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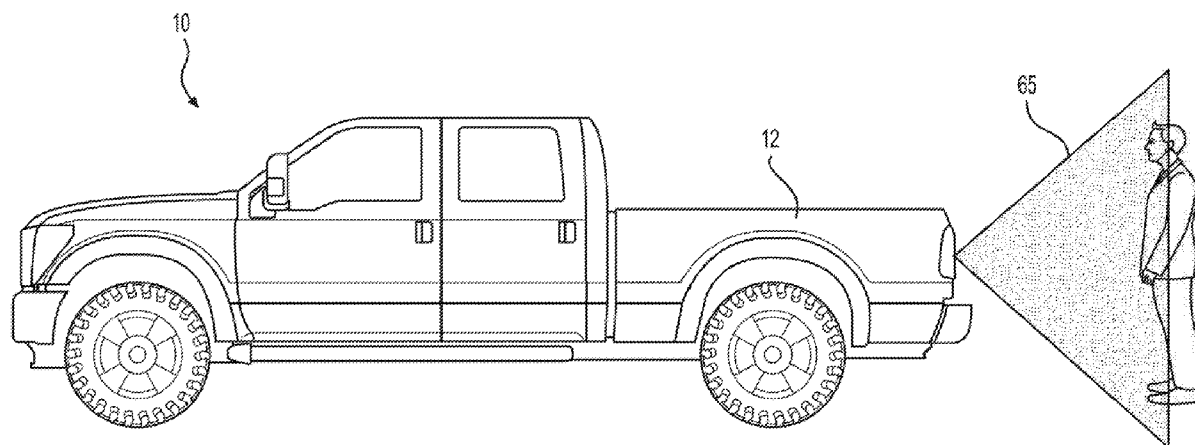


FIG. 1

(57) Abstract: An actuator assembly for opening and closing a closure of a vehicle, such as a door or a tailgate, is provided. The system includes a motor such as an electric motor which may be coupled to the closure via a linkage, with the linkage mechanically coupled to the closure and operable to move the closure between a closed position and an open position. The linkage includes one or more U-joints and may use torque fluctuations from the one or more U-joints to provide a mechanical advantage that varies as the closure moves between the closed and open positions. A high-bandwidth MR clutch having a high dynamic response may selectively couple the motor with the closure to provide a haptic or tactile feedback to a user interacting with the closure as it is opened or closed.



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VEHICLE CLOSURE ACTUATOR ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This PCT International Patent Application claims the benefit of U.S. Provisional Patent Application Serial No. 62/642,922 filed on March 14, 2018, and titled “Vehicle Closure Actuator Assembly”, the entire disclosure of which is hereby incorporated by reference.

BACKGROUND

[0002] Power actuated vehicle closures such as doors, tailgates, and liftgates are provided in a variety of vehicles such as mini-vans and sport utility vehicles, and may be available as an upgrade or included in a premium package, which can be highly profitable for a vehicle manufacturer. Tailgates are provided on many vehicles, such as pickup trucks and sport utility vehicles, for providing access to cargo areas and to aid in loading and unloading items or cargo from the vehicle. Power actuated or power assisted doors and liftgates are popular options for people who frequently have many items to load and unload from their vehicle, such as parents of small children. Power actuated or power assisted doors and liftgates are especially useful for persons who lack the physical stature or strength to easily open and close a vehicle door or liftgate manually.

[0003] Pickup trucks and sport utility vehicles have been increasingly popular and now account for a substantial percentage of new vehicle sales. There is a large and growing market for vehicles that include upgraded or premium features and fixtures, which may include power assisted or power actuated components, particularly ones with precise control that requires minimal effort to use.

SUMMARY

[0004] An actuator assembly for moving a closure of a vehicle having a body includes a linkage with an input shaft and an output shaft and a universal joint operatively disposed between the input and output shafts for transmitting torque therebetween. The actuator

assembly also includes a motor configured to be fixed to one of the body or the closure and coupled to the other one of the body or the closure through the linkage to move the closure between a closed position and an open position.

[0005] According to one exemplary embodiment, the vehicle closure may be a tailgate. According to another exemplary embodiment, the closure may be a hinged door. The actuator assembly may also be used with other types of vehicle closures such as, for example, a sliding door or window or a liftgate style tailgate as is commonly provided on minivans, hatchbacks, and sport utility vehicles.

DESCRIPTION OF THE DRAWINGS

[0006] The detailed description refers to the following drawings, in which like numerals refer to like items, and in which:

[0007] FIG. 1 is a side view of a vehicle showing a field of view of a rear-view camera;

[0008] FIG. 2 is a profile view of an embodiment of an actuator assembly;

[0009] FIG. 3 is a side view of a universal joint;

[0010] FIG. 4A is a perspective view of the actuator assembly of FIG. 2 located within a tailgate;

[0011] FIG. 4B is an enlarged view of the actuator assembly of FIG. 4A;

[0012] FIG. 5 is a profile view of another embodiment of an actuator assembly;

[0013] FIG. 6A is a perspective view of the actuator assembly of FIG. 5 located within a tailgate;

[0014] FIG. 6B is an enlarged view of the actuator assembly of FIG. 6A;

[0015] FIG. 7A is a cutaway front view of a segment of a tailgate with another embodiment of an actuator assembly located therein;

[0016] FIG. 7B is a cutaway rear view of a segment of the tailgate of FIG. 7A showing the actuator assembly located therein;

[0017] FIG. 8 is a side view of a vehicle with a liftgate and with yet another embodiment of the actuator assembly in a cutaway portion of the vehicle body; and

[0018] FIG. 9 is a graph showing output shaft speed as a function of input shaft speed of an actuator assembly with lines representing different joint angles.

DETAILED DESCRIPTION OF THE EXAMPLE EMBODIMENTS

[0019] The invention is described more fully hereinafter with references to the accompanying drawings, in which exemplary embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these exemplary embodiments are provided so that this disclosure is thorough, and will fully convey the scope of the invention to those skilled in the art. It will be understood that for the purposes of this disclosure, “at least one of each” will be interpreted to mean any combination the enumerated elements following the respective language, including combination of multiples of the enumerated elements. For example, “at least one of X, Y, and Z” will be construed to mean X only, Y only, Z only, or any combination of two or more items X, Y, and Z (e.g., XYZ, XZ, YZ, X). Throughout the drawings and the detailed description, unless otherwise described, the same drawing reference numerals are understood to refer to the same elements, features, and structures. The relative size and depiction of these elements may be exaggerated for clarity, illustration, and convenience. Unless otherwise stated, any reference to moving between two or more different positions should be construed as including moving in either direction from one position to another position or vice-versa.

[0020] Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, an actuator assembly **20** for moving a closure of a vehicle **10** is disclosed. The actuator assembly **20** may react to a user input, which may be, for example, a touch or other pressure applied to the closure or the press of a button on the vehicle or on a remote device such as a key fob. The user input may also be gesture based and may be sensed by a camera or other remote sensor located on the vehicle such as, for example, ultrasonic, capacitive, radar, etc. The actuator assembly **20** may then actuate the closure to move between its opened and closed positions or vice-versa. The actuator assembly **20** may respond to small changes in the velocity of the closure as it is being opened or closed and may provide very precise control of the motion of the closure sufficient to provide haptic or touch feedback. In this way, the actuator assembly **10** may enable a closure to operate in a power-assist mode in which the user may perceive the closure as having a very light weight.

[0021] As shown in FIG. 1, the vehicle **10** includes a body **12**, which includes a frame, chassis, a plurality of body panels and structural components such as pillars and frame members. A plurality of closures **14**, such as doors, a hood, a tailgate and/or liftgate are movably fixed to the body for opening and closing relative thereto to provide access to one or more compartments within the vehicle **10**, such as a passenger compartment, trunk, bed, or cargo area.

