or hybrid vehicle comprises an alternating current (AC) traction or propulsion motor, in which case the inverter provides a time varying, alternating current for powering the traction motor.

30 The converter or inverter unit may be operable to provide power to an electric traction motor and/or to an electric winch drive motor.

The converter or inverter unit may be operable to provide at least one of a time varying electric current, a time varying direct current, a pulsed direct current, a pulse code modulated direct current, a pulse amplitude modulated direct current, a pulse width
35 modulated direct current, a pulse position modulated direct current, a pulse density

modulated direct current, a pulse phase modulated direct current, and an alternating current to an electric traction motor and / or to an electric winch drive motor.

That is, in some embodiments the converter or inverter unit may be configured to
5 provide power as required to one or both of an electric traction motor and an electric winch drive motor. Alternatively in some embodiments the converter or inverter unit may be configured to provide power only to an electric winch drive motor.

In one aspect of the invention for which protection is sought there is provided a charge
10 storage module for an electric or hybrid electric vehicle comprising a system or according to a preceding aspect.

In a further aspect of the invention for which protection is sought there is provided a
15 method of controlling a by means of a winch control system a vehicle winch having an electric winch drive motor comprising the step of controlling the winch to maintain at least one selected from a substantially constant prescribed winch line tension and a substantially constant prescribed winch drum torque.

In one aspect of the invention for which protection is sought there is provided a winch
20 control system for a vehicle operable to control a winding speed of a winch having an electric drive motor to have a value that is dependent on a speed of rotation of a powertrain of the vehicle.

In an aspect of the invention for which protection is sought there is provided a charge
25 storage module for an electric or hybrid electric vehicle comprising a system according to a preceding aspect.

In a further aspect of the invention for which protection is sought there is provided a
30 winch control system for a vehicle operable in use to control a winch having an electric winch drive motor to maintain at least one selected from a substantially constant prescribed winch line tension and a substantially constant prescribed winch drum torque.

In a further aspect of the invention for which protection is sought there is provided a
35 winch control system for a vehicle operable in use to control a winch having an electric winch drive motor to limit to a prescribed value at least one selected from a winch line tension and a winch drum torque.

In one aspect of the invention for which protection is sought there is provided a winch control system for a vehicle operable in use to control a winding speed of a winch having an electric winch drive motor in dependence on a speed of travel of the vehicle over a driving surface.

The system may be operable to control the winding speed to match substantially the speed of travel of the vehicle over the driving surface.

10 In an aspect of the invention for which protection is sought there is provided a method of controlling a vehicle winch by means of a winch control system comprising the step of controlling automatically a winding speed of the winch in dependence on a speed of rotation of a powertrain of the vehicle.

15 In a still further aspect of the invention for which protection is sought there is provided a method of controlling a vehicle winch having an electric winch drive motor by means of a winch control system comprising the step of controlling the winch to limit to a prescribed value at least one selected from a winch line tension and a winch drum torque.

20 The method may comprise the step of controlling the winch drive motor to limit to the prescribed value the winch line tension or winch drum torque.

In an aspect of the invention for which protection is sought there is provided a method of controlling a vehicle winch having an electric winch drive motor by means of a winch control system comprising the step of controlling a winding speed of the winch to assume a value that is dependent on a speed of travel of the vehicle over a driving surface.

30 Within the scope of this application it is envisaged that the various aspects, embodiments, examples and alternatives, and in particular the individual features thereof, set out in the preceding paragraphs, in the claims and/or in the following description and drawings, may be taken independently or in any combination. For example features described in connection with one embodiment are applicable to all embodiments, unless such features are incompatible.

For the avoidance of doubt, it is to be understood that features described with respect to one aspect of the invention may be included within any other aspect of the invention, alone or in appropriate combination with one or more other features.

- 5 Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. Features described in connection with one embodiment are applicable to all embodiments, unless such
- 10 features are incompatible.

BRIEF DESCRIPTION OF THE DRAWINGS

- Embodiments of the invention will now be described, by way of example only, with
- 15 reference to the accompanying figures in which:

FIGURE 1 is a schematic illustration of a motor vehicle having a winch control system according to an embodiment of the present invention;

- 20 FIGURE 2 is a schematic illustration of the winch control system of the vehicle of FIG. 1; and

FIGURE 3 is a schematic illustration of two winch control panels for use in controls systems according to embodiments of the present invention.

25

DETAILED DESCRIPTION

- FIG. 1 shows a motor vehicle 100 according to an embodiment of the present invention. The vehicle 100 is a parallel-type hybrid electric vehicle (HEV) 100 having an engine 121
- 30 that may be coupled to a crankshaft integrated motor generator (CIMG) 123 via a clutch 122. The CIMG 123 is coupled in turn to a transmission 124. The CIMG 123 is arranged to be driven as an electric motor by a traction battery 132, or as an electric generator for recharging the battery 132. The CIMG 123 may be driven as an electric generator by the engine 121 or by one or more wheels 102, 104 to effect regenerative braking. The
- 35 engine 121 may also provide drive torque to the transmission 124 when the clutch 122 is closed.

