



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.08.2019 Bulletin 2019/32

(51) Int Cl.:
B25B 13/48 (2006.01) **B25B 17/00** (2006.01)
B25B 21/00 (2006.01)

(21) Application number: **18155033.6**

(22) Date of filing: **05.02.2018**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME
Designated Validation States:
MA MD TN

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(54) **TIGHTENING DEVICE AND METHOD OF ADJUSTING A SLIDABLE DOOR OF A VEHICLE**

(57) A tightening device (21) for tightening or loosening a bolt (18) arranged in a cavity with limited clearance (Δy , Δz), comprising: a ring gear (23) having outer teeth and having inner ridges (28); a driving gear set (24, 25, 26) comprising a driving gear (26) and at least one intermediate gear (24); the intermediate gear (24) located between the driving gear (26) and the ring gear (23); the ring gear (23) and the intermediate gear (24) accommo-

dated in a metal housing comprising a half-disk-shaped housing portion (29) and a rectangular beam-shaped housing portion (30), having a height (H) of at most 5 mm, and made of tempered steel having a hardness of about 40 HRC.

A method of adjusting a position of a slideable door (12) mounted to a vehicle body (11).

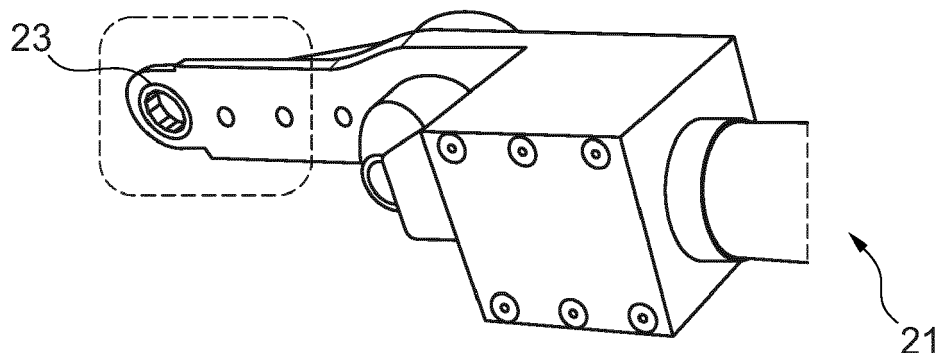


Fig. 9

Description

[0001] The present invention relates in general to a tightening device and to mounting a slidable door of a vehicle. The present invention relates more in particular to a tightening device for use in an automotive production environment for tightening or loosening a bolt arranged in a cavity with only very limited clearance, and to a method of adjusting a position of a slidable door using such a tightening device.

[0002] Motor vehicles with a slidable door are known in the art. The door is typically mounted by means of a bracket attached to the vehicle body. The bracket typically has an adjustment means in the form of a bolt which needs to be tightened or loosened for fine-positioning the door relative to the vehicle body.

[0003] Tightening devices for tightening or loosening bolts are known in the art, and come in many different shapes and sizes. Some of these devices are pneumatic, some of these devices have an electrical motor which can be configured to exert a specified maximum torque. From a mechanical point of view, these devices are typically made for approaching bolts from the top, but such devices can only be used if there is sufficient space to position the device relative to the bolt head.

[0004] GB 1,083,205 A discloses a swing door and a way of mounting said swing door.

[0005] KR 20080033655 A discloses a centre roller arm hinge assembly of a sliding door for a vehicle.

[0006] AU 2013203755 B2 discloses connection arrangements, pivots and mechanisms.

[0007] FR 2 915 122 B1 discloses an electrical and pneumatic tool for screwing screws, having a chip and an activation unit.

[0008] However, most prior art tightening devices require a space of at least about 10 cm around the bolt head.

[0009] The present invention has the object to provide a tightening tool or tightening device suitable for use in an automotive production environment for tightening or loosening a bolt arranged in a space with only a limited clearance.

[0010] It is a particular object of embodiments of the present invention to provide such a tightening tool suitable for tightening or loosening a bolt arranged inside a hollow object having a plurality of walls or wall sections such that the spacing or clearance between the bolt head and two of the walls or wall sections is only about 6 mm in a longitudinal direction of the bolt and is only about 6 mm in a radial direction of the bolt.

[0011] It is a particular object of embodiments of the present invention to provide such a tightening tool which is electrically powered.

[0012] The present invention also has the object to provide a method for adjusting a position of a slidable door mounted to a vehicle, involving tightening and/or loosening a bolt arranged inside the hollow object described above.

[0013] These objects are achieved by a tightening device having the features of claim 1, and by a method of adjusting a slidable door of a vehicle having the features of claim 6. Further, particularly advantageous embodiments of the invention are disclosed in the dependent claims.

[0014] It should be noted that the individual features listed in the description below can be combined in any technically meaningful way with each other and show further embodiments of the invention. The description of the invention is additionally characterized and specified particularly in connection with the figures.