[0022] FIG. 2 illustrates a first embodiment **20'** of the actuator assembly **20**, which includes a motor **22**, which may be an electric motor, and gearing to turn an output shaft **28b** at a desired output RPM. The motor **22** is selectively coupled to the body **12** of the vehicle **10** through a clutch **24**, a gearbox **26**, and a linkage **28** including a universal joint **30**. The linkage **28** includes an input shaft **28a** driven by the motor **22** and an output shaft **28b** for transmitting torque from the actuator assembly **20**. In the first embodiment **20'**, the output shaft **28b** is connected to rotate a tailgate pivot **32**. The tailgate pivot **32** couples the tailgate **14** to a lug

(not shown) which is fixed to the body **12** of the vehicle **10**. By exerting a rotary force on the tailgate pivot **32**, the actuator assembly **20** biases the tailgate in an opening or a closing direction. The tailgate pivot **32** includes a slot, which may allow the tailgate **14** to be removed from the vehicle **10**. A bracket **34** holds the actuator assembly **20** in a fixed position within the tailgate **14**, while allowing the linkage **28** to freely rotate. In the first embodiment **20'**, the bracket **34** is a simple piece of sheet metal having two straight bends disposed at an angle to each other to set a joint angle θ of the U-joint **30** (shown in FIG. 3) and to allow the wider body of the actuator assembly **22** to be moved away from the spatially-constrained zone at the bottom of the tailgate **14**. Mounting points **25** are formed in the clutch **24** and the motor **22** for securement to structural component of the closure **14** to support the actuator assembly **20** against rotary forces when the actuator assembly **20** is active. In other words, the mounting points **25** allow the actuator assembly **20** to be bolted to the structure of the closure, causing the closure **14** to move when the actuator assembly **20** applies a rotary or twisting force against the body **12** of the vehicle **10**.

[0023] The clutch **24** may be a high-bandwidth clutch **24** having a high dynamic response which may be, for example, greater than 10 Hz. More specifically, the clutch **24** may provide a dynamic response of 25 Hz or higher. The motor **22** may be a compact motor with a high output speed, which may be, for example, 10,000 to 20,000 RPM. Internal gearing (not shown) within the motor **22** may reduce the motor speed by a predetermined ratio, which may be, for example, a factor of thirty, and thereby increase the output torque. In some embodiments, the motor **22** may include an electric motor operating at a nominal speed of 15,000 RPM and the internal gearbox may reduce the output speed to 500 RPM. The separate gearbox **26** couples the motor **22** to the linkage **28** and may further reduce the speed that the input shaft **28a** of the linkage **28** is turned. The separate gearbox **26** may, for example, cause the input shaft **28a** to be driven at a constant speed of about 2.5 to 5.0 RPM. Where the linkage

28 provides a 1:1 average gear ratio, the input shaft **28a** rotating at 2.5 RPM would result in the closure being moved through a 90-degree range in 6.0 seconds; and the input shaft **28a** rotating at 5.0 RPM would result in the closure being moved through a 90-degree range in 3.0 seconds.

[0024] The clutch **24** may be controllable by varying one or more properties of a fluid, which may be a magnetorheological (MR) fluid that varies in viscosity due to an applied magnetic field. Alternatively, a stepper motor, which may or may not include gearing, may directly actuate the linkage **28** without a clutch **24**. In some embodiments, the clutch **24** may be rated to transfer a torque of at least about 5 Nm.

[0025] As shown in FIG. 3, the universal joint **30**, which may also be called a U-joint, may be a cardan joint including an input member **36** configured to rotate about a first axis **A1** and an output member **38**, configured to rotate about a second axis **A2**, with a yoke **40** pivotably connected to each the input member **36** and the output member **38** for transferring rotary motion therebetween. As also shown in FIG. 3, the universal joint **30** defines a joint angle θ as the angle between the first axis **A1** and the second axis **A2**.

[0026] FIG. 5 illustrates a second embodiment **20''** of the actuator assembly **20**, which is generally similar to the first embodiment **20'**, as described above, except for the configuration of the linkage **28**, which includes two universal joints **30**. FIGS. 6A and 6B illustrate the second embodiment **20''** of the actuator assembly **20** as mounted within the tailgate **14**. An intermediate member **42** is disposed at an angle between the two universal joints **30**. This provides for the actuator assembly **20** to be packaged within the tailgate **14** as shown in FIGS. 6A and 6B, with the motor **22** and the clutch **24** and the gearbox **26** extending in a generally straight line, parallel, but spaced apart from the pivoting axis of the tailgate pivot **32**, which may be located adjacent the lowermost edge of the tailgate **14**.

[0027] FIGS. 7A and 7B illustrate a third embodiment **20'''** of the actuator assembly **20**, which is generally similar to the second embodiment **20''**, as described above, except for the configuration of the bracket **34**, which includes a cylindrical portion **44** separated from a base plate **46** by four legs **48**. The third embodiment **20'''** of the actuator assembly **20** also includes a support bracket **54** extending about the motor **22**, opposite the clutch **24**, for holding the motor **22** in place within the tailgate **14**, and with the support bracket **54** having a rubber or urethane isolation insert **55** for noise abatement, and defining a hole **56** between the motor **22** and the edge of the tailgate **14** for allowing a full length torsion bar (not shown) to pass through. A mounting plate **58** is fixed to the tailgate pivot **32** for securement onto the body **12** of the vehicle, thereby allowing the actuator assembly **20** to open or close the tailgate **14** by exerting a rotating force between the tailgate **14** and the body **12**. As shown in FIG. 7B, an inner wall **16** of the tailgate **14** defines an access opening **60** to the interior of the tailgate **14** to allow the actuator assembly **20** to be installed and to be serviced.

[0028] FIG. 8 illustrates a fourth embodiment **20''''** of the actuator assembly **20**, which is generally similar to the second embodiment **20''**, as described above, except that the actuator assembly **20''''**, including the linkage **28** with two universal joints **30**, is disposed within the body **12** of the vehicle **10**, and not inside of the liftgate **14**. Because the actuator assembly **20** extends generally transversely to the pivoting axis of the liftgate **14**, the fourth embodiment **20''''** may require additional mechanical coupling, such as a pair of bevel gears (not shown) to translate the rotary motion from the actuator assembly **20** to a direction of the pivoting axis of the liftgate **14**.

[0029] In some embodiments the linkage **28** produces a variable gear ratio between the output shaft **28b** and the input shaft **28a**, with the variable gear ratio having a ratio that varies with an input angle γ_1 of the input shaft **28a**, which is a measure of the rotation of the input shaft **28a** as the input shaft **28a** is driven by the motor **22**. The variable gear ratio is shown

graphically on FIG. 9, which plots varying rotational speed of an output shaft **28b** of a universal joint **30** with its input shaft **28a** rotated at a constant speed. As shown in FIG. 9, the rotational speed of the output shaft **28b** varies sinusoidally with the input angle γ_1 , with the severity of the variable gear ratio effect depending on the joint angle θ . The impact of the joint angle θ on the variable gear ratio effect is shown in the different lines on FIG. 9, where line (a) represents the rotational speed of the output shaft **28b** relative to rotational speed of the input shaft **28a** of a universal joint **30** with a joint angle $\theta = 15$ degrees; line (b) represents the rotational speed of the output shaft **28b** relative to rotational speed of the input shaft **28a** of a universal joint **30** with a joint angle $\theta = 30$ degrees; line (c) represents the rotational speed of the output shaft **28b** relative to rotational speed of the input shaft **28a** of a universal joint **30** with a joint angle $\theta = 45$ degrees; and line (d) represents the rotational speed of the output shaft **28b** relative to rotational speed of the input shaft **28a** of a universal joint **30** with a joint angle $\theta = 60$ degrees. In the first embodiment **20'** of the actuator assembly **20**, having a single universal joint **30** with a joint angle θ of about 15 degrees, this effect is negligible, and the universal joint **30** provides about a 1:1 gear ratio regardless of the input angle γ_1 , as shown in line (a).