With the clutch 122 open the vehicle 100 is operable in an electric vehicle (EV) mode in which the CIMG 123 alone provides drive torque to the transmission 124.

- 5 Operation of the engine 121, clutch 122 and CIMG 123 is controlled by a powertrain controller 140.

The vehicle 100 is operable in a two wheel drive mode in which only rear wheels 104 of the vehicle 100 may be driven or a four wheel drive mode in which front wheels 102 may
10 be driven in addition to the rear wheels 104.

The vehicle 100 has a winch 110 operable under the control of a winch controller 110C to unwind a winch cable 114 from a winch drum 112 and to rewind the cable 114 when required. The winch controller 110C draws power from the traction battery 132 to power
15 a winch motor 116 that drives the winch drum 112 via a gearbox 116G (FIG. 2). The winch motor 116 may be of any suitable type such as an AC motor, a DC motor, a stepper motor, a reluctance motor such as a switched reluctance motor or any other suitable type of motor. Switched reluctance motors are particularly advantageous due to their inherent robustness and ability to operate over a relatively wide speed range.

20

The vehicle 100 is provided with a winch control panel 150A as shown in FIG. 3(a). The control panel 150A allows a user to select a required operational mode of the winch controller 110C. The control panel 150A has a dial 152 allowing the user manually to control a speed at which the winch controller 110C reels the cable 114 in or out. The dial
25 152 is a monostable joystick-type device having a joystick 152J that returns when automatically upon release to a central 'zero' speed position, being the position in which the joystick 152J is shown in FIG. 3(a). In the example shown, if the joystick 152J is pushed in a forward direction the controller 110C reels the cable 114 in whilst if the joystick 152J is pulled in a reverse direction the controller 110C reels the cable 114 out.
30 When the joystick 152J is in the central position the controller 110C locks the drum 112 in a stationary position. A separate lock button 156 (placarded 'L') is also provided for locking the drum 112 in a stationary position. When the lock button is pressed the controller 110C locks the position of the drum 112 regardless of a position of the joystick 152J or any other selector switch.

35

In a first mode of operation the winch controller 110C is operable to control a winch cable line speed automatically according to a speed of rotation of one or more wheels 102, 104 of the vehicle 100. The first mode may be selected by means of an 'auto' selector switch 154 of the control panel 150A (placarded 'A'). The panel 150A also has a ratio selector switch 157. The ratio selector switch 157 allows the driver to select a required ratio between the speed at which the vehicle will be driven by the wheels 102, 104 and the line speed of the cable 114. If a free end of the cable 114 is directly coupled to a fixed object with no mechanical advantage the selector switch 157 is set to position '1' corresponding to a 1:1 ratio of line speed to vehicle speed. If the free end is passed around a fixed object (such as a tree, post or pulley) and coupled back to the vehicle 100, a 2:1 ratio of line speed to vehicle speed may be selected, corresponding to position '2' of the selector switch 157. A 3:1 ratio may be selected by setting the selector switch 157 to position '3'. Other arrangements are also useful.

When the first mode is selected and the vehicle 100 is stationary, the winch controller 110C is operable to allow a user to pay out or reel in the winch cable 114 by means of the joystick 152J. The user may set the winch such that a desired tension is established in the cable 114. The user may begin to drive the vehicle 100, controlling the vehicle 100 to apply torque to one or both pairs of wheels 102, 104 depending on whether two wheel drive mode or four wheel drive mode has been selected. As the wheels begin to rotate, the winch controller 110C simultaneously begins to reel in the cable 114.

It is to be understood that the user may concentrate his or her attention on driving the vehicle 100 whilst the winch controller 110C controls the winch 110 to drag the vehicle 100 forward at a speed corresponding to that at which the user is attempting to drive the vehicle 100. If at any time the vehicle 100 lurches forward, for example whilst driving over an obstacle such as a rock or a log, the winch controller 110C recognises the corresponding increase in wheel speed as the vehicle 100 lurches, and increases a rate of winding of the drum 112. If the vehicle speed falls after negotiating the obstacle, the controller 110C reduces the rate of winding of the drum 112 accordingly.

It is to be understood that when the vehicle 100 lurches forwards, a risk exists that the cable 114 becomes slack and that the winch 100 becomes bound by the cable 114 as a result. By controlling the winch to reel in the cable 114 at a rate corresponding to wheel speed, the risk that the cable 114 slackens sufficiently to cause binding is reduced.

