



(51) International Patent Classification:

E05F 15/603 (2015.01) *E05F 15/614* (2015.01)
E05F 15/611 (2015.01) *E05F 15/63* (2015.01)

(21) International Application Number:

PCT/EP2017/062013

(22) International Filing Date:

18 May 2017 (18.05.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

201621019994 10 June 2016 (10.06.2016) IN

(71) Applicant: **JAGUAR LAND ROVER LIMITED**
[GB/GB]; Abbey Road, Whitley, Coventry Warwickshire
CV3 4LF (GB).

(72) Inventors: **MANIKKATH, Arun**; c/o Jaguar Land Rover,
Patents Department W/1/073, Abbey Road - Whitley,

Coventry Warwickshire CV3 4LF (GB). **SURAPALAN
NAIR, Suresh**; c/o Jaguar Land Rover, Patents Depart-
ment W/1/073, Abbey Road - Whitley , Coventry War-
wickshire CV3 4LF (GB). **BADGER, Stephen**; c/o Jaguar
Land Rover, Patents Department W/1/073, Abbey Road -
Whitley , Coventry Warwickshire CV3 4LF (GB). **JONES,
Anthony**; c/o Jaguar Land Rover, Patents Department
W/1/073, Abbey Road - Whitley , Coventry Warwickshire
CV3 4LF (GB). **PUNNATHARA, Swaroop**; c/o Jaguar
Land Rover, Patents Department W/1/073, Abbey Road -
Whitley , Coventry Warwickshire CV3 4LF (GB).

(74) Agent: **DITUM, Caroline**; c/o Jaguar Land Rover, Patents
Department W/1/073, Abbey Road - Whitley, Coventry
Warwickshire CV3 4LF (GB).

(81) Designated States (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,

(54) Title: POWER-OPERATED SYSTEM FOR VEHICLE CLOSURE MEMBERS

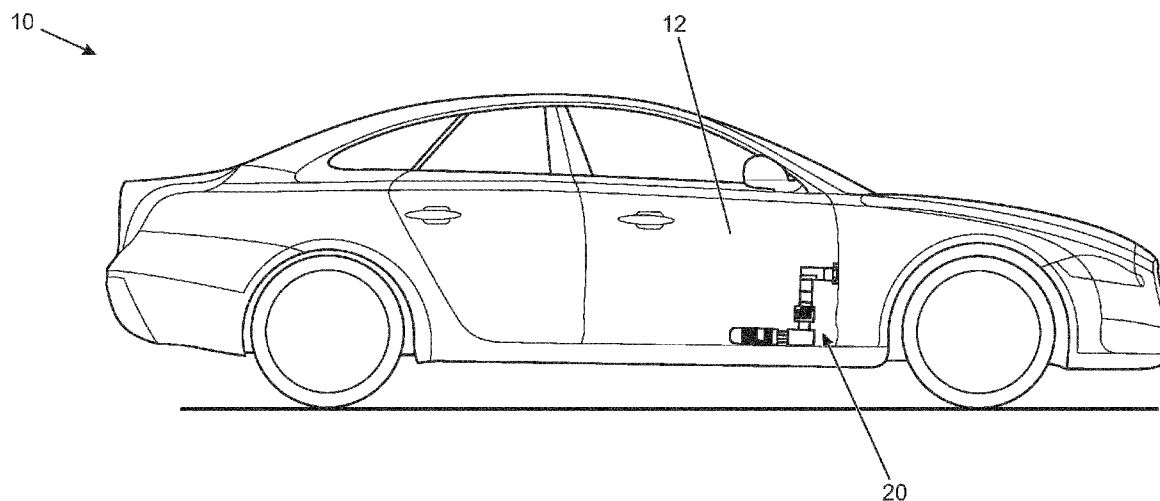


Figure 1

(57) Abstract: The present invention relates to a power-operated system for a closure member of a vehicle comprising an actuator, control means and a sensor for detecting a force and/or a torque applied to the closure member. The system has a first mode in which the control means controls the actuator to resist movement of the closure member. If the force and/or torque applied to the closure member exceeds a first threshold value when the system is in the first mode the system exits the first mode and assumes a second mode in which the control means controls the actuator to apply a force and/or torque to the closure member. The system may improve user convenience by assisting with opening and closing of the closure member.



HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

POWER-OPERATED SYSTEM FOR VEHICLE CLOSURE MEMBERS

TECHNICAL FIELD

The present disclosure relates to a power-operated system for vehicle closure members.

- 5 Aspects of the invention related to a power-operated system for a closure member of a vehicle and to a method of operating a power-operated system that is configured to at least assist with opening and/or closing of a closure member of a vehicle.

BACKGROUND

- 10 It is known to provide vehicle doors with check arms that define a number of stable open positions of the door relative to the vehicle. When the door is in an open position that is not one of the defined stable positions the check arm may bias the door towards one of the stable positions, and when the door is in one of the stable positions a threshold force may be needed to move it away from the stable position. A disadvantage of such check arms is that
- 15 a user may wish to leave the door in a position other than one of the defined stable positions, for example if they are exiting the vehicle when it is parked near to an obstacle.

- Another problem with existing vehicle doors, especially vertically hinged vehicle doors or closure members, such as bonnets or tailgates, is that they may be difficult for some users to
- 20 open or close due to the weight of the door. This may be a particular problem when the vehicle is parked on an incline, so that the height of the door (relative to a horizontal datum) changes as it is opened and closed.

- The present invention aims to at least partially mitigate the problems described above.
- 25

SUMMARY OF THE INVENTION

- Aspects of the invention provide a vehicle, a power-operated system for a closure member of a vehicle, a system for a closure member of a vehicle and to a method of operating a power-operated system that is configured to at least assist with opening and/or closing of a
- 30 closure member of a vehicle as claimed in the appended claims.

According to an aspect of the invention there is provided a power-operated system for a closure member of a vehicle, the system comprising:

- an actuator;
- 35 control means configured to control the actuator; and
- a sensor in communication with said control means and configured to detect a force and/or a torque applied to the closure member, wherein:

the system has a first mode in which the control means controls the actuator to resist movement of the closure member; and

if the force and/or torque applied to the closure member exceeds a first threshold value when the system is in the first mode the system is configured to exit the first mode and to
5 assume a second mode in which the control means controls the actuator to apply a force and/or torque to the closure member, thereby to assist opening or closing of the closure member. The first mode may alternatively be referred to as a “hold mode”, and the second mode may alternatively be referred to as a “power assist mode”, and may comprise power assisted opening and/or power assisted closing.

10 Advantageously, the system provides a resistance to movement when small forces are applied, but assists movement when larger forces, which may be indicative of a user's intention to move the closure member, are applied.

15 In some embodiments the control means may comprise a controller. The controller may comprise a processor and electronic memory, for example a non-transitory computer readable media. In some embodiments the controller or control means may be an electronic control unit (ECU). It will be understood that the ECU may also control other functions, and it is not necessary for the ECU to function only as part of the system of the present invention.

20 In some embodiments the sensor may be disposed in series with the actuator.

In some embodiments the control means may be configured to control the actuator to reduce the force and/or torque applied to the closure member by the actuator to zero when an
25 external force and/or a torque applied to the closure member ceases.

In some embodiments the power-operated system may comprise a brake and the control means is configured to actuate the brake when an external force and/or a torque applied to the closure member ceases.

30 In an embodiment, when the system is in the second mode the control means may be configured to vary the magnitude of the force and/or torque applied by the actuator in dependence upon the force and/or torque applied to the closure member.

35 The system may comprise a second sensor, optionally a tilt sensor, in communication with the control means and being configured to measure a parameter relating to an orientation of the vehicle. Optionally, the first threshold value may be dependent on the parameter relating

to an orientation of the vehicle. Varying the first threshold value in dependence on the parameter relating to the orientation of the vehicle can at least partially account for a contribution to the measured force and/or torque due to the weight of the closure member. It will be understood that the tilt sensor may comprise a gyroscopic sensor of the type that may be fitted to vehicles as part of a vehicle inertial measurement unit, which detect vehicle orientation using one or more gyroscopic sensors.