[0030] In some embodiments, such as the second, third, and fourth embodiments **20''**, **20'''**, **20''''** of the actuator assembly **20**, described above, the linkage **28** has two universal joints **30**. In typical applications, such as in vehicle driveshafts, the variable gear ratio effect is detrimental, and is minimized by orienting two universal joints **30** such that the effect is cancelled-out. However, in some embodiments of the present disclosure, this variable gear ratio effect used advantageously to provide a gear ratio that varies with an input angle as the linkage **28** is rotated by the motor **22**. The two universal joints **30** of the of the actuator assembly **20**, may be oriented to have a constructive interference, thereby causing the gear ratio of the linkage **28** to be a multiple of the gear ratios of the constituent universal joints **30** within the linkage **28**.

[0031] The gear ratio of the linkage **28** may therefore also vary with the position of the vehicle closure. For example, where the closure is a tailgate **14**, the actuator assembly **20** may provide a first gear ratio with the tailgate **14** in a closed position and a second gear ratio that is higher than the first gear ratio with the tailgate **14** in an opened position. This provides additional torque to lift the tailgate **14** against the full force of gravity when the tailgate **14** is fully horizontal. As the tailgate **14** moves closer to the closed, or upright position, less torque is required to overcome the force of gravity, and at the same time, the higher gearing ratio allows the actuator assembly **20** to move the tailgate **14** at a faster speed, thereby reducing the amount of time needed to complete an opening or closing operation. In some embodiments, the first gear ratio may be less than 1:1 with the output shaft **28b** rotating at a lower RPM than the input shaft **28a**. In some embodiments, the second gear ratio may be greater than 1:1 with the with the output shaft **28b** rotating at a higher RPM than the input shaft **28a**. This variable gear ratio effect may also be applied where the actuator assembly **20** is used with other types of closures such as a liftgate **14** or a trunk lid.

[0032] In some embodiments, the linkage **28** includes two or more joints **30** configured so that the variable gearing between the output shaft **28b** and the input shaft **28a** of the linkage **28** is greater than the gear ratio of any of the constituent joints **30** within the linkage **28**. For example, in an actuator assembly **20** having two universal joints **30** each with a joint angle $\theta = 45$ degrees and which are oriented to magnify one-another, the gear ratio of each of the universal joints **30** may vary from 1.4:1 with the input angle $\gamma_1 = 0$ degrees to 0.7:1 with the input angle $\gamma_1 = 90$ degrees. This is shown in line (c) of FIG. 9, as described above. The combined variable gear ratio of the linkage **28** would, therefore, vary from $1.4 \times 1.4 = 1.96:1$ with the input angle $\gamma_1 = 0$ degrees to $0.7 \times 0.7 = 0.49:1$ with the input angle $\gamma_1 = 90$ degrees. In this example, the linkage **28** is configured to have a maximum gear ratio of 1.96:1, greater than 1:1, with the tailgate **14** in an upright, or fully-closed position and a minimum gear ratio

of 0.49:1, less than 1:1, with the tailgate **14** in a horizontal, or fully-opened position. The lower gear ratio may be beneficial to provide additional torque to lift the tailgate **14** against the full force of gravity that is greatest with the tailgate **14** in the opened position, and the larger gear ratio may be beneficial to more quickly move the tailgate **14**, particularly where the tailgate **14** is closer to the upright position, where less torque is required to overcome the force of gravity. It should be appreciated that these gear ratios are merely examples and that the actuator assembly **20** may be provided with different gear ratios.

[0033] The actuator assembly **20** may be substantially or completely disposed within the tailgate **14**, which may leave the area immediately above and beside the tailgate **14** unobstructed, providing a cleaner, more attractive look and providing for easier access onto the tailgate **14** and into the vehicle when compared with prior art designs that include cables or linkages between the sides of the tailgate and the body of the vehicle. The system of the present invention may allow a tailgate **14** to be provided without a physical handle, allowing for a cleaner and more attractive style. It should be noted that the arrangement shown in FIGS 4A, 4B, 6A, 6B, 7A, and 7B may be reversed with the actuator assembly **20** packaged within the body **12** of the vehicle **10**.

[0034] According to an aspect, the linkage **28** may be mechanically coupled to the body **12** of the vehicle **10** and operable to move the tailgate **14** between the closed position and the open position in either an opening or a closing direction. The clutch **24** may be adjusted to a plurality of intermediate positions between its engaged and disengaged positions, in which linkage **28** is partially coupled to rotate with the output of the gearbox **26**, but not fully fixed thereto, so the linkage **28** may rotate at the same speed or at a different speed than the output of the gearbox **26**. A spring (not shown) may bias the tailgate **14** toward the closed position and may oppose the pull of gravity which normally biases the tailgate **14** toward the opened

position. The spring may include, for example, a gas cylinder or a clock spring or a torsion spring.

[0035] According to an aspect, and as illustrated in FIG. 1, the actuator assembly **20** may be used in a system including a rear-view camera or another sensor (not shown) having a field of view **65** behind the vehicle and configured to provide an image to a controller for object classification and motion detection. The rear-view camera or other sensor may be configured to recognize gestures within the field of view **65** and to provide a signal for an actuator controller to operate the motor **22** and selectively engage the clutch **24** to move the tailgate **14** between the open position and the closed position in response to a predetermined gesture.

[0036] According to a further aspect, the system may react to a user's application of force on the tailgate **14** without using a pressure sensor. For example, the system may respond to the angular location of the tailgate **14**, which may be sensed by an encoder. In this way, the system may detect the external application of force as a difference from a typical force of the tailgate **14** including the force of gravity and forces resulting from motion at a given position and at a given velocity and/or acceleration. The system may determine the typical force by reference to a calculated or predefined relationship, e.g. by reference to a look-up table, which may provide typical forces that result from a given angular location of the tailgate **14** and torque output of the clutch **24**.

[0037] The system may include anti-pinch functionality, which may cause the actuator controller to stop or to reverse direction of the closure in response to a detected obstruction while the closure is being opened or closed. Obstruction detection for such anti-pinch functionality may use the pressure sensor, feedback from the motor **22**, feedback from the clutch **24**, another sensor or sensors, or any combination thereof.

[0038] The clutch **24** may default in an unpowered state to an open or isolated condition. An alternative arrangement with a normally closed clutch or a partially closed clutch

is also feasible, which may be particularly advantageous for a power side door application. The clutch **24** may allow the vehicle closure to be manually operated without being impacted by drag forces due to the motor **22** or the gearbox **26**. With the clutch **24** in a fully activated, or locked condition, and with the motor **22** stationary, the actuator assembly **20** may function to hold or to lock the vehicle closure in a desired position. For example, the actuator assembly **20** may function to securely hold a tailgate **14** in the opened position which may prevent it from vibrating or bouncing as the vehicle is driven. The holding function of the actuator assembly **20** may provide an “infinite check” feature, allowing the closure **14**, which may be a side door, to be stopped and held at any intermediate position between fully closed and fully opened. Such an “infinite check” feature may provide improved feel and functionality over fixed detents commonly used in current vehicles.

[0039] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure. Many modifications and variations of the present invention are possible in light of the above teachings and may be practiced otherwise than as specifically described while within the scope of the appended claims.

CLAIMS

What is claimed is:

Claim 1. An actuator assembly for moving a closure of a vehicle having a body and comprising:

a linkage including an input shaft and an output shaft and a universal joint operatively disposed between said input shaft and said output shaft for transmitting torque therebetween;

a motor configured to be fixed to one of the body or the closure and to be coupled to the other one of the body or the closure through said linkage and operable to move the closure between a closed position and an open position by rotating said input shaft of said linkage.