[0015] In an advantageous embodiment, the present invention discloses a tightening device for use in an automotive production environment for tightening and/or loosening a bolt located inside a cavity with limited clearance between the bolt head and walls or wall sections of the cavity, the tightening device comprising: a ring gear having outer teeth for engaging a driving gear set, and having inner ridges for engaging an outer periphery of a head of the bolt to be tightened or loosened; the driving gear set comprising a driving gear and at least one intermediate gear, the at least one intermediate gear being located between the driving gear and the ring gear; the ring gear and the at least one intermediate gear being accommodated in a metal housing comprising a half-disk-shaped housing portion and a rectangular-beam-shaped housing portion; the half-disk-shaped housing portion and the rectangular beam-shaped housing portion having a height of at most 5 mm, and being made of tempered steel having a hardness in the range from 40 to 45 HRC, for example equal to about 40 HRC.

[0016] It is an advantage of using a ring gear and a driving gear set that a chain of gears can be formed for exerting a torque at a distal location, offset from the axis of the driving gear.

[0017] It is a further advantage of using a metal housing having the dimensions and shape described above, because it allows to insert the metal housing in a very small area.

[0018] It is a further advantage of using a tempered metal housing having a hardness of 40 to 45 HRC, because it increases the resistance of the housing to withstand deformation during use.

[0019] It is a further advantage of using a rectangular-beam-shaped housing portion (rather than a tapered or trapezoidal housing portion) that it can be used to fasten or loosen a bolt arranged within a space leaving only a small clearance in the longitudinal direction of the bolt, but also a small clearance in a radial direction of the bolt.

[0020] According to a further advantageous embodiment of the present invention, the tightening device further comprises an electrical motor operatively connected to the driving gear set and configured to exert a torque less than 12 Nm, for example a torque less than 11 Nm, for example a torque equal to about 10 Nm.

[0021] It is an advantage of using a relatively low torque in that the tightening device is capable of withstanding

the forces and tensions exerted on the metal housing, but is still capable of reliably fastening or loosening the bolt of the bracket of the slidable door.

[0022] According to a further advantageous embodiment of the present invention, the driving gear set comprises at least two intermediate gears between the driving gear and the ring gear, each of the intermediate gears being collinear with the ring gear and the driving gear, i. e. the centres of the ring gear, the intermediate gears and the driving gear are all arranged on one single virtual line which allows for a narrow arrangement of the gears.

[0023] It is an advantage of using at least two intermediate gears because it allows the ring gear to be offset from the driving gear by a larger distance, e.g. in case the intermediate gears have the same diameter, over a distance of at least 2x this diameter.

[0024] According to a further advantageous embodiment of the present invention, the number of ridges of the ring gear is at least twelve.

[0025] While a bolt head typically has only six sides, it is an advantage of using a ring gear having at least twelve ridges. This allows easier engagement of the ring gear and the bolt head, and may provide more accurate adjustment.

[0026] According to a further advantageous embodiment of the present invention, the rectangular beam-shaped housing portion has a constant width; and the width is smaller than the sum of an outer diameter of the ring gear plus 10 mm.

[0027] According to another advantageous embodiment of the present invention, the present invention discloses a method of adjusting a position of a slidable door mounted to a vehicle body by means of a bracket comprising a bolt to be adjusted, the bracket being accommodated inside a cavity of a hollow object having a plurality of walls or wall sections, the hollow object being mounted to the vehicle body; the method comprising the steps of: i) providing a tightening device as described above; ii) inserting the half-disk-shaped housing portion and at least a part of the rectangular beam-shaped housing portion of the tightening device inside the hollow object between a first wall or first wall section of the hollow object and the bolt head; iii) moving the tightening device such that the ring gear engages a head of the bolt; iv) tightening or loosening the bolt of the bracket by exerting torque on the driving gear.

[0028] According to a further advantageous embodiment of the present invention, the bracket is mounted inside the cavity defined by the hollow object with a first clearance Δz equal to about 6 mm between a first wall or first wall section of the hollow object and the head of the bolt in a longitudinal direction of the bolt.

[0029] According to a further advantageous embodiment of the present invention, the bracket is mounted inside the cavity defined by the hollow object with a second clearance Δy equal to about 6 mm between a second wall or second wall section of the hollow object and the head of the bolt in a radial direction of the bolt.

[0030] According to a further advantageous embodiment of the present invention, the tightening device further comprises an electrical motor; and step iv) comprises: the motor exerting a torque on the ring gear lower than 11 Nm.

[0031] According to a further advantageous embodiment of the present invention, a wall or wall portion of the hollow object comprises a groove or a recess for guiding the beam-shaped housing portion of the tightening tool towards the head of the bolt.

[0032] It is an advantage of providing a hollow, e.g. tub-shaped, object comprising a wall or wall section having a groove or recess because it helps to find the bolt head easier and faster, especially if the bolt head cannot be seen during operation of the tightening device.

[0033] According to a further advantageous embodiment of the present invention, the hollow object is made of plastic.