Optionally, when the system is in the second mode the control means may be configured to vary the magnitude of the force and/or torque applied by the actuator in dependence upon the parameter relating to an orientation of the vehicle. This may account for changes in the force required to move the closure member due to the weight of the closure member.

Optionally, if the force and/or torque applied to the closure member exceeds a second threshold value greater than said first threshold value and the direction of the force and/or torque applied to the closure member is such that it acts to close the closure member, the system is configured to assume a third mode in which the control means is configured to control the actuator to fully close the closure member. The third mode may alternatively be referred to as a "power close mode".

A force exceeding the second threshold value may be indicative of a user's intention to fully close the closure member without continuing to apply force to the closure member.

The system may comprise a third sensor configured to detect the presence of objects in the expected path of the closure member.

Optionally, when the system is in the third mode and the third sensor detects an object in the expected path of the closure member the system may be configured to exit the third mode and to enter a fourth mode in which the control means is configured to control the actuator to bring the closure member to rest without fully closing the closure member. The fourth mode may alternatively be referred to as an "anti-trap mode".

In an embodiment the actuator may comprise a motor. Optionally, the actuator may comprise a motor and a brake.

Optionally, the system may comprise a user interface in communication with the control means, the user interface being configured to receive user instruction to close the closure member, wherein upon receipt of said user instruction to close the closure member the

system is configured to assume a third mode in which control means is configured to control the actuator to fully close the closure member. The user interface may be configured to receive a user instruction to open the closure member, wherein upon receipt of said user instruction to open the closure member the system is configured to assume a fifth mode in which the control means is configured to control the actuator to move the closure member to an open position. The third mode may alternatively be referred to as a power close mode, and the fifth mode may alternatively be referred to as a powered opening mode.

In an embodiment the system may comprise a clutch having an open state in which the actuator is not operable to apply force and/or torque to the closure member and a closed state in which the actuator is operable to apply force and/or torque to the closure member. Optionally, the control means may be configured to control the clutch, and the clutch may be configured to assume the open state when the closure member is fully closed. This embodiment prevents the system from interfering with the operation of the closure member if the system fails once the closure member is closed. Indeed, the clutch may be configured to always assume the open state when the system does not receive a power input. Alternatively, or in addition, the clutch may have a maximum torque value above which the clutch is configured to slip.

In an embodiment the system may comprise a first attachment means configured to be attached to the closure member and a second attachment means configured to be attached to a body of the vehicle, wherein the actuator is operable to cause a force and/or torque to act between the first and second attachment means, thereby to apply a force and/or torque to the closure member.

Optionally, the system is configured to transmit force and/or torque between the first attachment means and the second attachment means via a gear train.

Optionally the system is configured to transmit force and/or torque between the first attachment means and the second attachment means via a crank.

In an embodiment the first and second attachment means may comprise first and second brackets.

According to another aspect of the invention there is provided a vehicle having a power-operated system as described above.

According to another aspect of the invention there is provided a method of operating a power-operated system that is configured to at least assist with opening and/or closing of a closure member of a vehicle, the method comprising:

assuming a first mode of operation in which an actuator is controlled to resist
5 movement of the door;

detecting a force and/or torque applied to the closure member; and

if the force and/or torque exceeds a first threshold value, exiting the first mode
of operation and assuming a second mode of operation in which the actuator is controlled to
apply a force and/or torque to the closure member, thereby to assist opening or closing of
10 the closure member.

Optionally, if the force and/or torque applied to the closure member exceeds a second
threshold value greater than said first threshold value and the direction of the force and/or
torque applied to the closure member is such that it acts to close the closure member, the
15 method may comprise assuming a third mode in which the control means is configured to
control the actuator to fully close the closure member.

According to another aspect of the invention there is provided a controller configured to
implement a method as described above.

According to another aspect of the invention there is provided a system for a closure
member of a vehicle comprising:

a first attachment means configured to be attached to the closure member;

a second attachment means configured to be attached to a body of the vehicle;

25 a geartrain or a crank;

a control means; and

a brake,

wherein the first attachment means is connected to the second attachment means by the
geartrain or the crank and the brake is controllable by said control means to resist movement
30 of the geartrain or the crank, thereby to resist relative movement of the first and second
attachment means.

According to an aspect of the invention there is provided a power-operated system for a
closure member of a vehicle, the system comprising:

35 an actuator;

control means configured to control the actuator; and

a sensor in communication with said control means and configured to detect a force and/or a torque applied to the closure member, wherein:

the system has a first mode in which the control means controls the actuator to resist movement of the closure member; and

- 5 if the force and/or torque applied to the closure member exceeds a second threshold value and the direction of the force and/or torque applied to the closure member is such that it acts to close the closure member, the system is configured to assume a third mode in which the control means is configured to control the actuator to fully close the closure member.

- 10 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. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination unless such
- 15 features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

20 BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

- Figure 1 shows a vehicle including a power-operated system in an embodiment of the
- 25 present invention;

Figure 2 shows a schematic diagram of the hardware of a power-operated system in an embodiment of the present invention;

Figure 3 shows a power-operated system in an embodiment of the present invention;

Figure 4 shows a power-operated system in another embodiment of the present invention

- 30 Figure 5 shows a flow chart illustrating a control strategy for a power operated system capable of providing power assisted opening and closing and fully powered closing according to embodiments of the present invention; and

Figure 6 illustrates the procedure for mounting a door including a power-operated system according to an embodiment of the present invention on a vehicle.

35

DETAILED DESCRIPTION

Detailed descriptions of specific embodiments of vehicles, systems, methods and programs of the present invention are disclosed herein. It will be understood that the disclosed embodiments are merely examples of the way in which certain aspects of the invention can be implemented and do not represent an exhaustive list of all of the ways the invention may be embodied. Indeed, it will be understood that vehicles, systems, methods and programs described herein may be embodied in various and alternative forms. The Figures are not necessarily to scale and some features may be exaggerated or minimised to show details of particular components. Well-known components, materials or methods are not necessarily described in great detail in order to avoid obscuring the present disclosure. Any specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the invention.

Figure 1 shows a vehicle 10 having a power-operated system 20 configured to assist opening and closing of door 12 and/or to automatically close the door 12. Some embodiments may also be operable to automatically open the door 12. Although an outline of the power-operated system 20 is shown in figure 1, it will be understood that the power-operated system will generally be disposed in a cavity within the door 12. Alternatively, all or part of the power-operated system could be located within the body of the vehicle 10.

The embodiment shown in figure 1 only shows a power-operated system 20 for front door 12. However, the skilled person will understand that the power-operated systems described herein would be equally suitable for use with other closure members, including but not limited to rear passenger doors, horizontally hinged tailgates, the upper and lower portions of split, horizontally hinged tailgates and vertically hinged tailgates. Accordingly, the terms "vehicle door", "door of a vehicle" and variations thereof as used herein is considered to include (among other things), all vehicle closure members, including passenger doors, vehicle bonnets, vertically hinged tailgates including portions of split, vertically hinged tailgates, and horizontally hinged tailgates including portions of a split, horizontally hinged tailgate.

Figure 2 shows schematic diagram of a power-operated system 20 configured to either assist with opening and closing of vehicle closure members or doors or to automatically open and/or close vehicle closure members or doors. The system 20 may be disposed in a cavity within a vehicle door 12, as illustrated in figure 1. The system 20 comprises an actuator, which is an electric motor 22 in the illustrated embodiment. The electric motor 22 is connected to a gearbox 28 via a clutch 24. Clutch 24 is in communication with and controlled

by electronic control unit (ECU) 32. Indeed, in the absence of an input from ECU 32 clutch 24 may be configured to assume an open state. This may prevent the system from failing to a state in which it provides resistance to movement of the door but does not provide any assistance torque.