Claim 2. The actuator assembly as set forth in Claim 1, further comprising a clutch selectively coupling the motor with the closure.

Claim 3. The actuator assembly as set forth in Claim 2, wherein said clutch has a dynamic response of greater than 10 Hz.

Claim 4. The actuator assembly as set forth in Claim 1, wherein said linkage includes two universal joints each operatively disposed between said input shaft and said output shaft for transmitting torque therebetween.

Claim 5. The actuator assembly as set forth in Claim 1, wherein said linkage produces a variable gear ratio between said output shaft and said input shaft, with the variable gearing having a ratio that varies with an input angle as said input shaft is rotated by said motor.

Claim 6. The actuator assembly as set forth in Claim 5, wherein said linkage includes two universal joints each operatively disposed between said input shaft and said output shaft for transmitting torque therebetween;

wherein each of said two universal joints produces a variable gear ratio; and

wherein said variable gear ratio between said output shaft and said input shaft is greater than the gear ratio of any individual one of said universal joints within said linkage.

Claim 7. The actuator assembly as set forth in Claim 5, wherein said variable gear ratio of said linkage has a maximum gear ratio of at least about 1.96:1.

Claim 8. The actuator assembly as set forth in Claim 5, wherein the closure is a tailgate;

wherein said linkage is configured to provide a first gear ratio with said tailgate in an closed position;

wherein said linkage is configured to provide a second gear ration with said tailgate in a opened position;

and wherein said first gear ratio is greater than said second gear ratio.

Claim 9. The actuator assembly as set forth in Claim 8, wherein first gear ratio is greater than 1:1.

Claim 10. The actuator assembly as set forth in Claim 8, wherein second gear ratio is less than 1:1.

Claim 11. The actuator assembly as set forth in Claim 1, wherein the closure is a tailgate.

Claim 12. The actuator assembly as set forth in Claim 11, wherein an area immediately above and beside the tailgate is unobstructed with the tailgate in an open position.

Claim 13. The actuator assembly as set forth in Claim 1, wherein the actuator assembly is configured to hold the closure in one of an opened position or a closed position or an intermediate position between the opened position and the closed position.

Claim 14. The actuator assembly as set forth in Claim 1, wherein said motor and said universal joint are enclosed within the closure.

Claim 15. The actuator assembly as set forth in Claim 1, wherein said motor and said universal joint are enclosed within the body of the vehicle.