[0034] It is an advantage of providing a hollow, e.g. tub-shaped, object made of plastic, because it is somewhat flexible and can absorb shocks, for example caused by contact between the half-disk-shaped housing portion of the tightening device and the hollow object, thereby reducing the risk of inadvertently damaging the tightening device.

[0035] FIG. 7 shows a tool for tightening or loosening bolts, known in the art.

[0036] Further features and advantages of the present invention will become apparent from the following description of a non-limiting embodiment of the invention which will be explained below with reference to the drawing, wherein:

FIG. 1 is a rear view of a first vehicle with a slidable door which is closed. A guiding rail for guiding the slidable door is protruding from a side of the vehicle body and is clearly visible.

FIG. 2 is a side view of a portion of the vehicle of FIG. 1.

FIG. 3 shows a portion of the slidable door of FIG. 1 in a partially open state, seen from the inside of the vehicle. Also visible is a first mounting bracket connected to a post of the vehicle body.

FIG. 4 is a rear view of a second vehicle, which can be seen as an improved version of the vehicle of FIG. 1. The second vehicle also has a slidable door and a guiding rail for guiding the slidable door, but the guiding rail is largely hidden, which is more elegant.

FIG. 5 is a side view of the vehicle of FIG. 4.

FIG. 6 shows a portion of the slidable door of FIG. 4 in a partially open state, seen from the inside of the vehicle. Also visible is a second mounting bracket arranged inside the cavity defined by a tub-shaped object connected to a post of the vehicle body. It is a challenge to reach the bolt head (pointed to by a black arrow) for

- adjusting the position of the slidable door.
- FIG. 8 shows an embodiment of a tightening device according to the present invention, as a modification of the tool shown in FIG. 7.
- FIG. 9 is an enlarged perspective view of a portion of the tightening device shown in FIG. 8.
- FIG. 10 is a schematic view of an exemplary set of gears as may be used in the tightening device of FIG. 9.
- FIG. 11 is a schematic view of a portion of the housing of the tightening device of FIG. 9.
- FIG. 12 is an enlarged side view of a portion of the tightening device of FIG. 9. The thickness of the housing portion is ultra-thin for this kind of applications.

[0037] In the various figures, equivalent elements with respect to their function are always provided with the same reference numerals so that these elements are usually described only once.

[0038] FIG. 1 and FIG. 2 are pictures of a vehicle 1 with a slidable door 2 in a closed position. The slidable door 2 is guided in a rail 3 mounted to the outside of the vehicle 1.

[0039] The slidable door 2 is attached to the vehicle using a mounting bracket 4 shown in FIG. 3. The mounting bracket 4 is connected to a post 5 of the vehicle body, using a plurality of screws 6, in manners known per se in the art. The bracket 4 is highly accessible for adjusting the position of the slidable door 2 relative to the vehicle body 1.

[0040] A design team changed the design of vehicle 1 (shown in FIG. 1), in particular by changing the mounting of the slidable door 2, to create the vehicle 11 (shown in FIG. 4 and FIG. 5) having a more elegant design. The vehicle 11 has a slidable door 12, which is guided by a guiding rail 13, but the guiding rail 13 is largely concealed by being incorporated at least partially into the bodywork of the vehicle 11.

[0041] However, the design team also changed the mounting bracket. While the original mounting bracket 4 (see FIG. 3) is easily accessible, a mounting bracket 14 (see FIG. 6) of the newly designed vehicle 11 is concealed, which again is more elegant, but created a technical challenge for the production team, as can be appreciated from FIG. 6.

[0042] In order to fine-tune the positioning of the slidable door 12, a bolt 18 needs to be adjusted after the slidable door 12 is mounted to the vehicle body. However, in the new design, the mounting bracket 14 is no longer mounted to the outside of the post 15, but is accommodated in a cavity 17 formed by a hollow object 16, e.g. a tub-shaped object 16 mounted to the vehicle body.

[0043] As can be seen in FIG. 6, the clearance or spacing Δz between an upper wall or wall section of the hollow object 16, e.g. tub-shaped object 16, and the bolt head 18 (in a longitudinal direction of the bolt) is very small, for example only about 6 mm, and the clearance or spac-

ing Δy between a side wall of the hollow object 16, e.g. tub-shaped object 16, and the bolt head 18 (in a radial direction of the bolt) is also very small, for example only about 6 mm.

[0044] While it may be possible to fasten or loosen the bolt head 18 manually with an openended wrench, it is not an acceptable or preferred solution for an automotive production environment, because it is very time consuming, and because it does not allow to control the torque exerted on the bolt head 18 accurately.

[0045] Well-known and highly reputable professional tool vendors were consulted, which expressed the opinion, based on decades of experience, that it is impossible to build a tool for tightening or loosening a bolt 18 positioned in a cavity 17 with such a small clearance Δy , Δz in radial and longitudinal direction.

[0046] Rather than further adjusting the design of the vehicle, the inventors came to the idea of making a new tool to address this specific problem, contrary to the opinion of the tool experts. Quite surprisingly they found a satisfactory solution, taking due account of the small dimensions involved, the forces or torque involved, and taking into consideration that the tool must be suitable for use in an automotive production environment, where the tool is used many times per day.