5

A motor brake may be integrated within the electric motor 22 in figure 2, for example in the form of a power on – release type motor brake.

A torque sensor 30 is disposed in series with gearbox 28 and is in communication with ECU 32. The torque sensor 30 is connected to a secondary gear train or crank 34. In 10 embodiments where the power-operated system 20 is located within a cavity in the door 12 and is rigidly attached to the door 12 a portion of the secondary gear train or crank 34 will be attached to the body of the vehicle 10, preferably at a position substantially coaxial with the hinges of the door 12. In this way torque produced by the motor 22 when the clutch 24 is 15 closed may be transmitted, via the gearbox 28, the torque sensor 30 and the secondary gear train or crank 34 to the body of the vehicle, thereby causing a torque to act between the body of the vehicle 10 and the door 12. Such torque may provide assistance to a user opening or closing the door 12. The ECU 32 may control the amount of torque produced by the motor 22 in dependence on inputs from various sensors, including tilt sensor 40, which 20 may be an on board gyroscopic sensor, torque sensor 30 and door angle sensor 36.

The system shown in figure 2 may also provide a powered closing function, in which the system automatically closes the door upon receipt of a user instruction to close the door. Such an instruction may be provided through user interface 41. User interface 41 may be a 25 switch located on the door itself or on the body of the vehicle. In some embodiments the user interface 41 may be a remote user interface, which may be located on a key fob or within a mobile phone app. Alternatively, the user interface may be configured to recognise a gesture from the user, and to initiate powered closing upon detection of a predetermined or user-defined gesture. It will be understood that more than one user interface may be 30 provided, and that in some embodiments a combination of the above user interfaces may be provided.

In some embodiments a powered opening mode in which the system automatically opens the door upon receipt of a user instruction to open the door may be provided additionally or 35 instead. In such embodiments an additional user interface may be provided, or a single user interface may be configured to receive both the instruction to close the door and the instruction to open the door. For example, a single switch may be provided, and the system

may be configured to interpret actuation of the switch as an instruction to close the door when the door is open and as an instruction to open the door when the door is closed.

In embodiments that provide powered closing and/or opening it may be necessary to provide one or more sensors 39 configured to detect objects that the door would be likely to collide with during powered opening or closing. If sensor 39 detects an object the door would be likely to collide with during powered opening or closing then the ECU 32 may be configured to control the actuator to stop the door before the collision occurs.

It will be understood that changes may be made to the positions of the various components shown in the schematic diagram in figure 2 without affecting the overall function of the power-operated system 20. For example, the clutch 24 could instead be located downstream from the gearbox 28. In this case a clutch with higher torque capacity may need to be employed, as the gearbox 28 will typically be a reduction gearbox that causes an increase in torque. Similarly, although the motor brake is integrated with the motor in figure 2, in some embodiments a motor that does not include a brake could be used and a separate brake could be used instead of the motor brake. In such embodiments the brake may be located downstream from gearbox 28. This may require a brake having a higher torque capacity, but may improve the response time of the system. The position of the torque sensor 30 may be also changed, and it will be understood that the correlation between the torque measured by the torque sensor 30 and the force and/or torque applied to the door 12 will vary depending on which gearboxes are located between the door 12 and the sensor 30.

Figure 3 shows an assembled power-operated system 20` in an embodiment of the present invention. The system shown in figure 3 includes a motor 22, clutch 24, planetary gearbox 28, torque sensor 30 and secondary gear train 34` as shown in figure 2. However, the power-operated system shown in figure 3 also includes a right-angle gearbox 26. Depending upon the location of other components in the door cavity, provision of a right-angle gearbox may make packaging the system 20 within the door 12 easier. As will be understood by the skilled person, the right-angle gearbox may or may not provide a reduction ratio, and all or part of the reduction provided by the planetary gearbox 28 could be incorporated into the right-angle gearbox 26. In some embodiments the right-angle gearbox and/or the planetary gearbox may provide an increased the speed of rotation at the output as compared to the input.

The secondary gear train 34` shown in figure 3 is attached to brackets 42 and 44. Bracket 42 is configured for attachment to a portion of the door 12, for example at a location close to a

hinge of the door 12, and bracket 44 is configured to be attached to a portion of the body of the vehicle 10, which portion may also be close to the hinge. The motor 22 is configured to apply a torque that acts to cause rotation of bracket 42 relative to bracket 44. Accordingly, when bracket 42 is mounted to a portion of the door 12 and bracket 44 is mounted to a portion of the body of the vehicle 10 the motor 22 is operable to apply a torque that acts to cause rotation of the door relative to the vehicle. The application of such torque may be controlled by an ECU (not shown in figure 3).

Figure 4 shows an assembled power-operated system 20'' according to another embodiment of the present invention. The system shown in figure 4 is similar to that shown in figure 3, except that it does not include a right-angle gearbox, and the secondary gear train 34' is replaced with a crank 34''. The embodiment shown in figure 4 has fewer components than that shown in figure 3, and accordingly the overall length of the system may be less than that shown in figure 3. Under certain circumstances it may be easier to package the system 20'' within a door 12 than it is to package the system 20' within a door 12. However the skilled person will understand that this will depend on the location of other components within the door 12.

In another embodiment, which is not shown in the drawings, the electric motor and the clutch shown in figure 2 may be omitted, and a linear actuator may be employed instead. The linear actuator may be attached to a door beam or a part that is configured to move with the door, for example a door mounting bracket. The other end of the linear actuator may be attached to a portion of the body of the vehicle, or a component that is configured to be attached thereto. Both ends of the linear actuator may be pivotable relative to the parts they are attached to. In this way, the door can be caused to rotate about its hinges by changes in the length of the linear actuator. In some embodiments more than one linear actuator may be provided, which may increase the amount of force the system can produce. It will be understood that it may not be necessary to provide a clutch in embodiments where the actuator is a linear actuator rather than a motor.

In the example illustrated in Figures 3 and 4, a system is illustrated and described as comprising a planetary gearbox 28, torque sensor 30 and secondary gear train 34'. In an alternative embodiment, the system may comprise a worm drive, thereby avoiding the need for a motor brake and using a bigger electromagnetic clutch after the secondary gear train 34'. Additionally/alternatively, a torque limiter may be used as a safety mechanism when a worm drive is used without a clutch, for example after the secondary gearbox in the planetary gear mechanism.

Figure 5 shows a flow chart 100 illustrating a control algorithm for controlling power-operated systems in embodiments of the present invention. The flow chart in figure 5 illustrates an embodiment of the present invention which is configured to provide power assisted opening and closing and fully powered closing. The control algorithm will be described with particular reference its use in controlling a power-operated system as shown in figures 2-4. However, the skilled person will recognise that it could equally be applied to other power-operated systems.

It will be understood that an ECU such as the ECU 32 shown in the schematic diagram in figure 2 may be configured to control the other components of the power-operated system in accordance with the flow chart 100. The ECU 32 may comprise a non-transitory computer readable media having instructions stored thereon for controlling the other components of the power-operated system 20 in accordance with the flow chart 100.

After the algorithm is started, it proceeds to step 102, in which the operating range of the door angle sensor 36 is set as 0 degrees to a maximum value in degrees. For example, the maximum value may be around 70 degrees for side passenger doors of vehicles and around 90 degrees for vertically-hinged tailgates. The algorithm then proceeds to step 104, in which the torque sensor working range is set in dependence on the vehicle orientation, as measured by tilt sensor 40, which may be a gyroscopic sensor.

The algorithm then proceeds to read the door angle sensor input position Φ at step 106 and, using the door angle position Φ , determines whether or not the door is fully closed at step 108. If the door is fully closed then the system enters a standby mode and returns to step 104. If the system determines that the door is fully closed then the algorithm proceeds to step 110, in which the power-operated system is put into a standby mode. In some embodiments the clutch 24 may be opened when the system is in the standby mode.