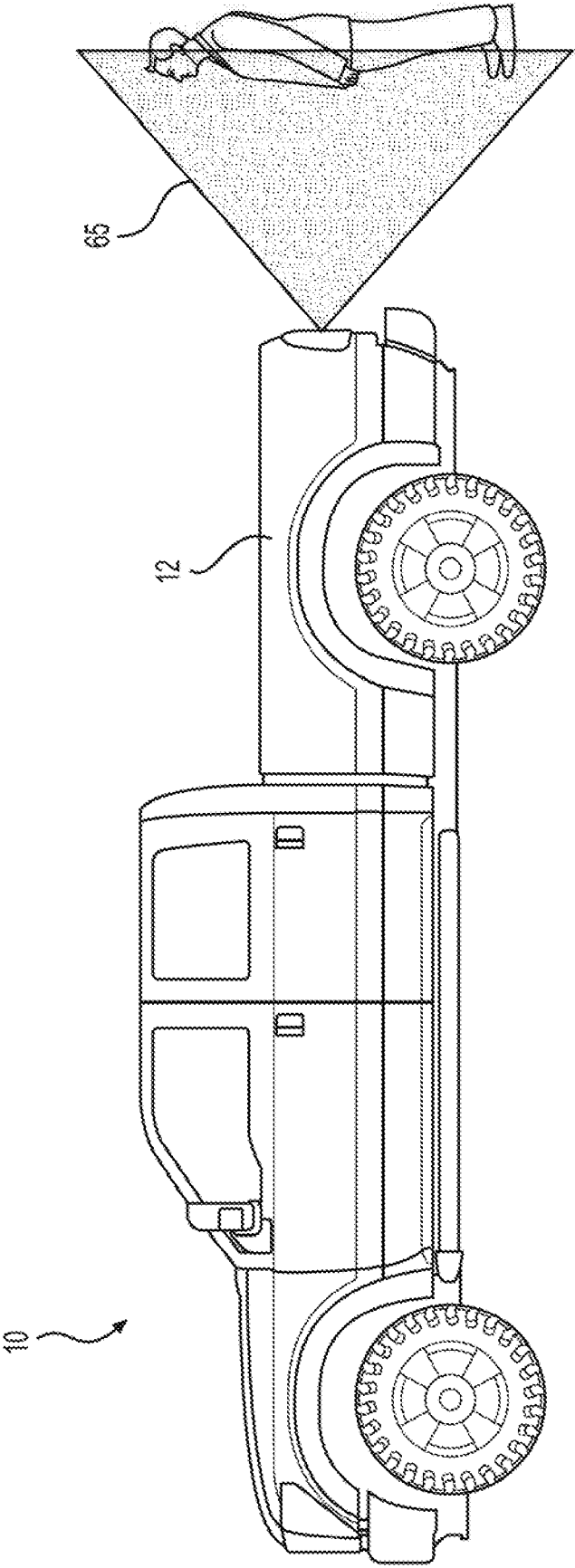


FIG. 1

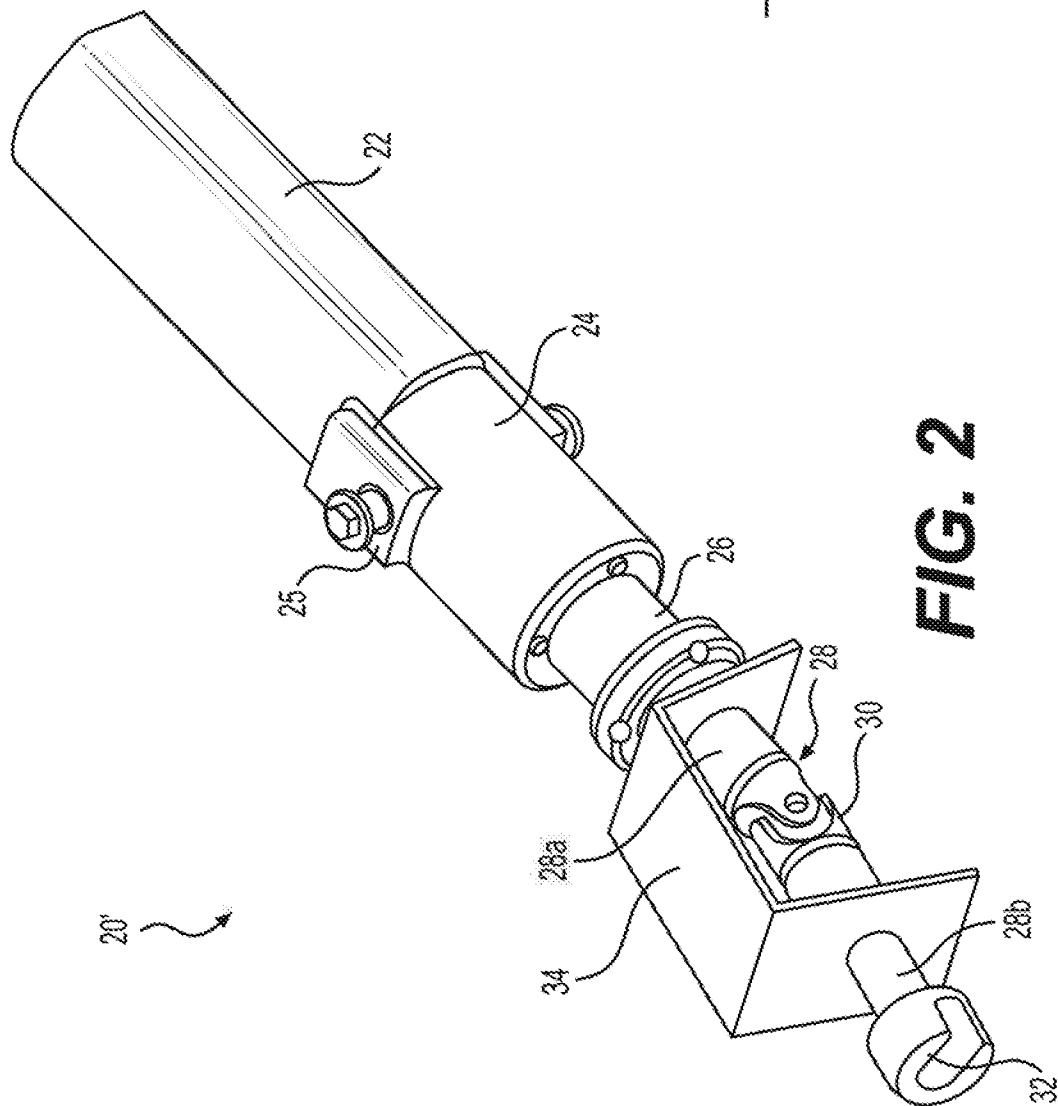


FIG. 2

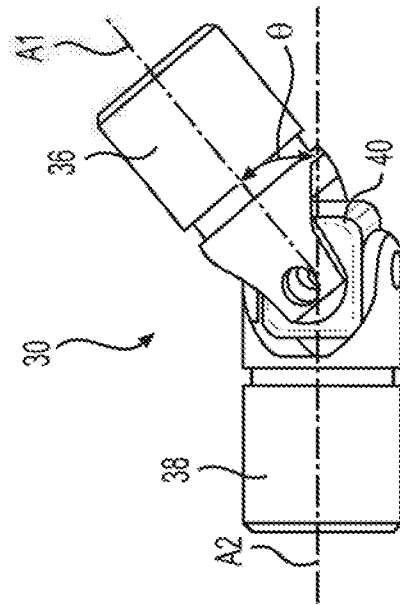


FIG. 3

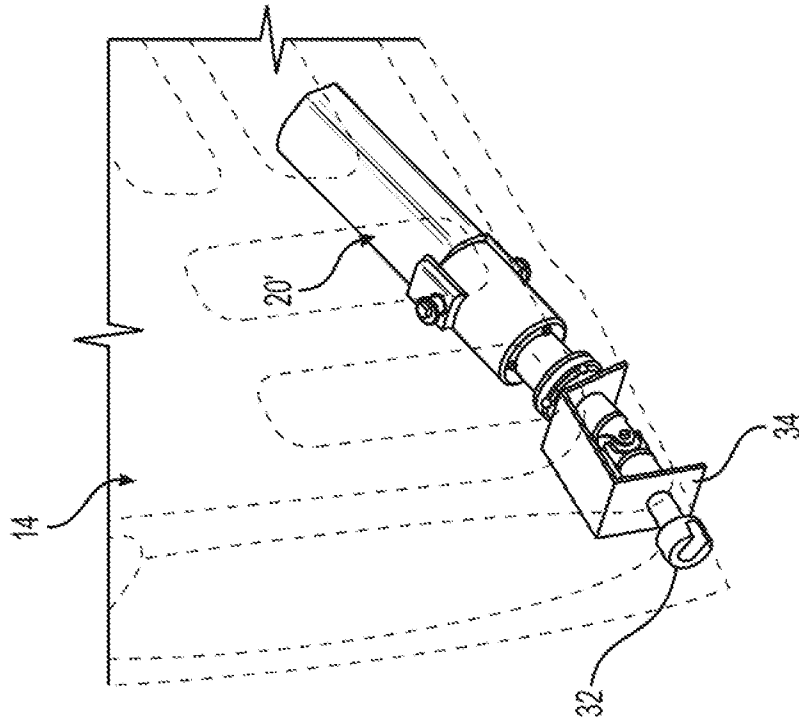


FIG. 4B

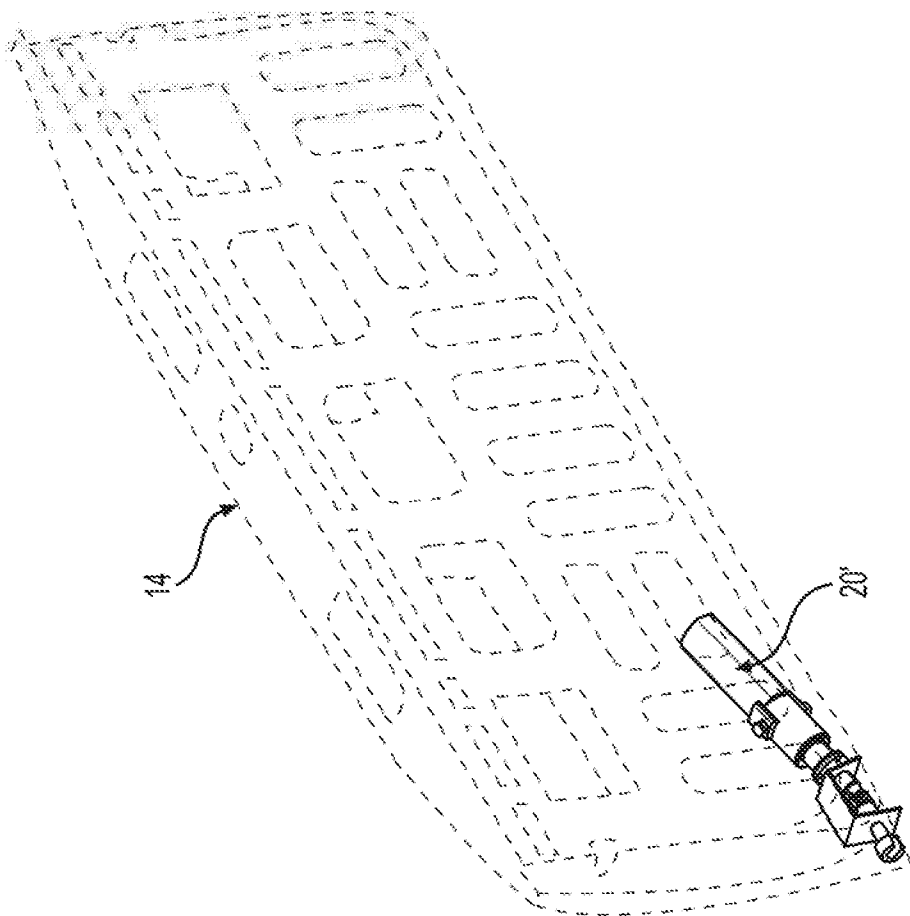


FIG. 4A

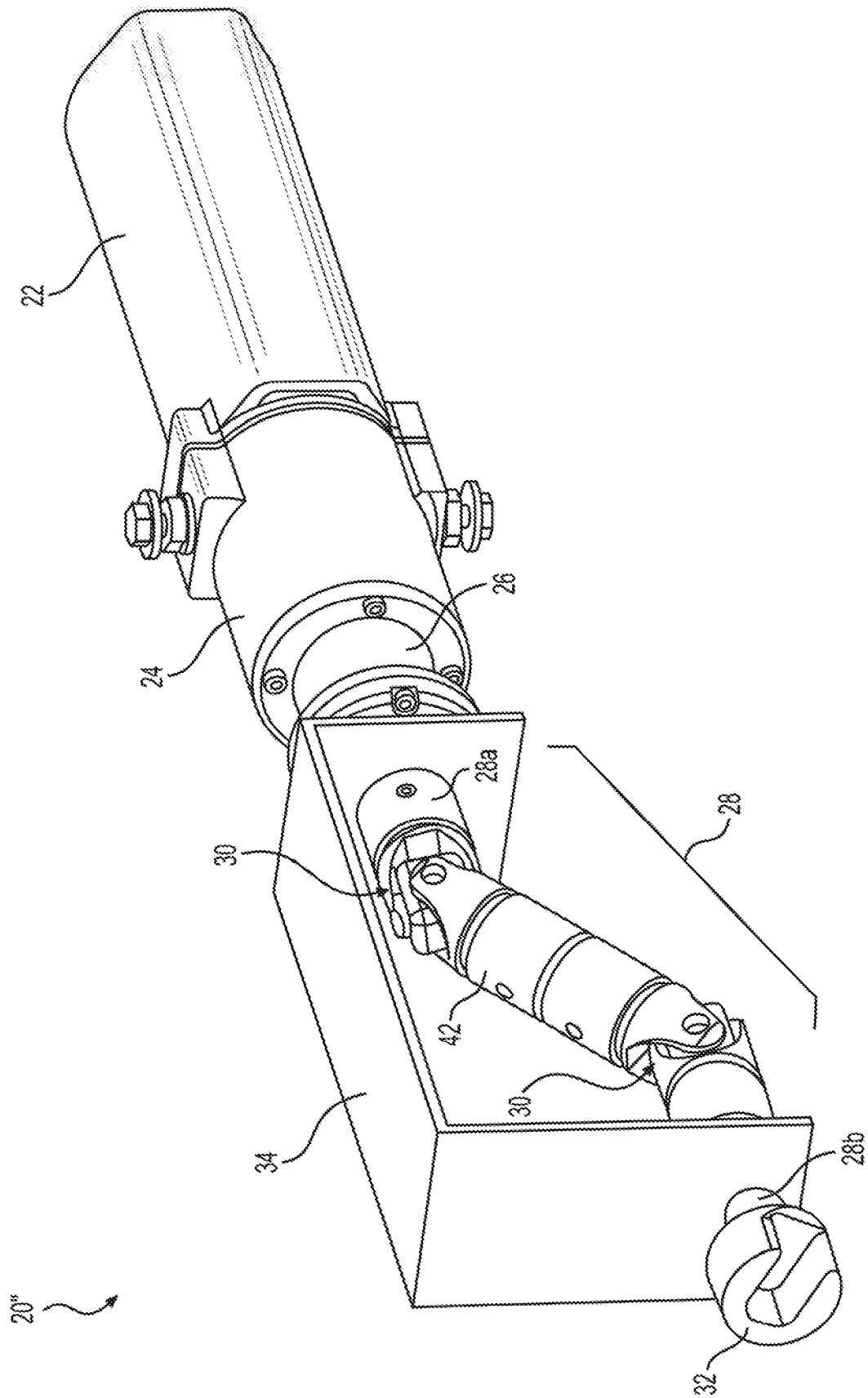


FIG. 5

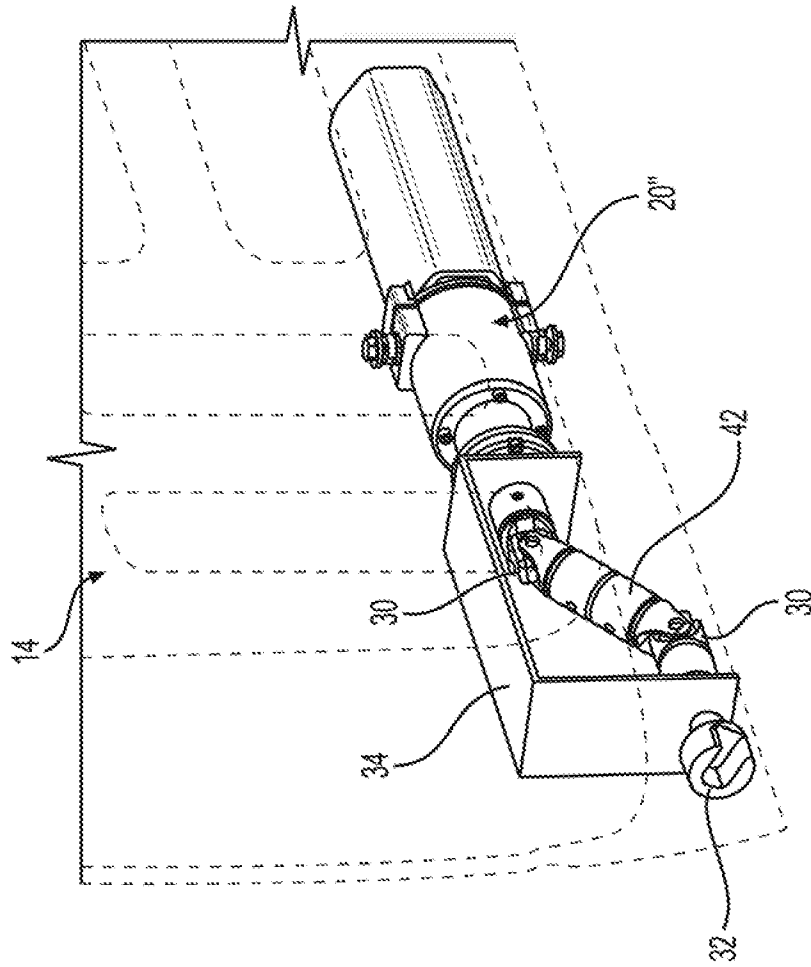


FIG. 6B

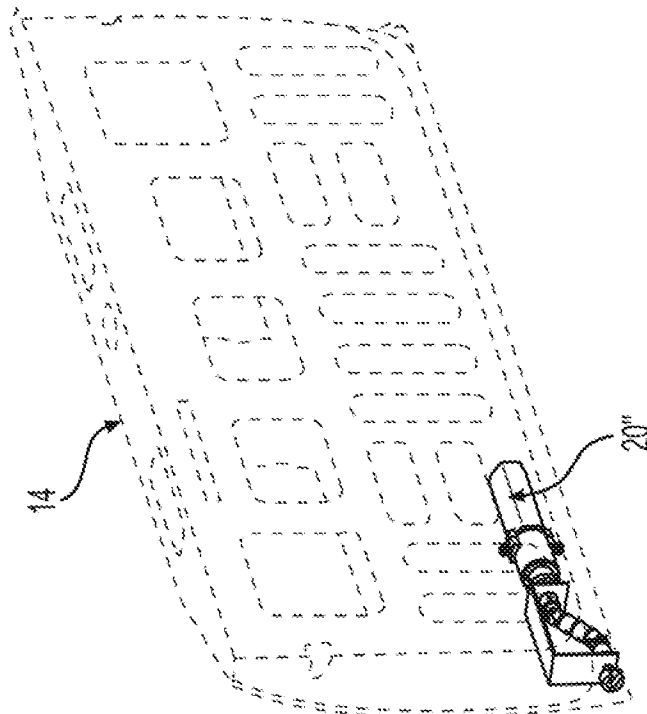


FIG. 6A

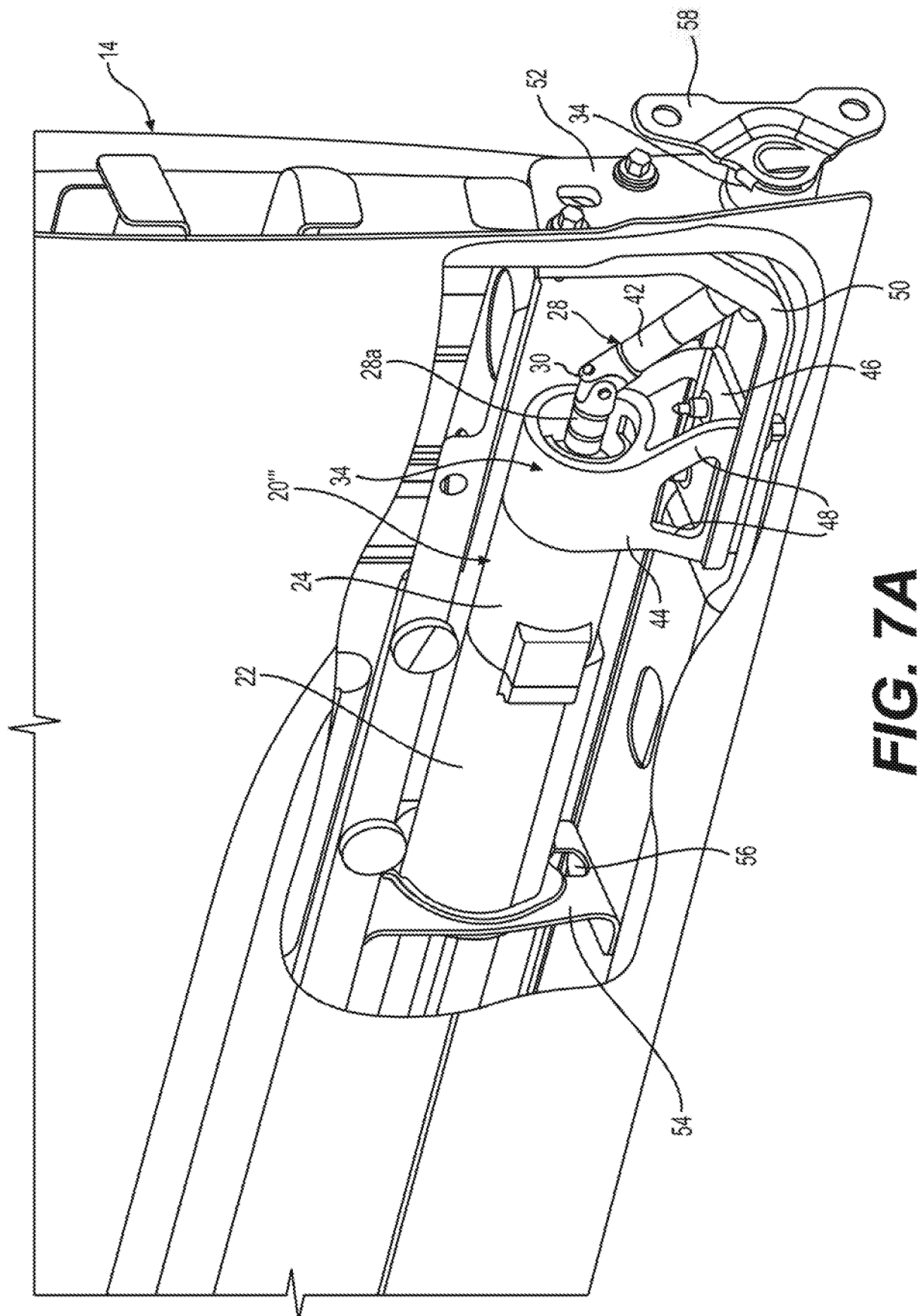