[0047] Specifically, the inventors started from an existing tool 20, illustrated in FIG. 7, which at the time of drafting this application. The inventors replaced the existing front end by a newly developed front end, and thereby created the new tightening device 21 shown in FIG. 8. Thus, simply stated, the new tightening device 21 has a different front end.

[0048] Before discussing a preferred embodiment of the front end in more detail, first it will be explained at high level what is shown in FIG. 9 to FIG. 12.

[0049] FIG. 9 shows the front end of the tightening device 21 of FIG. 8 in more detail. The most relevant parts for the purpose of the present invention are the ring gear 23 and the housing for accommodating the ring gear 23 and one or more intermediate gears.

[0050] FIG. 10 is a schematic view of an exemplary set of gears 23-26 as may be used in the tightening device 21 of FIG. 9. It is noted that FIG. 10 is only intended to explain how the invention works. As will be appreciated by the skilled person, several details are omitted from this figure, such as for example bushings, screws and/or bolts, etc.

[0051] FIG. 11 is a schematic view of a portion of the housing of FIG. 9 for accommodating at least some of the gears 23-26. In practice, the housing may comprise an upper part and a lower part.

[0052] FIG. 12 shows a portion of the tightening device 21 of FIG. 9 in further detail, and in side view. It should be appreciated, that the thickness H of the housing portion is unusually thin for this kind of applications.

[0053] With reference to FIG. 9 to FIG. 12, the following more detailed description can now be understood.

[0054] The tightening device 21 comprises a ring gear

23 having outer teeth for engagement with a driving gear set 24, 25, 26 (see FIG. 10), and having inner ridges 28 for engagement with an outer periphery of a head of a bolt 18 (see FIG. 6), e.g. a hexagonal bolt head.

[0055] The tightening device 21 further comprises the driving gear set comprising a driving gear 26 and at least one intermediate gear 24 located between the driving gear 26 and the ring gear 23. Preferably the ring gear 23 and the at least one intermediate gear 24 have substantially the same outer diameter, but that is not absolutely required.

[0056] The ring gear 23 and the at least one intermediate gear 24 are accommodated in a metal housing, preferably comprising a half-disk-shaped housing portion 29 and a rectangular beam-shaped housing portion 30. The length of the rectangular beam-shaped housing portion 30 depends on the number of intermediate gears 24, 25.

[0057] According to an important aspect of the present invention, the half-disk-shaped housing portion 29 and the rectangular beam-shaped housing portion 30 have a height H of at most 5 mm, which is extremely small for this kind of applications, namely an automotive production environment. The length of the half-disk-shaped housing portion 29 and the rectangular beam-shaped housing portion 30 is indicated by reference sign L in FIG. 11 and 12.

[0058] The half-disk-shaped housing portion 29 and the rectangular beam-shaped housing portion 30 are furthermore made of tempered steel having a hardness in the range from 40 to 45 HRC, preferably equal to about 40 HRC.

[0059] The housing portion 29 preferably has two circular openings aligned with opposite sides of the ring gear 23 for allowing the bolt head 18 to pass through the housing to engage with the ridges of the ring gear 23.

[0060] The number of ridges 28 of the ring gear 23 may be six, or preferably be twelve.

[0061] Depending on how deep the bolt head 18 is located inside the cavity (in the X-direction of FIG. 6), a driving gear set with only a single intermediate gear 24 may suffice. In this case the ring gear 23 and the intermediate gear 24 and the driving gear 26 are arranged collinear, i.e. the centres of the ring gear 23, the intermediate gear 24 and the driving gear 26 are all arranged on one single virtual line.

[0062] In another embodiment, the driving gear set may comprise at least two intermediate gears 24, 25 (as illustrated in FIG. 10). In this case the ring gear 23 and the two intermediate gears 24 and 25 and optionally also the driving gear 26 are arranged in a collinear fashion, too.

[0063] As suggested by FIG. 11, preferably the rectangular beam-shaped housing portion 30 has a constant width W. The width W is preferably smaller than the sum of the outer diameter of the ring gear 23 plus 10 mm (thus plus 5 mm on either side).

[0064] A tightening device 21 is described above, but

the present invention also provides a method for adjusting the position of a slidable door 12 mounted to a vehicle body 11 (see. FIG. 4 to 6) by means of a bracket 14 comprising a bolt 18 to be adjusted, where the bracket 14 is accommodated inside a hollow space 17 defined by a hollow object 16, e.g. a tub-shaped object 16, mounted to the vehicle body 11, the hollow object 16 having a size and shape for accommodating the bracket 14.

[0065] The position of the slidable door 12 can be adjusted by applying the following steps:

- i) providing a tightening device 21 described above;
- ii) inserting the half-disk-shaped housing portion 29 and at least a part of the rectangular beam-shaped housing portion 30 of the tightening device 21 inside the hollow space 17 of the hollow object 16 between a first (e.g. upper) wall section of the hollow object 16 and the bolt head 18;
- iii) moving (e.g. lowering) the tightening device 21 such that the ring gear 23 engages the bolt head 18;
- iv) tightening or loosening the bolt 18 of the bracket 14 by operating the tightening device 21 to exert a torque on the driving gear 26, and thus indirectly (via the intermediate gears 24 and/or 25) to exert a torque on the ring gear 23.