If the system determines that the door is not fully closed then it proceeds to check for an input on a power close button, which may be a user interface 41 as shown in figure 2. If a user instruction to close the door is received then the algorithm proceeds to step 114, in which the system checks whether or not an object would become trapped in the door or collide with the door during powered closing, for example using an output from sensor 39. If no objects are detected at step 114 then the system enters a power close mode at step 118, in which the ECU controls the actuator 22 to fully close the door, before the algorithm returns to step 104. If an object is detected at step 114 then the system enters an anti-trap mode at

step 116, in which the system initiates anti-trap control. The anti-trap control could comprise automatically stopping the door before it is fully closed, using the actuator 22. Alternatively, upon initiation of the anti-trap control the ECU may be configured to control the actuator 22 to bring the door to a halt and then reverse the direction of movement of the door for a short distance, before bringing the door to a halt again. Once the anti-trap control is complete and the door is stationary the system enters a hold mode at step 120, in which the door is held stationary by the actuator 22. In embodiments where the actuator 22 comprises a motor with a brake the brake may be actuated in step 120 to hold the door stationary. The skilled person will understand that the motor may be provided with a separate brake, or the motor may be controlled such that it acts as a brake when the system is in the hold mode.

If the system does not detect the user pressing the powered close button 41 at step 112 then the algorithm proceeds to step 122, at which it is determined whether or not a force and/or torque exceeding a first threshold value is being applied to the door. It will be understood that the force and/or torque applied to the door may be measured using torque sensor 30. Alternatively another sensor, such as a force transducer, may be provided in addition to or instead of the torque sensor 30. It will be understood that a particular advantage of a torque sensor disposed in series with the actuator is that the reading on a torque sensor is not dependent on the position at which a force and/or torque is applied by a user.

The first threshold value may be selected so that a confident determination that a user wishes to move the door can be made when the first threshold value is exceeded. However, it is important that the first threshold value is not so high that some users may not be able to provide sufficient force and/or torque to exceed the first threshold value. In some embodiments the first threshold value may be dependent on the orientation of the vehicle or other parameters such as the current weight of the door, including any additional components that are disposed on the door and will move with the door when it is opened and closed. An additional sensor may be provided for measuring the current weight of the door if the weight may be expected to change significantly. This may allow the system to compensate for contribution to the force and/or torque measured by the torque sensor 30 caused by the weight of the door. Indeed, when the torque sensor working range is set in step 104 this may include an offset to compensate for the effect of the weight of the door in the current vehicle orientation. In some embodiments, especially embodiments in which the power-operated system is configured to control a tailgate door which may sometimes have a spare wheel connected to the tailgate door, the additional sensor for measuring the weight of the door may instead be a proximity sensor configured to detect the presence or absence of a spare wheel or another component that may be disposed on the door. Because the weight

of the spare wheel and the door itself may both be known, merely detecting the presence of the spare wheel may be sufficient to determine the current weight of the door and attached spare wheel.

- 5 If the system does not detect a force and/or torque exceeding the first threshold value then the algorithm proceeds to step 124, in which the door is held stationary by the actuator 22. If the system detects a force and/or torque exceeding the first threshold value then the algorithm proceeds to step 126, in which the ECU checks the direction of the force and/or torque applied to the door to see whether it acts to open the door or to close the door. If the
10 detected force and/or torque is acting in a direction that tends to open the door then the system enters a power assist mode at step 136, in which power assisted opening is initiated.

- If the detected force and/or torque is acting in a direction that tends to close the door then the algorithm proceeds to step 128, in which the ECU checks whether or not the applied
15 force and/or torque is greater than a second threshold value greater than the first threshold value. The second threshold value may be selected so that a confident determination that a user wishes to close the door without maintaining a grip on the door for the entirety of its travel to its closed position can be made when a force and/or torque exceeding the second threshold value is applied. If the force and/or torque applied to the door exceeds the second
20 threshold value then the algorithm proceeds to step 130, in which a door slam close control is initiated.

- Once the door slam close control is initiated the algorithm proceeds to step 114, in which the system checks whether or not an object would become trapped in the door or collide with the
25 door during powered closing. The control then proceeds from step 114 in a similar manner to if step 114 had been reached by the user pressing the powered close button in step 112. However, it will be understood that the precise way in which the actuator is controlled to fully close the door in step 118 may be different, because the force applied by the user will cause the door to have an initial velocity when step 118 is reached after the slam close control is
30 initiated. In some embodiments the ECU may be configured to control the door to close at a target angular velocity or within a target angular velocity range during step 118. The target angular velocity or angular velocity range may be different dependent upon whether step 118 was reached by virtue of the powered close button being pressed in step 112 or by virtue of the applied torque exceeding the second threshold value in step 128.

35

If the torque acting to open or close the door in step 128 is less than the second threshold value then the system enters a power assist mode at step 132, in which power assisted

closing is provided. For both power assisted opening and power assisted closing the ECU 32 may be configured to control the actuator 22 to provide an assistance torque in dependence on the force and/or torque applied by the user. In some embodiments a look-up table is provided in a memory portion of ECU 32, which look-up table relates the measured force and/or torque to the assistance torque to be provided by the actuator 22. In some embodiments the assistance torque to be provided by the actuator may be proportional to the force and/or torque applied by the user when the force and/or torque applied by the user is below a predetermined maximum value at which a corresponding maximum value of assistance torque is provided. The maximum value of assistance torque may be provided for all applied force and/or torque values above the predetermined maximum value. It will be understood that non-linear relationships between the force and/or torque applied by the user and the assistance torque applied by the actuator may also be provided. Furthermore, the relationship between the assistance torque and the force and/or torque applied by the user may vary dependent on various factors including the door opening angle and the orientation of the vehicle as measured by tilt sensor 40.

For both power assisted closing and power assisted opening the ECU 32 is configured to control the actuator 22 to gradually reduce the assistance torque to zero when an external force and/or a torque applied to the closure member ceases, for example when the user ceases to apply a force and/or torque to the door. Additionally, the ECU 32 may be configured to actuate the brake when an external force and/or a torque applied to the closure member ceases, for example when the user ceases to apply a force and/or torque to the door. Once the door has been brought to rest the system enters a hold mode at step 134, in which the door is held stationary by the actuator 22. In embodiments where the actuator 22 comprises a motor with a brake, or a standalone brake, the ECU 32 may be configured to actuate the brake may be actuated in step 120 to hold the door stationary. The algorithm then returns to step 104.

It will be understood that holding the door stationary using actuator 22, for example using a brake (not shown) that is integrated into a motor, may provide a similar functionality to a conventional check-arm. However, in contrast to a conventional check-arm, the system of the present invention allows the door to be held stationary in substantially any orientation relative to the body of the vehicle, because the resistance to movement is provided by applying the motor brake and closing the clutch 24, which is not dependent on the angular position of the door. Furthermore, the system of the present invention is capable of varying the amount of force and/or torque required to displace the door from a stationary position. For example, the door may remain stationary when the applied force and/or torque is below

the first threshold value, as no assistance torque is provided when the applied force and/or torque is below the first threshold value and a force and/or torque below the first threshold value may not, by itself, be sufficient to overcome the motor brake.

- 5 The force required to displace the door from a stationary position may be varied by changing the first threshold value. Indeed, it will be understood that changing the torque sensor working range in dependence on vehicle orientation may have the effect of changing the first threshold value, as the threshold may be a threshold output from the torque sensor. Changing the first threshold value or adjusting the torque sensor working range in
10 dependence on the orientation of the vehicle may compensate for any contribution to the torque observed by torque sensor 30 due to the weight of the door. This may be especially important for premium vehicles, which may have relatively heavy doors.