FIG. 7A

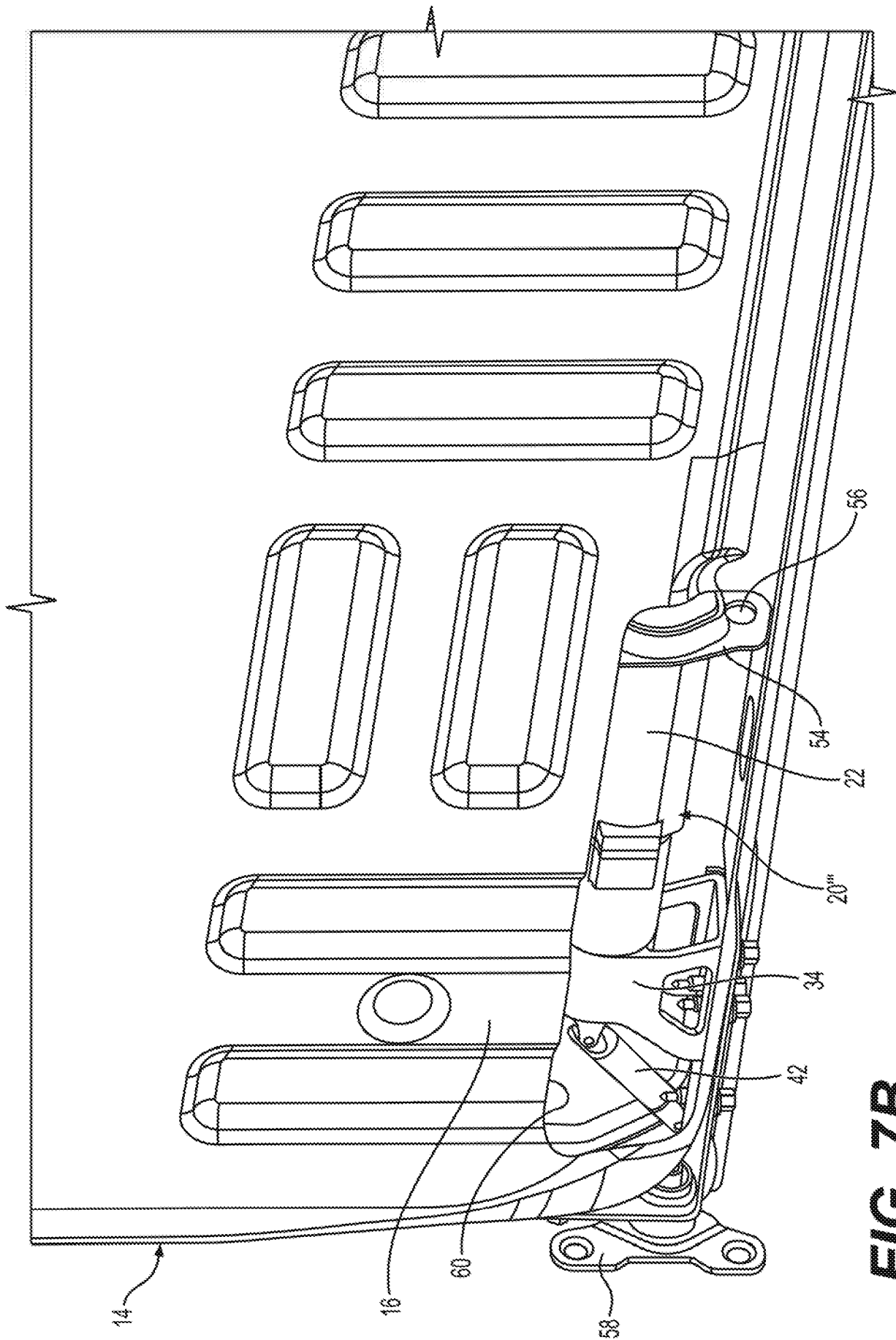


FIG. 7B

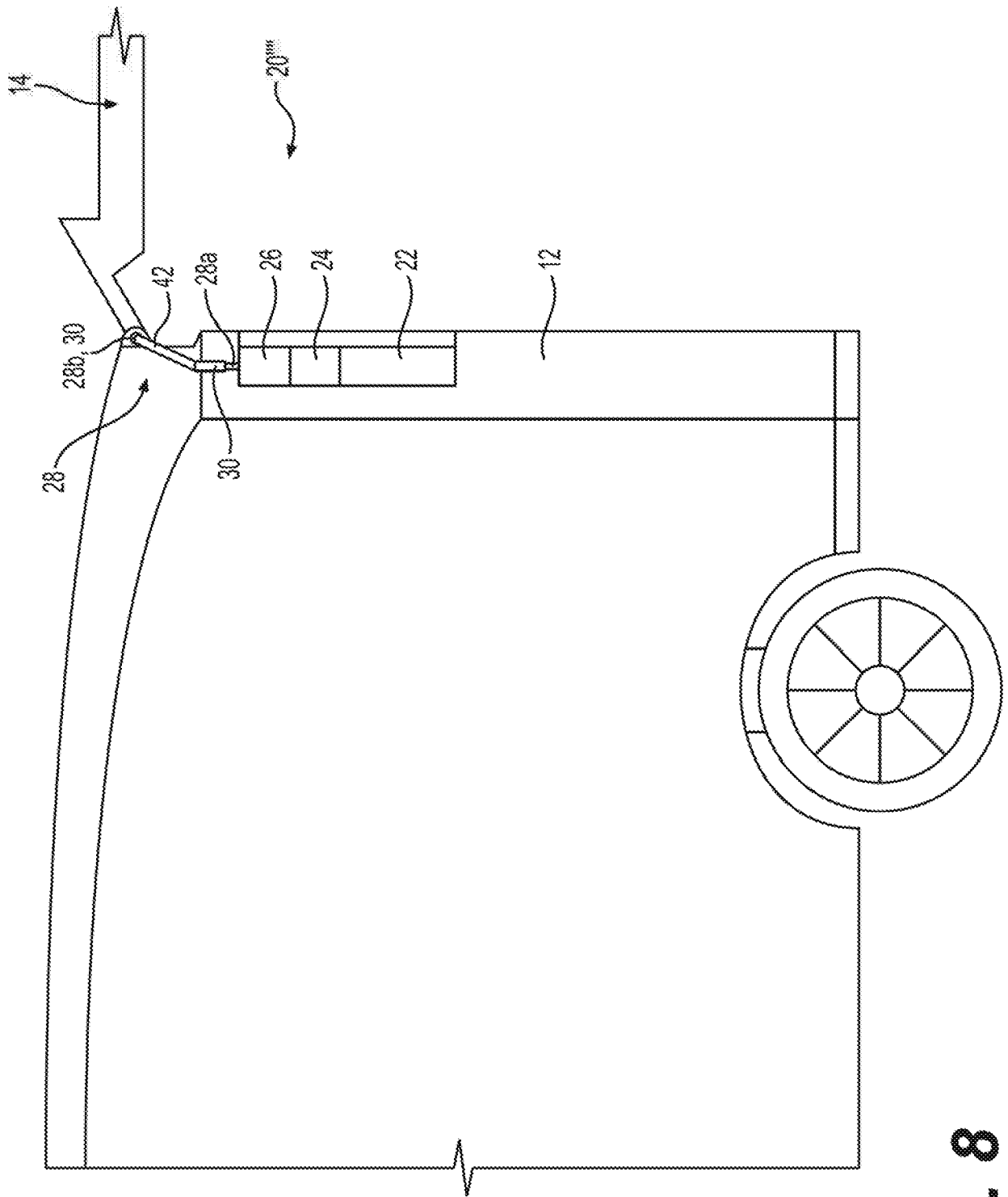


FIG. 8

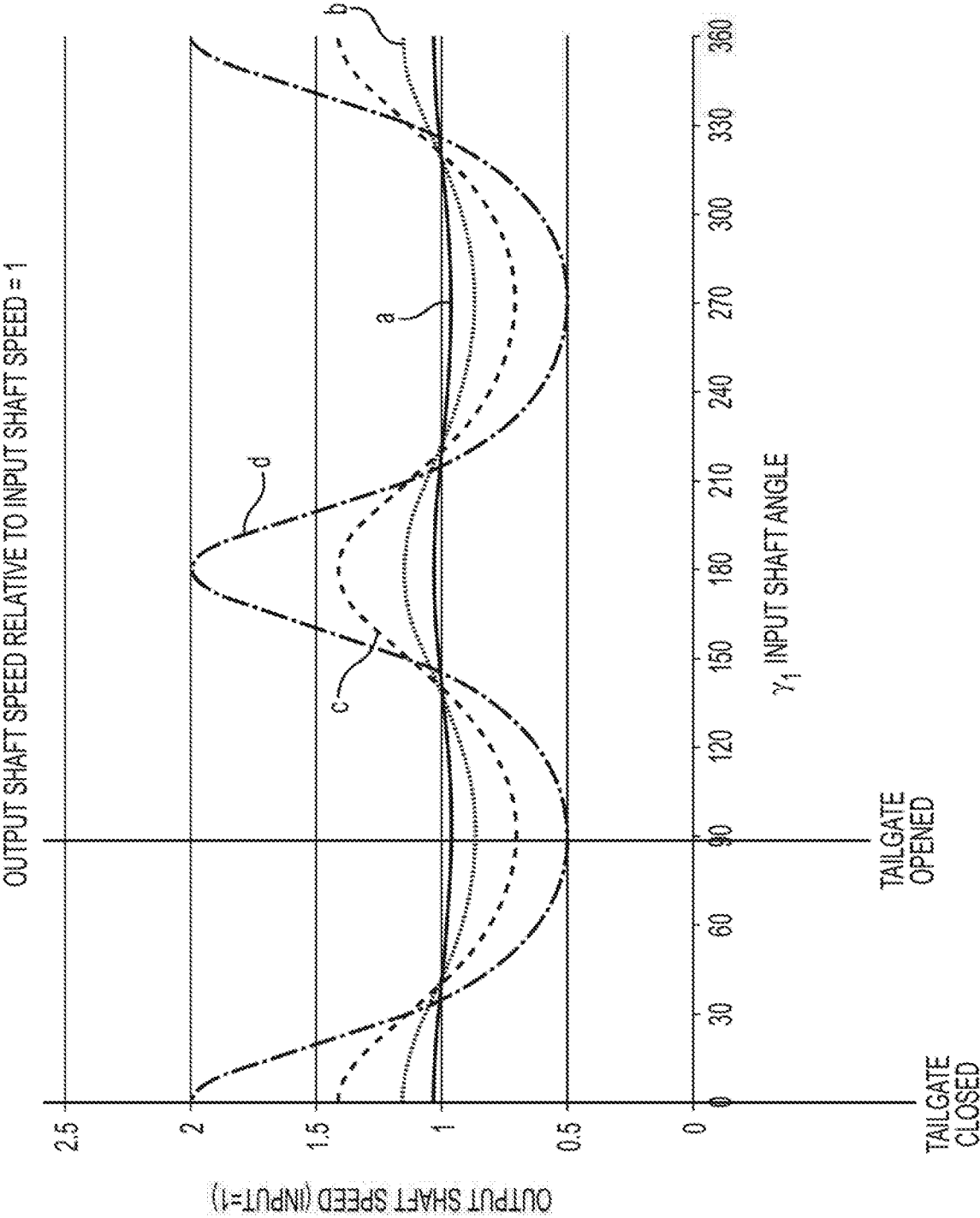


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2019/022004

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - E05F 15/611; B62D 33/03; E05F 15/70 (2019.01)

CPC - B62D 33/0273; E05Y 2201/216; E05Y 2201/41; E05Y 2201/422; E05Y 2900/532; E05Y 2900/546 (2019.02)

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)

See Search History document

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

USPC - 49/139; 49/360; 296/146.8; 310/75R; 310/83; 310/99 (keyword delimited)

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	WO 2018/023096 A1 (MAGNA INTERNATIONAL INC) 01 February 2018 (01.02.2018) entire document	1-3 --- 8-12
X --- Y	US 2015/0059250 A1 (MAGNA CLOSURES INC) 05 March 2015 (05.03.2015) entire document	1, 2, 4-7, 13-15 --- 8-12
A	US 2013/0169087 A1 (KUMMER) 04 July 2013 (04.07.2013) entire document	1-15
A	US 2014/0304942 A1 (OUBAO SECURITY TECHNOLOGY CO., LTD.) 16 October 2014 (16.10.2014) entire document	1-15

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"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

17 April 2019

Date of mailing of the international search report

14 JUN 2019

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