It is to be understood that in some embodiments the winch controller 110C is configured to calculate a line speed of the cable 114 being a relative speed of the vehicle 100 and cable 114. In some embodiments the controller 110C determines line speed responsive to a rate of rotation of the drum 112 and a diameter of the drum 112 including any
5 portion of cable 114 wound thereon. From this information the speed of a point on an outer surface of the wound cable 114, which corresponds to the line speed, may be determined.

In some embodiments the diameter of the drum 112 including cable 114 wound thereon
10 is determined by knowing the diameter of the drum 112 including cable 114 when the drum 112 is fully wound and when fully unwound, the number of turns required of the drum 112 between these positions, and the number of turns of the drum 112 that have been made from the fully wound or unwound position. Other arrangements are also useful.

15 In some alternative embodiments a speed of a portion of cable 114 relative to the vehicle 100 as the portion of cable 114 is wound towards the drum 112 may be measured by means of a speed sensor. For example in some embodiments the cable 114 may be brought into contact with a roller, the rotational speed of the roller being measured,
20 allowing line speed to be determined.

It is to be understood that in some embodiments if winch speed is matched to vehicle speed over ground as determined by reference to wheel speed or a powertrain speed corresponding to wheel speed, errors in vehicle speed calculation due to wheel slip may
25 in some embodiments result in the winch winding faster than the vehicle speed rather than slower than the vehicle speed. Thus the winch speed varies in a manner that does not increase a risk of slackening of the cable 114 and therefore a risk of binding of the cable 114 on the drum 112. In some embodiments wheel slip may be taken into account so as to ensure that the winch does not wind at a speed greater than that of the vehicle
30 100 over ground.

In some embodiments, actual speed over ground regardless of wheel speed may be determined, for example by reference to data obtained by a position determination system such as a global satellite positioning system (GPS), or by reference to other data
35 such as images captured by a camera, parking sensor data or any other suitable data source by means of which vehicle speed over ground may be determined.

The winch controller 110C is also operable in a second mode in which the controller 110C controls winding or unwinding of the cable 114 such that an amount of tension applied to the cable 114 does not exceed a prescribed value. The vehicle 100 has a
5 second control panel 150B which allows the driver to select a desired value of maximum tension according to the position of a tension selector dial 158. In the embodiment of FIG. 2 the dial 158 allows selection of a maximum tension so as to allow a line tension in the range from around 2kN to around 50kN in 2kN increments to be established, although other values are also useful. Other arrangements are also useful. A tension
10 select button 159 (placarded 'T') is provided, selection of which causes the controller 110C to control rotation of the drum 112 until the selected maximum amount of tension is applied to the drum 112. Thus the tension select button 159 causes the amount of tension applied to the drum 112 to correspond to the setting of tension selector dial 158. It is to be understood that in some embodiments the controller 110C may be operable to
15 limit a speed of rotation of the drum 112 such that the rotational speed does not exceed a prescribed value even if the amount of tension applied by the drum 112 has not yet attained to the prescribed value set by the user.

In the embodiment of FIG. 2 the controller 110C is operable to determine the value of
20 torque applied to the drum 112 according to an amount of current drawn by the winch motor 116 although other arrangements are also useful.

In some embodiments the controller 110C is operable to determine the amount of torque that should be applied to the drum 112 in order to obtain the desired line tension, and to
25 apply the required amount of torque. As noted above the controller 110C may take into account an effective diameter of the drum 112 in embodiments in which the diameter is dependent on the amount of cable 114 wound on the drum 112.

It is to be understood that the winch motor 116 is an electric machine operable as a
30 motor (to apply a positive torque to the winch drum 112) or an electrical generator (to apply a negative torque to the winch drum 112). When paying out the winch cable 112 against a sufficiently high pulling force on the cable 114, the controller 110C may control the motor 116 to employ regenerative braking in order to maintain the prescribed value of torque on the drum 112.

It is to be understood that in some embodiments a user-operable brake control may be provided. That is, the user may command the controller 110C to control the motor 116 to apply a braking action to the drum 112. This feature has the advantage that a friction brake may not be required to be deployed in order to slow the drum 112. Friction brakes
5 have the disadvantage that they may generate excessive amounts of heat during prolonged use, whilst regenerative braking allows recharging of the battery 132. In a scenario in which a vehicle is controlling descent of a slope by itself or by a third party vehicle coupled to the cable 114, a substantial amount of energy may be recovered in this manner.