Figure 6 illustrates a procedure by which a door 202 including a power-operated system in
15 an embodiment of the present invention may be mounted to the body of a vehicle 200. The door 202 is initially mounted on the body of the vehicle 200 by attaching door-side hinge parts 204A,B to corresponding vehicle-side hinge parts 206A,B, and the alignment of the door relative to the vehicle is then checked. Once the door 202 is attached to the vehicle 200 and correctly aligned the bracket 44 is attached to the body of the vehicle by inserting bolts
20 through the holes in the bracket 44 and through corresponding ones of the holes 208 in the vehicle body. The holes 208 and/or the holes in the bracket 44 may be larger than the neck of the bolts that are intended to attach the bracket 44 to the vehicle 200. This may allow the positioning of the bolts to compensate for any tolerance on the positioning of the hinge parts. Once the bracket 44 is attached to the body of the vehicle the clutch (not shown in figure 6)
25 may be closed. In some embodiments the clutch is closed when the door 202 is in its fully closed position, so as to give a zero position for door angle sensor 36.

Figure 6 also schematically illustrates an example of an output from sensor 39 described above in the form of an anti-pinch strip 210 arranged to detect when an object becomes
30 trapped in the door 202 or collides with the door 202 during powered closing. An additional/alternative example of an output sensor 39 described above include ultrasonic sensors for detect objects that the door would be likely to collide with during powered opening or closing.

35 Although as described above and shown in the accompanying drawings the closure member is a door, in particular a front door of a vehicle, arranged for rotation about a vertically disposed pivot axis, the skilled person will understand that the invention is not limited to a

power-operated system suitable for a vehicle front door, but would be equally suitable for use with other closure members, including but not limited to rear passenger doors, horizontally hinged tailgates, the upper and lower portions of split, horizontally hinged tailgates and vertically hinged tailgates. Accordingly, the terms “vehicle door”, “door of a vehicle” and variations thereof as used herein is considered to include (among other things), all vehicle closure members, including passenger doors, vehicle bonnets, vertically hinged tailgates including portions of split, vertically hinged tailgates, and horizontally hinged tailgates including portions of a split, horizontally hinged tailgate.

CLAIMS

1. A power-operated system for a closure member of a vehicle, the system comprising:
an actuator;
5 control means configured to control the actuator; and
a sensor in communication with said control means and configured to detect a force and/or a torque applied to the closure member, wherein:
the system has a first mode in which the control means controls the actuator to resist movement of the closure member; and
10 if the force and/or torque applied to the closure member exceeds a first threshold value when the system is in the first mode the system is configured to exit the first mode and to assume a second mode in which the control means controls the actuator to apply a force and/or torque to the closure member, thereby to assist opening or closing of the closure member.
- 15 2. A power-operated system as claimed in claim 1, wherein the sensor is disposed in series with the actuator.
3. A power-operated system as claimed in claim 1 or claim 2, wherein the control
20 means is configured to control the actuator to reduce the force and/or torque applied to the closure member by the actuator to zero when an external force and/or a torque applied to the closure member ceases.
4. A power-operated system as claimed in any preceding claim, wherein the power-
25 operated system comprises a brake and the control means is configured to actuate the brake when an external force and/or a torque applied to the closure member ceases.
5. A power-operated system as claimed in any preceding claim, wherein, when the system is in the second mode the control means is configured to vary the magnitude of the
30 force and/or torque applied by the actuator in dependence upon the force and/or torque applied to the closure member.
6. A power-operated system as claimed in any preceding claim, comprising a second sensor in communication with the control means and being configured to measure a
35 parameter relating to an orientation of the vehicle.

7. A power-operated system as claimed in claim 6, wherein the first threshold value is dependent on the parameter relating to an orientation of the vehicle.

8. A power-operated system as claimed in claim 6 or claim 7, wherein when the system is in the second mode the control means is configured to vary the magnitude of the force and/or torque applied by the actuator in dependence upon the parameter relating to an orientation of the vehicle.

9. A power-operated system as claimed in any preceding claim, wherein, if the force and/or torque applied to the closure member exceeds a second threshold value greater than said first threshold value and the direction of the force and/or torque applied to the closure member is such that it acts to close the closure member, the system is configured to assume a third mode in which the control means is configured to control the actuator to fully close the closure member.

10. A power-operated system as claimed in any preceding claim, comprising a third sensor configured to detect the presence of objects in the expected path of the closure member.

11. A power-operated system as claimed in claim 10 where dependent from claim 9, wherein, when the system is in the third mode, or is about to enter the third mode, and the third sensor detects an object in the expected path of the closure member, the system is configured to enter a fourth mode in which the control means is configured to control the actuator to bring the closure member to rest without fully closing the closure member.

12. A power-operated system as claimed in any preceding claim, wherein the actuator comprises a motor.

13. A power-operated system as claimed in claim 12, wherein the actuator comprises a motor and a brake.

14. A power-operated system as claimed in any preceding claim, wherein the system comprises a user interface in communication with the control means, the user interface being configured to receive user instruction to close the closure member, wherein upon receipt of said user instruction to close the closure member the system is configured to assume a third mode in which control means is configured to control the actuator to fully close the closure member.

15. A power-operated system as claimed in claim 14, wherein the user interface is configured to receive a user instruction to open the closure member, wherein upon receipt of said user instruction to open the closure member the system is configured to assume a fifth mode in which the control means is configured to control the actuator to move the closure member to an open position.

16. A power-operated system as claimed in any preceding claim, comprising a clutch having an open state in which the actuator is not operable to apply force and/or torque to the closure member and a closed state in which the actuator is operable to apply force and/or torque to the closure member.

17. A power-operated system as claimed in claim 13, wherein the control means is configured to control the clutch, and the clutch is configured to assume the open state when the closure member is fully closed.

18. A power-operated system as claimed in any preceding claim comprising a first attachment means configured to be attached to the closure member and a second attachment means configured to be attached to a body of the vehicle, wherein the actuator is operable to cause a force and/or torque to act between the first and second attachment means, thereby to apply a force and/or torque to the closure member.

19. A power-operated system as claimed in claim 18 wherein the system is configured to transmit force and/or torque between the first attachment means and the second attachment means via a gear train.

20. A power-operated system as claimed in claim 18 wherein the system is configured to transmit force and/or torque between the first attachment means and the second attachment means via a crank.

21. A power-operated system as claimed in any one of claims 18-20, wherein the first and second attachment means comprise first and second brackets.

22. A vehicle comprising a power-operated system as claimed in any one of claims 1-21.

23. A method of operating a power-operated system that is configured to at least assist with opening and/or closing of a closure member of a vehicle, the method comprising:

assuming a first mode of operation in which an actuator is controlled to resist movement of the closure member;

detecting a force and/or torque applied to the closure member; and

5 if the force and/or torque exceeds a first threshold value, exiting the first mode of operation and assuming a second mode of operation in which the actuator is controlled to apply a force and/or torque to the closure member, thereby to assist opening or closing of the closure member.

10 24. A method as claimed in claim 23, wherein, if the force and/or torque applied to the closure member exceeds a second threshold value greater than said first threshold value and the direction of the force and/or torque applied to the closure member is such that it acts to close the closure member, the method comprises assuming a third mode in which the control means is configured to control the actuator to fully close the closure member.

15 25. A controller configured to implement a method as claimed in claim 23 or claim 24.

26. A power-operated system substantially as described herein with reference to the accompanying drawings.

20 27. A method substantially as described herein with reference to the accompanying drawings.