[0066] In the specific example of FIG. 6, the bracket 14 is mounted inside the hollow space 17 defined by the hollow object 16, e.g. tub-shaped object 16, with a first clearance Δz equal to about 6 mm between a first (e.g. upper) wall or wall section of the hollow object 16 and the bolt head 18 in a longitudinal direction Z of the bolt, and with a second clearance Δy equal to about 6 mm between a second (e.g. side) wall or wall section of the hollow object 16 and the bolt head 18 in a radial direction Y of the bolt.

[0067] Preferably the tightening or loosening is performed in a controlled manner, so as to exert a specific maximum torque on the ring gear 23. Preferably step iv) comprises: exerting a torque on the ring gear 23 lower than 11 Nm, for example a torque of at most 10 Nm, by, for example, an electrical motor (not shown) arranged inside the tightening device 21.

REFERENCE NUMERALS

[0068]

- 1 first vehicle,
- 2 slidable door,
- 3 guiding rail,
- 4 mounting bracket,
- 5 post,
- 11 second vehicle,
- 12 slidable door,
- 13 guiding rail,
- 14 mounting bracket
- 15 post,

16 hollow object, e.g. tub-shaped object,
 17 hollow space,
 18 bolt or bolt head,
 20 (known) tightening tool,
 21 tightening device,
 23 ring gear,
 24 first intermediate gear,
 25 second intermediate gear,
 26 driving gear,
 28 ridges,
 29 half-disk-shaped housing portion,
 30 rectangular-beam-shaped housing portion.

Claims

1. A tightening device (21) for use in an automotive production environment for tightening and/or loosening a bolt (18) located inside a cavity (17) with limited clearance (Δy , Δz) between a head of the bolt and wall sections of the cavity, the tightening device (21) comprising:

- a ring gear (23) having outer teeth for engaging a driving gear set (24, 25, 26) and having inner ridges (28) for engaging an outer periphery of a head of the bolt (18);
- the driving gear set (24, 25, 26) comprising a driving gear (26) and at least one intermediate gear (24), the at least one intermediate gear (24) being located between the driving gear (26) and the ring gear (23);
- the ring gear (23) and the at least one intermediate gear (24) being accommodated in a metal housing comprising a half-disk-shaped housing portion (29) and a rectangular-beam-shaped housing portion (30);
- the half-disk-shaped housing portion and the rectangular beam-shaped housing portion having a height (H) of at most 5 mm, and being made of tempered steel having a hardness in the range from 40 to 45 HRC.

2. A tightening device (21) according to claim 1, further comprising an electrical motor operatively connected to the driving gear set and configured to exert a torque less than 12 Nm.

3. A tightening device (21) according to claim 1 or 2, wherein the driving gear set (24, 25, 26) comprises at least two intermediate gears (24, 25) located between the driving gear (26) and the ring gear (23), each of the intermediate gears (24, 25) being collinear with the ring gear (23) and the driving gear (26).

4. A tightening device (21) according to any of the previous claims, wherein the number of ridges (28) is at least twelve.

5. A tightening device (21) according to any of the previous claims, wherein the rectangular beam-shaped housing portion (30) has a constant width (W); and wherein the width (W) is smaller than the sum of an outer diameter of the ring gear (23) plus 10 mm.

6. Method of adjusting a position of a slidable door (12) mounted to a vehicle body (11) by means of a bracket (14) comprising a bolt (18) to be adjusted, the bracket (14) being accommodated inside a cavity (17) of a hollow object (16) having a plurality of wall sections, the hollow object (16) being mounted to the vehicle body (11);

the method comprising the steps of:

- i) providing a tightening device (21) according to any of the previous claims;
- ii) inserting the half-disk-shaped housing portion (29) and at least a part of the rectangular beam-shaped housing portion (30) of the tightening device (21) inside the hollow object (16) between a first wall section of the hollow object (16) and a head of the bolt (18);
- iii) moving the tightening device (21) such that the ring gear (23) engages the head of the bolt (18);
- iv) tightening or loosening the bolt (18) of the bracket (14) by exerting torque on the driving gear (26).

7. Method according to claim 6, wherein the bracket (14) is mounted inside the cavity (17) defined by the hollow object (16) with a first clearance (Δz) equal to about 6 mm between a first wall section of the hollow object (16) and the head of the bolt (18) in a longitudinal direction (Z) of the bolt.

8. Method according to claim 6 or 7, wherein the bracket (14) is mounted inside the cavity (17) defined by the hollow object (16) with a second clearance (Δy) equal to about 6 mm between a second wall section of the hollow object (16) and the head of the bolt (18) in a radial direction (Y) of the bolt (18).