10

In some alternative embodiments, instead of setting an amount of tension applied to the winch drum 112 the controller 110C is arranged to allow a user to set a prescribed amount of torque that is to be applied to the drum 112 by means of a selector dial similar to dial 158 of the embodiment of FIG. 3(b). A torque select button corresponding to the
15 tension select button 159 of the embodiment of FIG. 3(b) may be provided by means of which the user may command the controller 110C to establish the required torque on the winch drum 112. The controller 110C may then set the prescribed value of torque by appropriate control of the winch motor 116. In some embodiments the torque select button allows selection of a maximum torque so as to provide a cable tension in the
20 range from 2kN to 50kN in 2kN increments although other values are also useful.

It is to be understood that in the embodiment shown the controller 110C is linked to a controller area network (CAN) bus 111 by means of which the controller 110C may transmit and receive signals to and from one or more other vehicle controllers such as
25 the powertrain controller 140. In the present embodiment the controller 110C is operable to read from the CAN bus 111 a current value of vehicle speed. The controller 110C also receives a signal indicative of a speed of rotation of the winch drive motor 116 and the amount of torque currently being applied by the motor 116 to the winch drum 112. The controller 110C also receives signals generated by the control panels 150A, 150B
30 responsive to user manipulation of controls 152J – 159. These signals may be transmitted to the controller 110C by a direct wired or wireless link, or via the CAN bus 111. Other arrangements are also useful.

Embodiments of the present invention may advantageously be employed in a number of
35 different scenarios. Some embodiments of the invention allow a user to coordinate wheel speed with a rate of reeling in or out of a winch cable thereby to prevent slackening of

the cable during a winching operation. Some embodiments of the invention allow an amount of tension applied to a winch cable to be limited to a maximum prescribed value (which in some embodiments is user selectable). This feature allows a magnitude of an impulse imparted to an object to which the winch is coupled to be limited, for example
5 when winching is commenced initially. Advantageously this feature also reduces the impulse imparted to winching accessories (e.g. strops etc.) and to the vehicle to which the winch is fitted when winching is initially commenced.

In some embodiments a rate of reeling in or out of a winch cable may be controlled in
10 dependence on a speed at which the vehicle moves over ground (as opposed to wheel speed, which may differ).

Embodiments of the invention have the advantage that a driver may concentrate attention on driving the vehicle at a speed suitable for the ground over which the vehicle
15 is travelling, whilst the winch is controlled to reel in or reel out at a speed corresponding to that at which the driver drives the vehicle.

It is to be understood that in some embodiments the vehicle may be an electric vehicle (EV) not being a HEV. In some embodiments the vehicle may be a conventional vehicle
20 having an internal combustion engine only and not an electric propulsion motor.

In one embodiment, a vehicle is provided in which a winch controller is operable to control the motor to assume a stall condition in which the motor may apply a torque opposing rotation thereof, thereby applying a braking action to a winch drum. In some
25 embodiments the motor may be controlled to provide incremental, step-wise rotational control. The motor may for example be a switched reluctance motor, a stepper motor or any other suitable motor.

In one embodiment, an electric vehicle or HEV is provided that has an inverter for
30 generating an alternating current for powering a vehicle traction (or propulsion) AC motor. Alternatively, where the vehicle traction (or propulsion) motor is a DC motor, the electric vehicle or HEV in this embodiment comprises a converter for generating a time varying (e.g. pulsed, optionally pulse width, position or phase modulated) direct current for powering the traction motor. Accordingly, although the following description of this
35 embodiment refers to an inverter, it will be readily apparent to the informed reader that the term converter should more correctly be read in place of the term inverter wherever a

DC traction motor is envisaged in the embodiment. The inverter is configured to provide power to the winch motor when winching is required. In some hybrid electric vehicles according to the present invention the inverter may be operable to provide electric power to the winch motor or the traction motor but not both simultaneously. Thus the winch
5 may be employed when it is not required to employ the traction motor, such as when an engine of the hybrid vehicle is being employed. In some alternative embodiments the inverter may be operable to provide electric power to the traction motor and to the winch motor at substantially the same time. Other arrangements are also useful.

10 In some embodiments the vehicle has an inverter for providing power to one or more traction motors, the inverter having spare circuit capacity for powering the winch motor. Thus if a customer requires a winch to be fitted to the vehicle, the winch may be fitted and the winch motor connected to the inverter that is already fitted to the vehicle. In some embodiments an inverter controller may also be configured to allow control of a
15 winch motor when the winch motor is connected. The inverter controller may require that a winch motor control capability of the controller is unlocked before such capability may be employed by the customer. In some embodiments, the inverter controller may require that a winch motor unlock code is input to the controller before allowing the winch motor control capability to be deployed. Other arrangements are also useful.