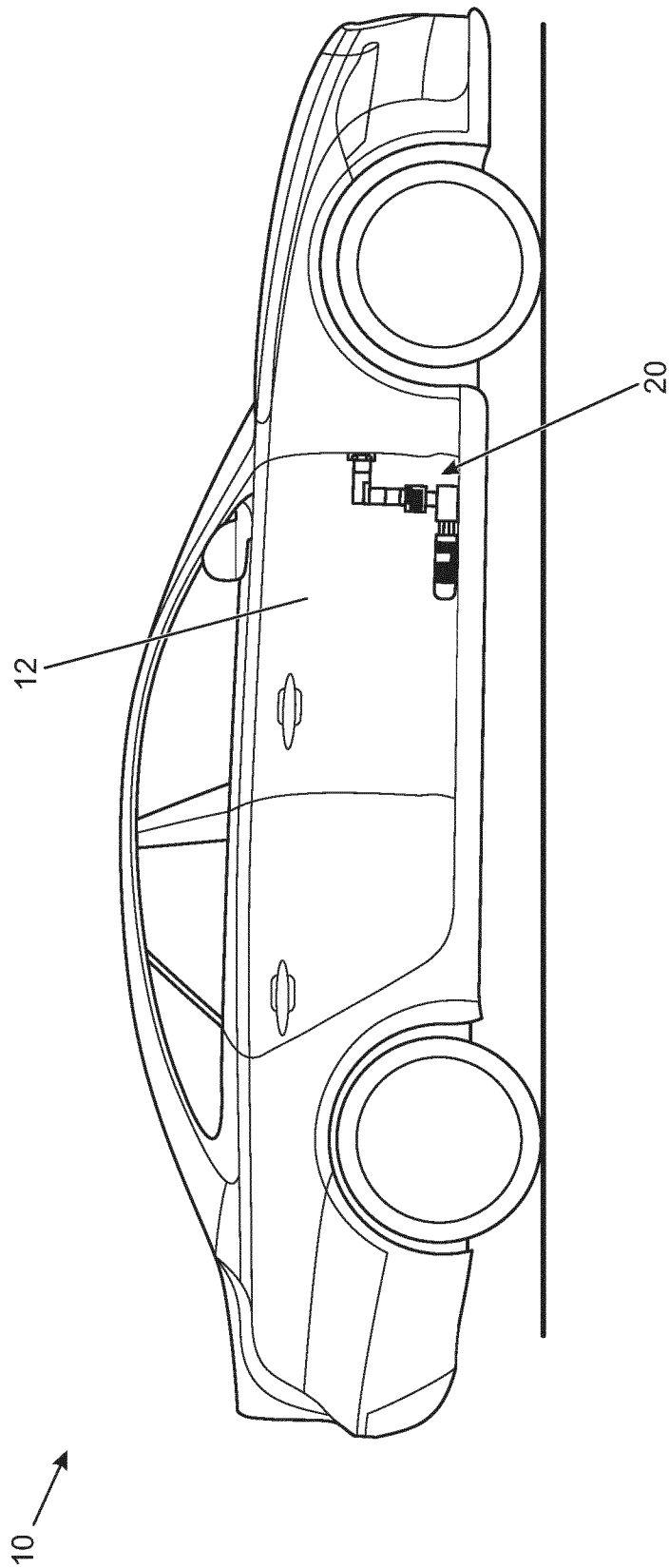


Figure 1

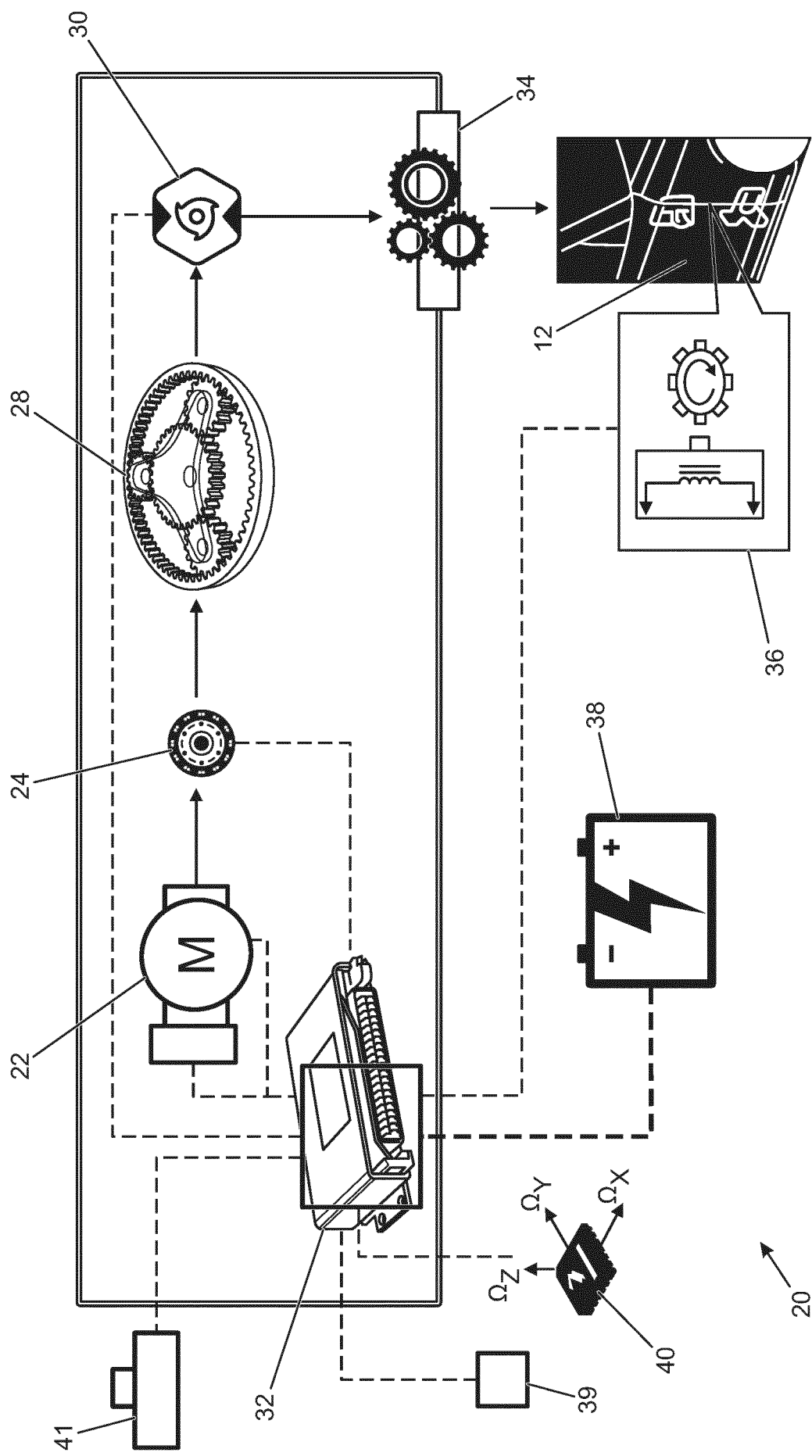


Figure 2