9. Method according to any of the claims 6 to 8, wherein the tightening device (21) further comprises an electrical motor; and wherein step iv) comprises: the motor exerting a torque on the ring gear (23) lower than 11 Nm.

10. Method according to any of the claims 6 to 9, wherein a wall section of the hollow object (16) comprises a groove or recess for guiding the beam-shaped housing portion (30) of the tightening tool (21) towards the head of the bolt (18).

11. Method according to any of the claims 6 to 10,
wherein the hollow object (16) is made of plastic.

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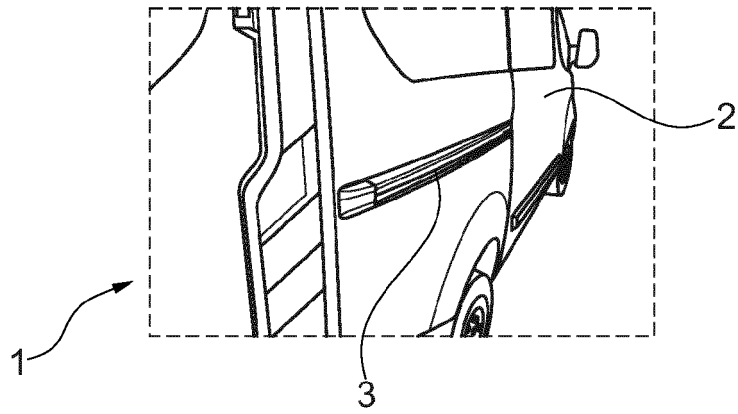