20

The main purposes for which winches may typically be used (e.g. self-recovery, third party vehicle recovery and the lifting of heavy or remote objects) would typically require a winch cable to be paid out by a person walking with the end of the cable pulling it to the object to which it is to be attached. However, there are situations where it is desirable to
25 transport the remote end of the winch cable using a drone or similar mobile item. For example, the attachment point may be a person requiring rescue from an inaccessible area. This is feasible with lightweight, synthetic cables. In this case, it is necessary to pay out the cable at a rate appropriate to the progress of the drone or mobile item and this is facilitated using the variable speed and torque control proposed in the forgoing
30 embodiments of the present invention.

Notwithstanding the use of the term “inverter” in some of the foregoing embodiments, the skilled reader will appreciate that said term should be interpreted interchangeably with “converter” in cases where the traction and winch motors comprise direct current
35 (DC) motors rather than alternating current (AC) motors.

Embodiments of the present invention may be understood by reference to the following numbered paragraphs:

1. A winch control system for a vehicle operable in use to control a winch having an electric winch drive motor to maintain at least one selected from a substantially constant prescribed winch line tension and a substantially constant prescribed winch drum torque.
2. A winch control system as described in paragraph 1 operable in use to control a winch having an electric winch drive motor arranged in direct mechanical communication with a winch drum to maintain the at least one selected substantially constant winch line tension or substantially constant winch drum torque.
3. A control system as described in paragraph 1 operable in use to limit to a prescribed value the winch line tension or winch drum torque.
4. A system as described in paragraph 1 arranged to take into account an increase in diameter of a winch drum as a winch cable is wound or unwound, wherein a speed of rotation of a winch drum is controlled to decrease as a winch drum increases in diameter.
5. A system as described in paragraph 1 operable to set a maximum rate at which the winch cable may be wound and/or unwound by the winch drive motor.
6. A system as described in paragraph 5 operable to allow a user to set a maximum rate at which the winch cable may be wound and/or unwound by the winch drive motor.
7. A system as described in paragraph 1 operable to allow a user to select the prescribed value of line tension or drum torque to be maintained.
8. A system as described in paragraph 7 comprising a user input device operable by a user to select the prescribed value of line tension or drum torque to be maintained.
9. A system as described in paragraph 1 operable to control a winch drive motor of a winch to apply a brake torque to a winch drum.

10. A system as described in paragraph 9 operable to control a winch drive motor to apply a brake torque to a winch drum to effect regenerative braking.
11. A system as described in paragraph 1 operable to limit a rate of increase of the amount of torque applied to a winch drum of a winch to a prescribed value.
12. A system as described in paragraph 1 wherein the electric drive motor is arranged to be supplied with electric power at a potential that is in the range from around 100V to around 5kV, optionally in the range from around 100V to around 1kV, further optionally in the range from around 200V to around 700V.
13. An electric or hybrid electric vehicle control system comprising a winch control system as described in paragraph 1.
14. A vehicle comprising a system as described in paragraph 1.
15. A converter unit for an electric or hybrid electric vehicle comprising a system as described in paragraph 1.
16. A converter unit as described in paragraph 14 operable to provide power to an electric traction motor and/or to an electric winch drive motor.
17. A converter unit as described in paragraph 16 operable to provide at least one of a time varying electric current, a time varying direct current, a pulsed direct current, a pulse code modulated direct current, a pulse amplitude modulated direct current, a pulse width modulated direct current, a pulse position modulated direct current, a pulse density modulated direct current, a pulse phase modulated direct current, and an alternating current to an electric traction motor and / or to an electric winch drive motor.
18. A charge storage module for an electric or hybrid electric vehicle comprising a system as described in paragraph 1 or a unit as described in paragraph 15.
19. A method of controlling a vehicle winch having an electric winch drive motor by means of a winch control system, comprising the step of controlling the winch to maintain at least one selected from a substantially constant prescribed winch line tension and a substantially constant prescribed winch drum torque.

Throughout the description and claims of this specification, the words “comprise” and “contain” and variations of the words, for example “comprising” and “comprises”, means “including but not limited to”, and is not intended to (and does not) exclude other
5 moieties, additives, components, integers or steps.

Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as
10 singularity, unless the context requires otherwise.

Features, integers, characteristics, compounds, chemical moieties or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described
15 herein unless incompatible therewith.