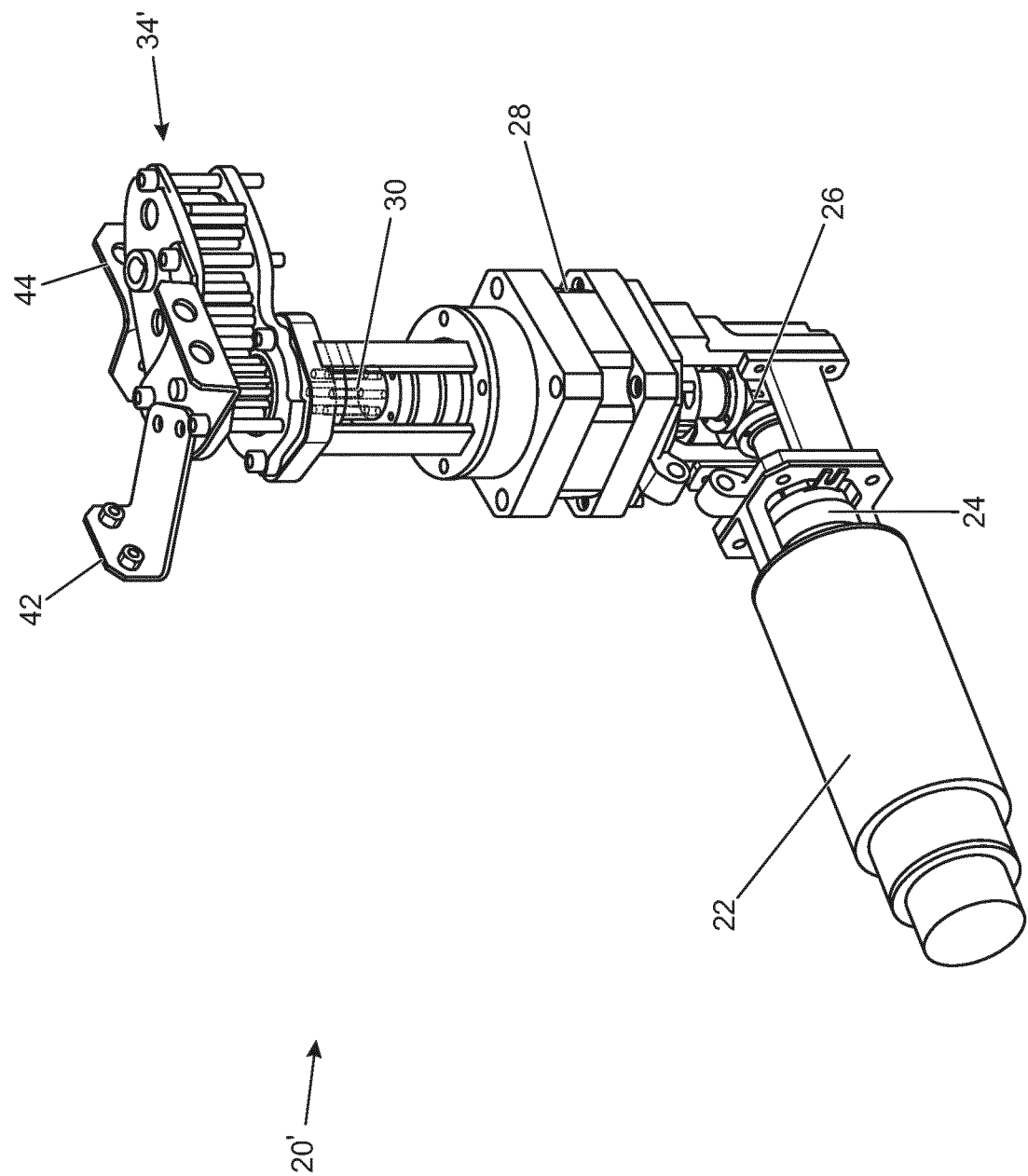


Figure 3

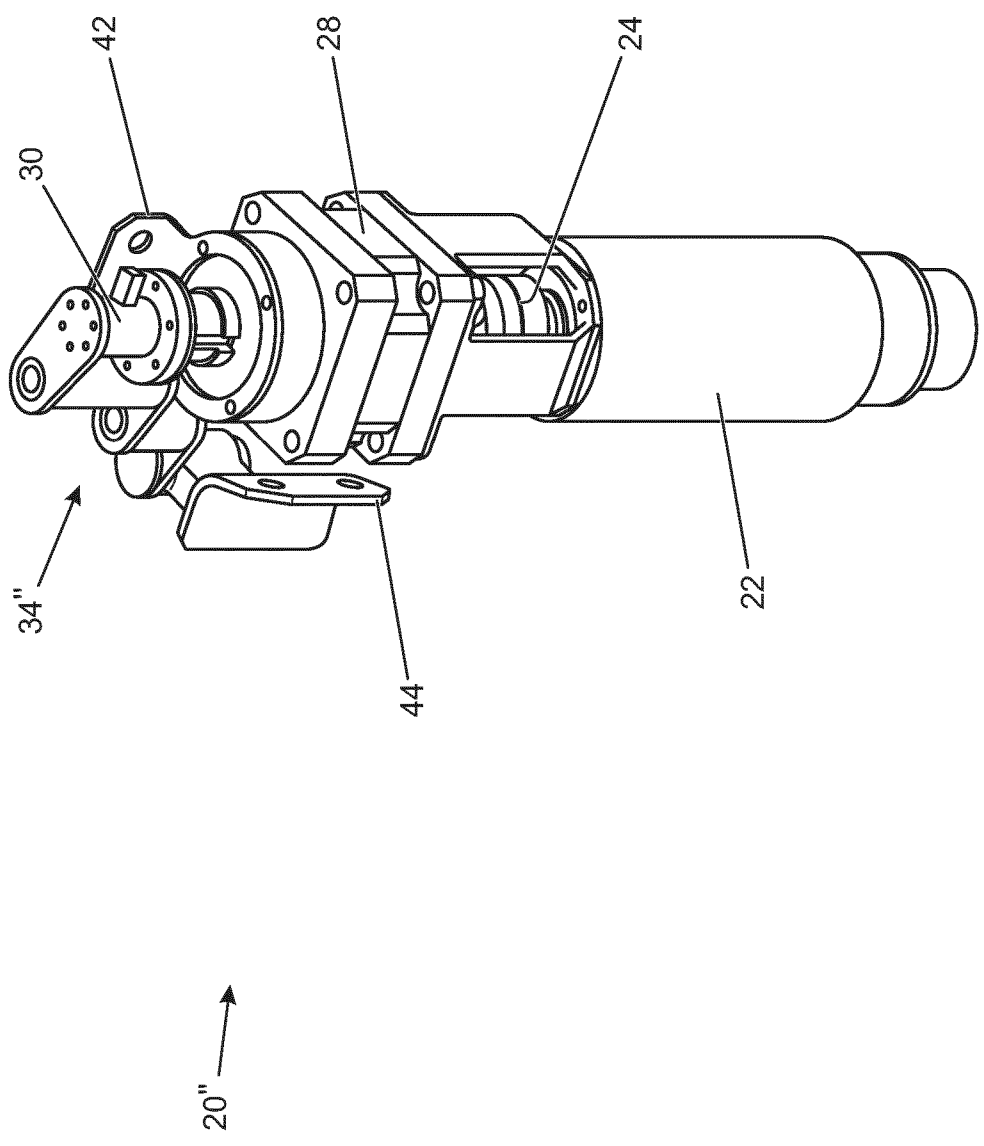
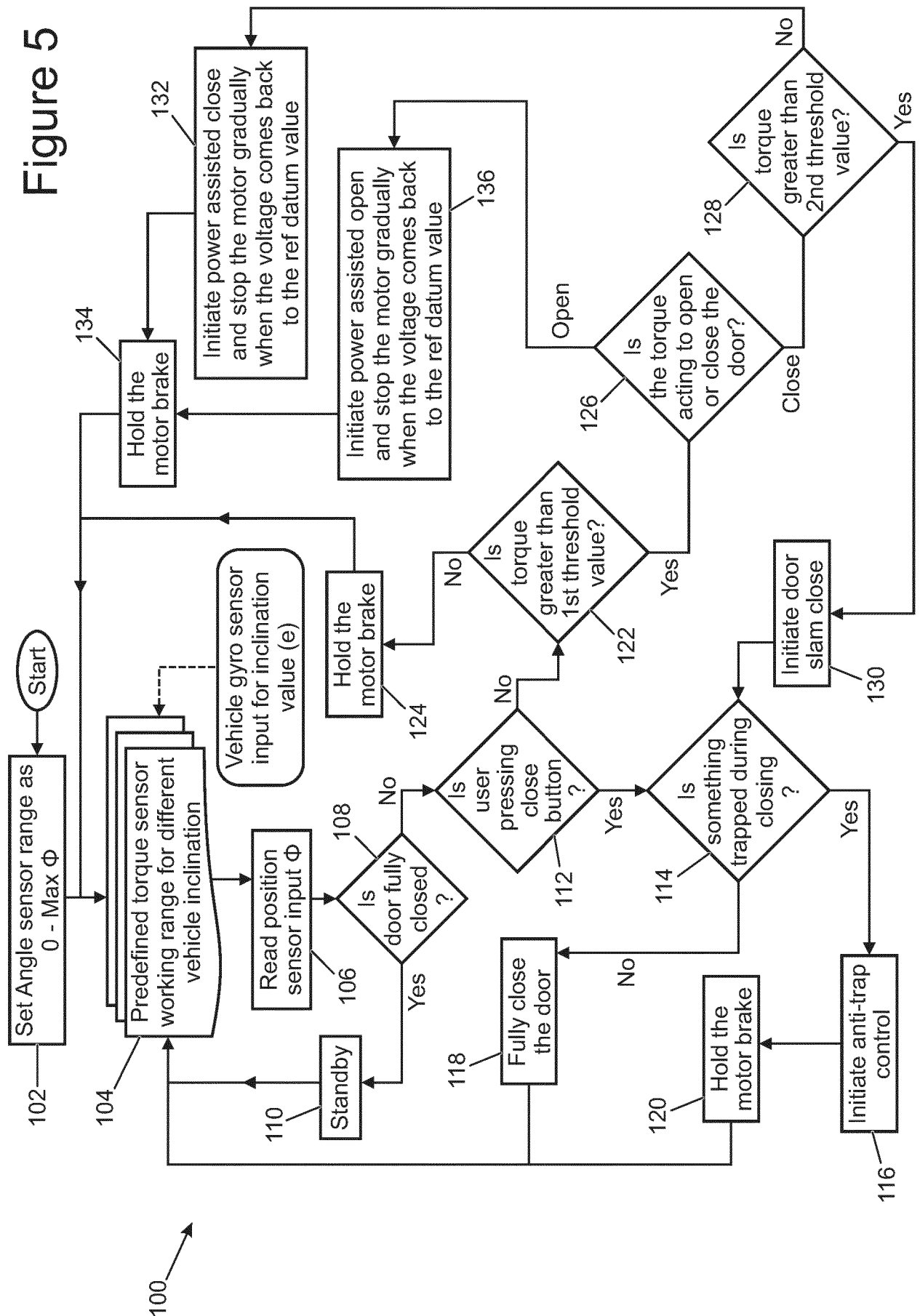