Fig. 1

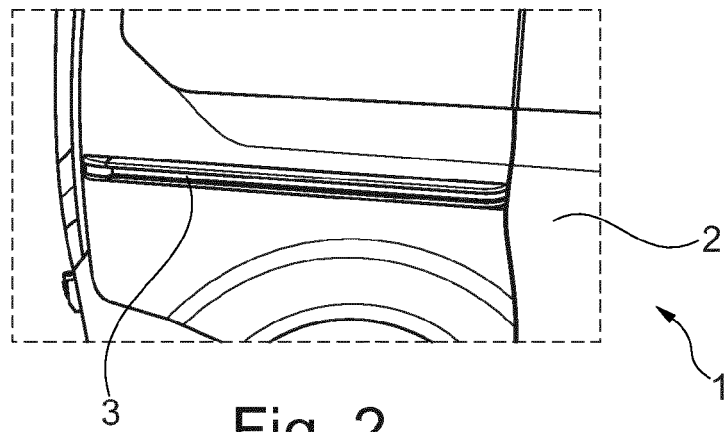


Fig. 2

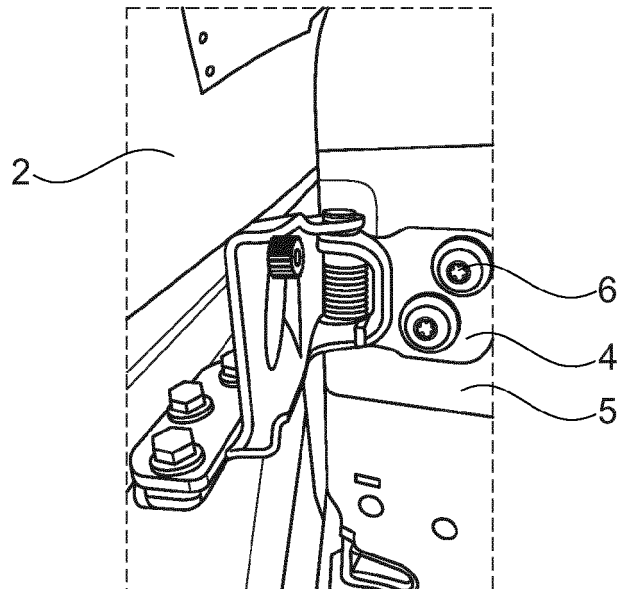


Fig. 3

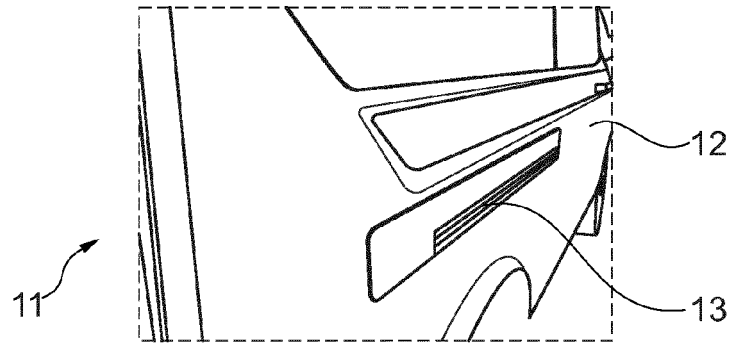


Fig. 4

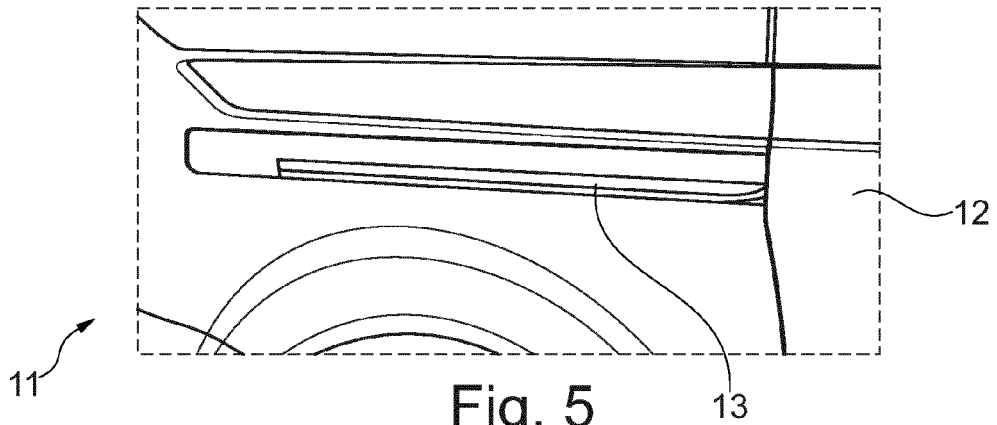


Fig. 5

Example:
 $\Delta y \approx 6 \text{ mm}$
 $\Delta z \approx 6 \text{ mm}$

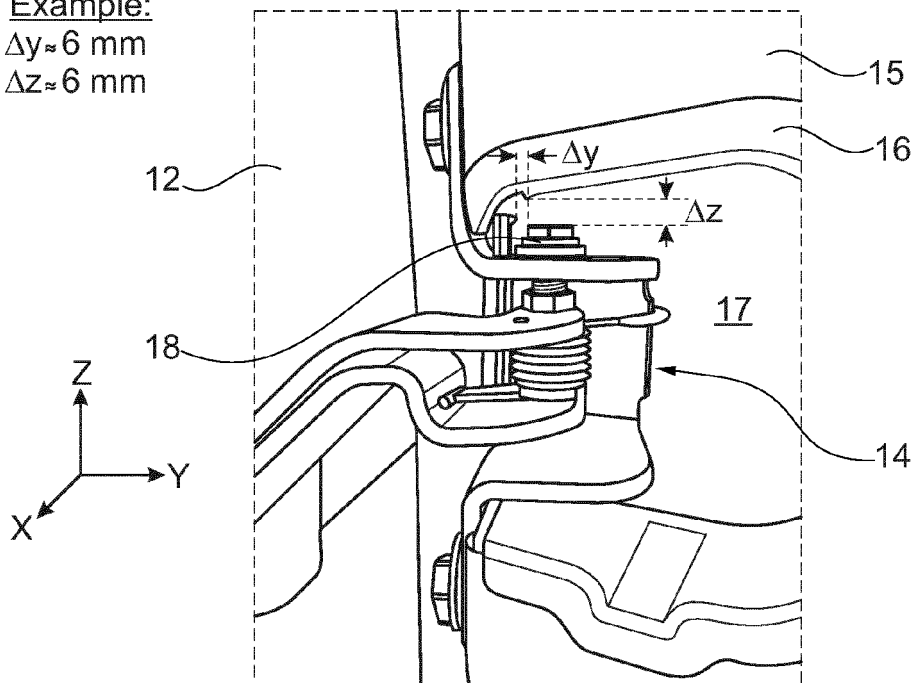


Fig. 6

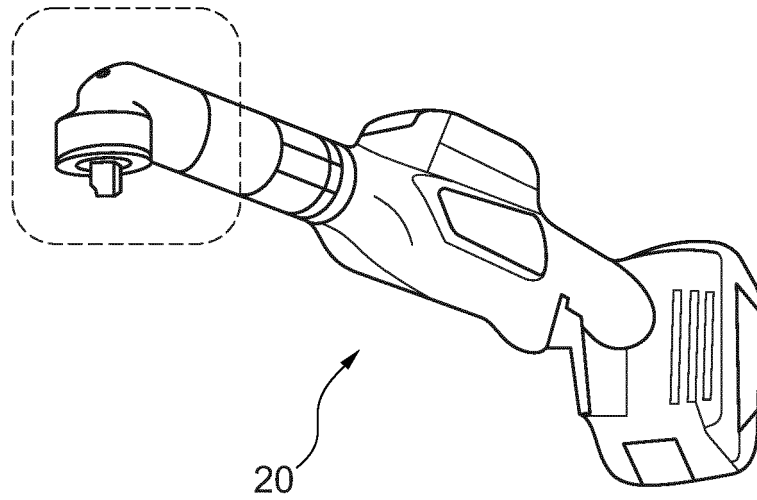


Fig. 7
(STATE OF THE ART)