CLAIMS:

1. A winch control system for a vehicle operable in use to control a winch having an electric winch drive motor to maintain at least one selected from a substantially constant winch line tension and a substantially constant winch drum torque.
5
2. A winch control system as claimed in claim 1 operable in use to control a winch having an electric winch drive motor arranged in direct mechanical communication with a winch drum to maintain the at least one selected substantially constant winch line
10 tension or substantially constant winch drum torque.
3. A system as claimed in claim 1 or claim 2 operable in use to limit to a prescribed value the winch line tension or winch drum torque.
- 15 4. A system as claimed in any one of claims 1 to 3 arranged to take into account an increase in diameter of a winch drum as a winch cable is wound or unwound, wherein a speed of rotation of a winch drum is controlled to decrease as a winch drum increases in diameter.
- 20 5. A system as claimed in any preceding claim operable to set a maximum rate at which the winch cable may be wound and/or unwound by the winch drive motor.
6. A system as claimed in claim 5 operable to allow a user to set a maximum rate at which the winch cable may be wound and/or unwound by the winch drive motor.
25
7. A system as claimed in any preceding claim operable to allow a user to select the prescribed value of line tension or drum torque to be maintained.
8. A system as claimed in claim 7 comprising a user input device operable by a user
30 to select the prescribed value of line tension or drum torque to be maintained.
9. A system as claimed in any preceding claim operable to control a winch drive motor of a winch to apply a brake torque to a winch drum.
- 35 10. A system as claimed in claim 9 operable to control a winch drive motor to apply a brake torque to a winch drum to effect regenerative braking.

11. A system as claimed in any preceding claim operable to limit a rate of increase of the amount of torque applied to a winch drum of a winch to a prescribed value.
- 5 12. A system as claimed in any preceding claim wherein the electric drive motor is arranged to be supplied with electric power at a potential that is in the range from around 100V to around 5kV, optionally in the range from around 100V to around 1kV, further optionally in the range from around 200V to around 700V.
- 10 13. An electric or hybrid electric vehicle control system comprising a winch control system as claimed in any preceding claim.
14. A vehicle comprising a system as claimed in any preceding claim.
- 15 15. A converter unit for an electric or hybrid electric vehicle comprising a system as claimed in any one of claims 1 to 13.
16. A converter unit as claimed in claim 15 operable to provide power to an electric traction motor and/or to an electric winch drive motor.
- 20 17. A converter unit as claimed in claim 16 operable to provide at least one of a time varying electric current, a time varying direct current, a pulsed direct current, a pulse code modulated direct current, a pulse amplitude modulated direct current, a pulse width modulated direct current, a pulse position modulated direct current, a pulse density
25 modulated direct current, a pulse phase modulated direct current, and an alternating current to an electric traction motor and / or to an electric winch drive motor.
18. A charge storage module for an electric or hybrid electric vehicle comprising a system as claimed in any one of claims 1 to 13 or a unit as claimed in any one of claims
30 15 to 17.
19. A method of controlling a vehicle winch having an electric winch drive motor by means of a winch control system, comprising the step of controlling the winch to maintain at least one selected from a substantially constant prescribed winch line tension
35 and a substantially constant prescribed winch drum torque.

23

20. A system, vehicle, unit, module or method substantially as hereinbefore described with reference to the accompanying drawings.