Figure 4

Figure 5



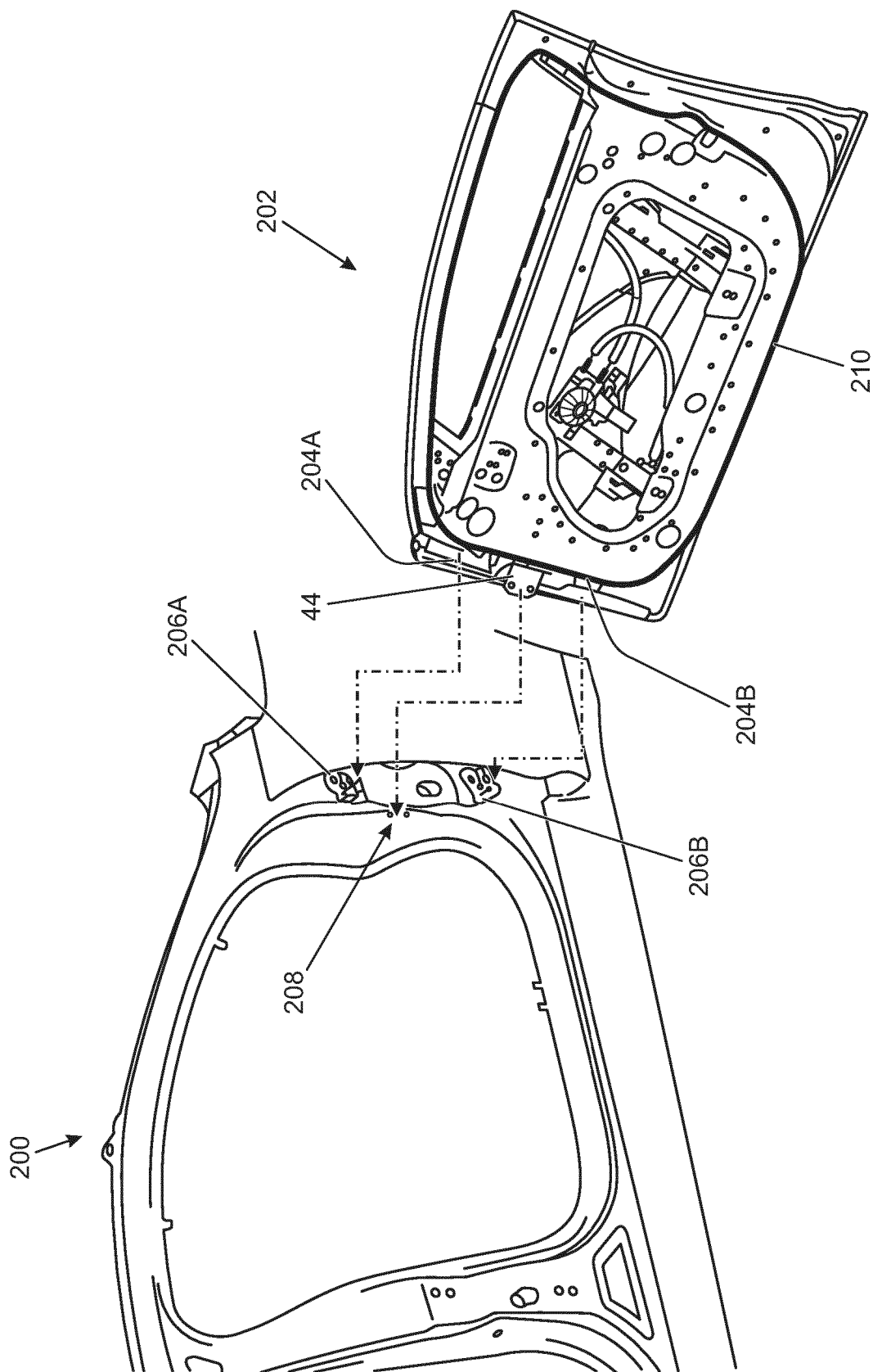


Figure 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/062013

A. CLASSIFICATION OF SUBJECT MATTER

INV. E05F15/603 E05F15/611
ADD. E05F15/614 E05F15/63

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)
E05F

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	JP 2000 356069 A (ASMO CO LTD) 26 December 2000 (2000-12-26)	1-9, 12-27
Y	paragraphs [0023], [0034] - [0121]; figures 1-16	10,11
A	----- DE 10 2010 023398 A1 (AUDI AG [DE]) 15 December 2011 (2011-12-15) paragraph [0025] - paragraph [0040]; figures 1-4	6-8
Y	----- DE 10 2014 225150 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 9 June 2016 (2016-06-09) paragraphs [0004], [0007], [0010], [0032] - [0051], [0057]; claims 1,11; figures 1,3,5	10,11
	----- -/-	



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

"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

2 August 2017

Date of mailing of the international search report

11/08/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Rémondot, Xavier

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/062013

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009/217596 A1 (NEUNDORF ROBERT [DE] ET AL) 3 September 2009 (2009-09-03) paragraph [0060]; figure 3a -----	13
X	DE 10 2007 062472 A1 (UNIV MUENCHEN TECH [DE]) 25 June 2009 (2009-06-25) paragraph [0036] - paragraph [0042]; figures 1,2 -----	1-25

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/062013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2000356069 A	26-12-2000	NONE	
DE 102010023398 A1	15-12-2011	NONE	
DE 102014225150 A1	09-06-2016	NONE	
US 2009217596 A1	03-09-2009	AT 483085 T CN 101379262 A DE 102005061610 A1 EP 1982030 A1 JP 4929291 B2 JP 2009520893 A US 2009217596 A1 WO 2007071641 A1	15-10-2010 04-03-2009 05-07-2007 22-10-2008 09-05-2012 28-05-2009 03-09-2009 28-06-2007
DE 102007062472 A1	25-06-2009	NONE	