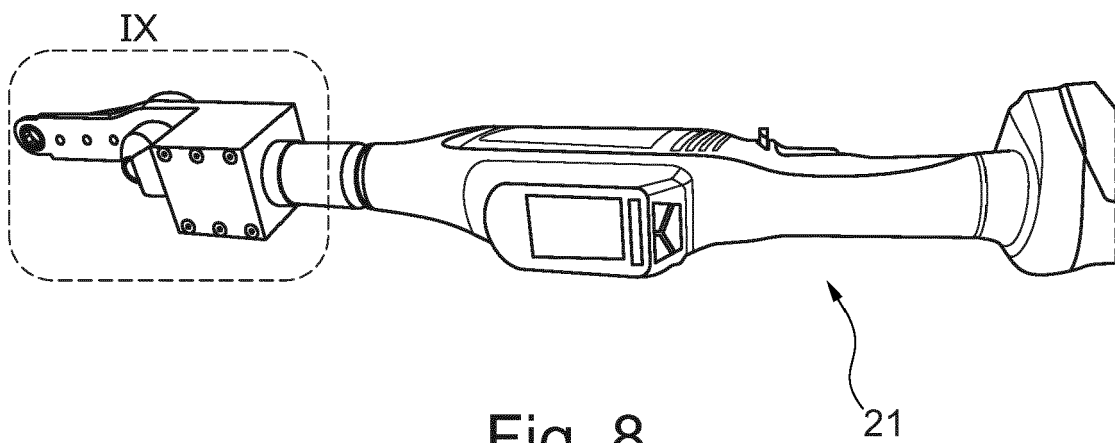


Fig. 8

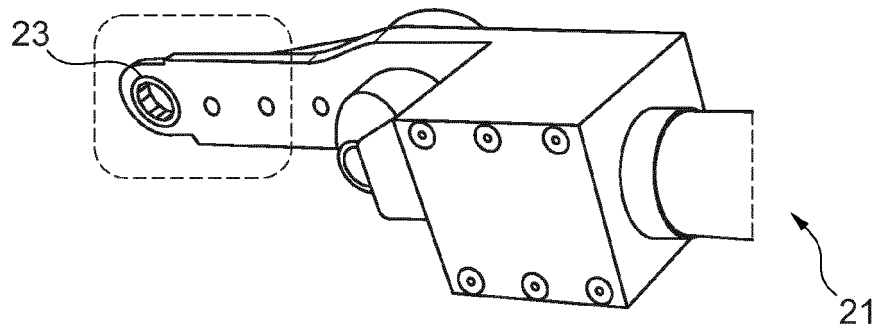


Fig. 9

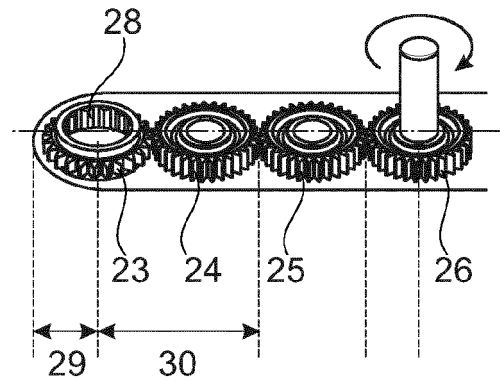


Fig. 10

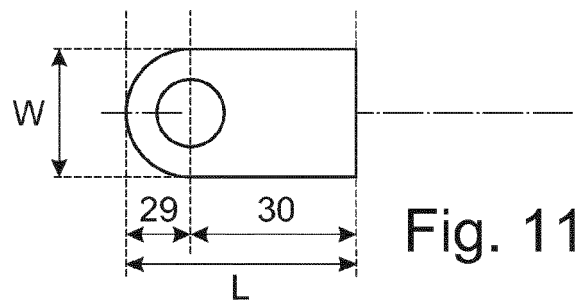


Fig. 11

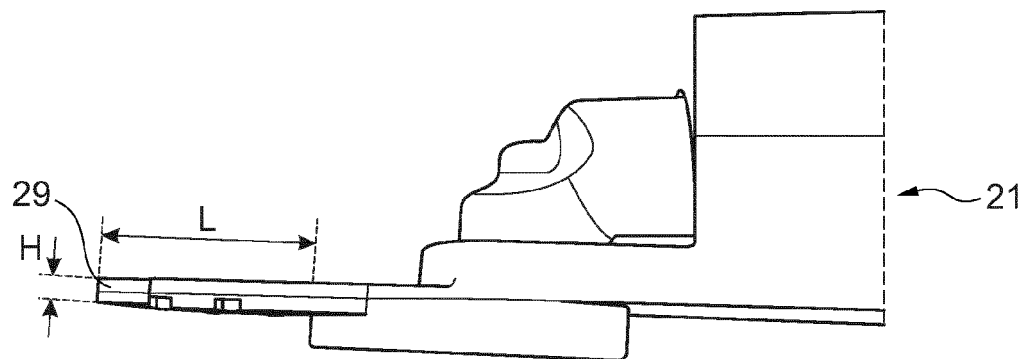


Fig. 12



EUROPEAN SEARCH REPORT

 Application Number
 EP 18 15 5033

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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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