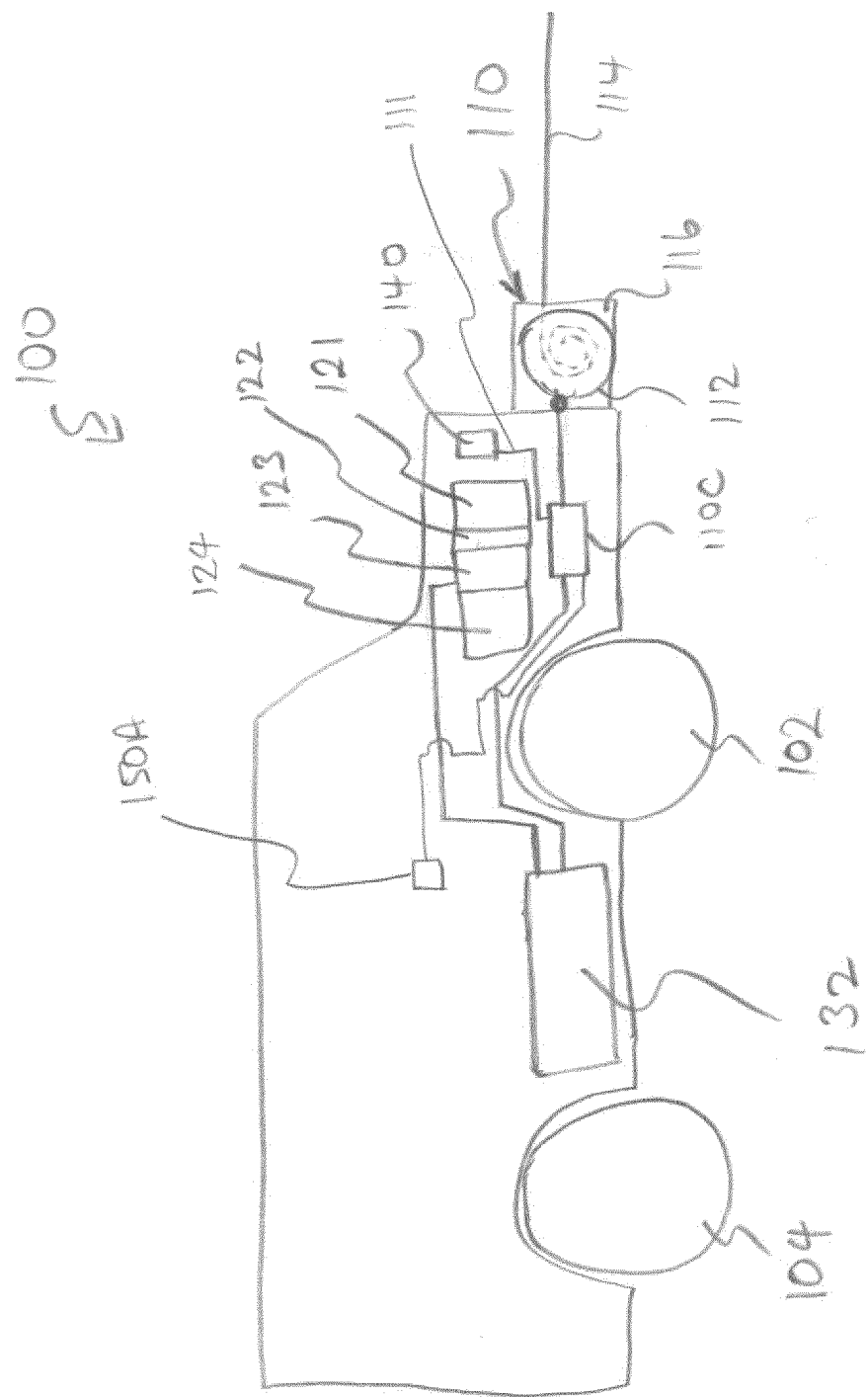


Figure 1

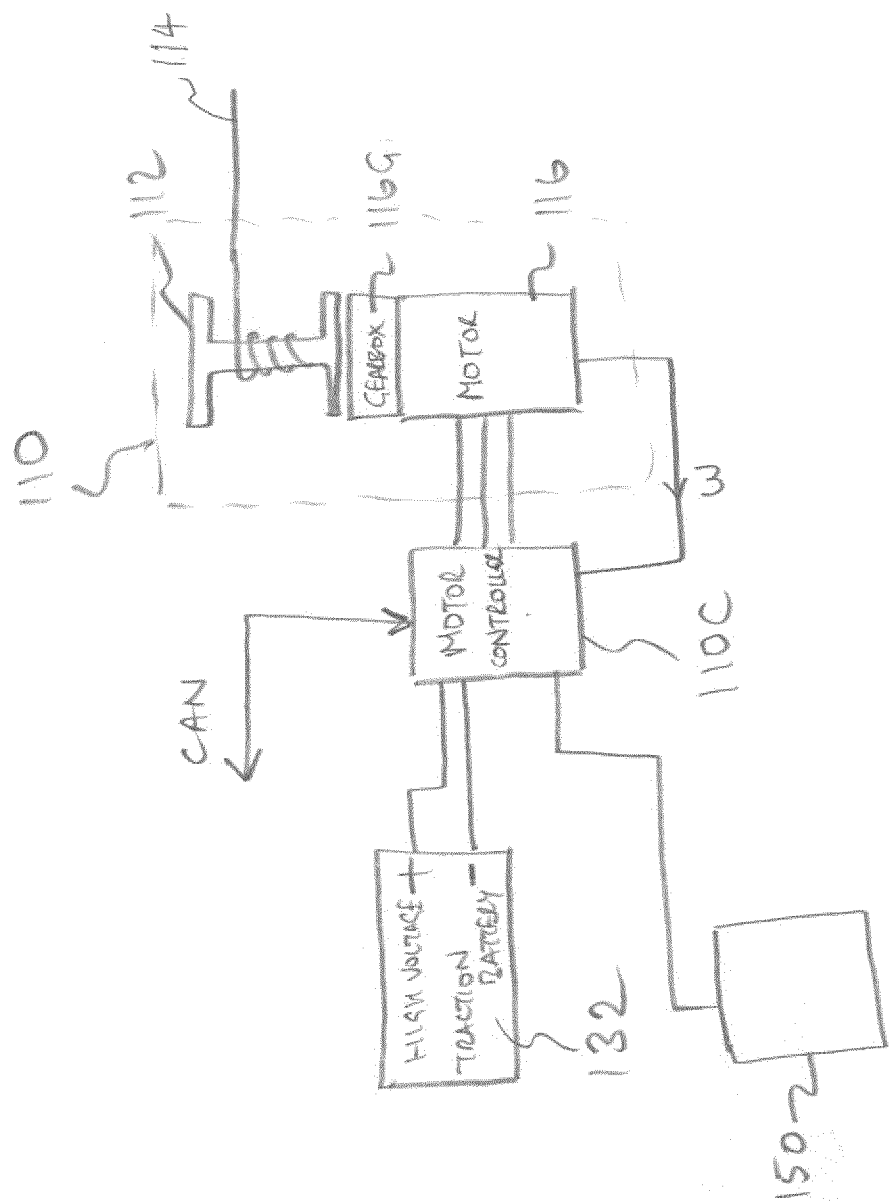


Figure 2

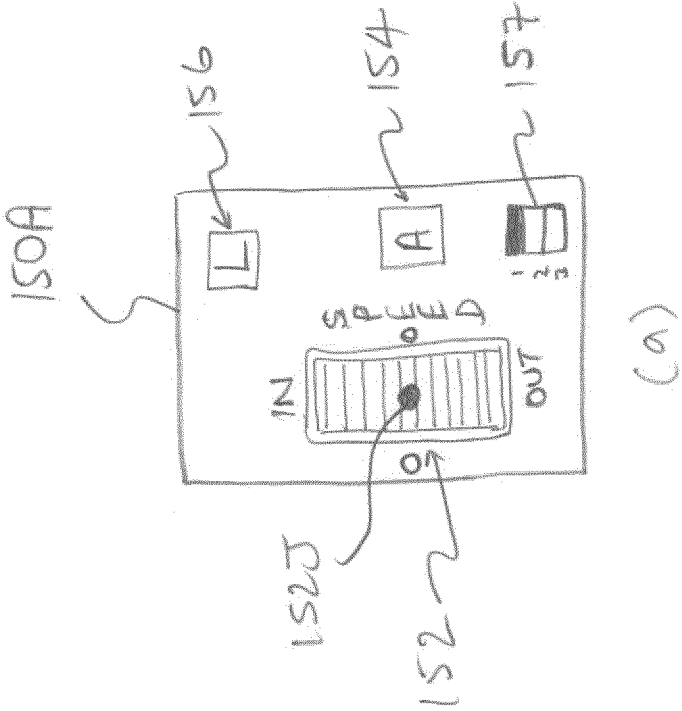
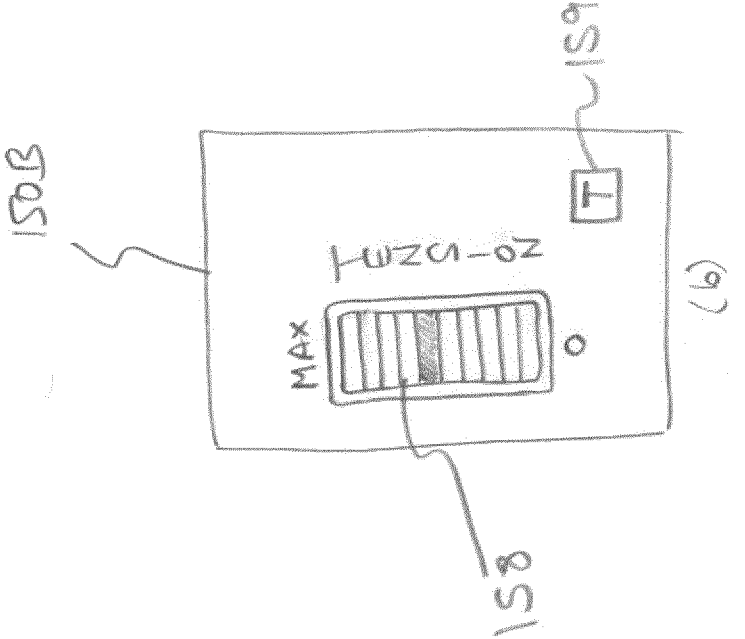


figure 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/056086

A. CLASSIFICATION OF SUBJECT MATTER
INV. B66D1/12
ADD.

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)
B66D B65H

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 361 897 A (ROVER GROUP [GB]; BAYERISCHE MOTOREN WERKE AG [DE]) 7 November 2001 (2001-11-07) the whole document	1-20
X	----- WO 84/02430 A1 (SUNDSTRAND CORP [US]) 21 June 1984 (1984-06-21) the whole document	1-20
A	----- US 4 276 498 A (STAGER ROBERT F ET AL) 30 June 1981 (1981-06-30) the whole document	1-20



Further documents are listed in the continuation of Box C.



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

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"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

15 May 2014

Date of mailing of the international search report

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Faymann, L

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2014/056086

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2361897	A	07-11-2001	NONE

WO 8402430	A1	21-06-1984	EP 0128910 A1 27-12-1984
			US 4537364 A 27-08-1985
			WO 8402430 A1 21-06-1984

US 4276498	A	30-06-1981	NONE
