(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 June 2014 (05.06.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/083376 A1

(51) International Patent Classification:
B62D 21/15 (2006.01) *B60R 19/56* (2006.01)

(21) International Application Number:
PCT/IB2012/002999

(22) International Filing Date:
27 November 2012 (27.11.2012)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant *(for all designated States except US)*: **RENAULT TRUCKS** [FR/FR]; 99 route de Lyon, F-69800 Saint Priest (FR).

(72) Inventors; and
(71) Applicants *(for US only)*: **BREVET, Marc** [FR/FR]; 137 Avenue Franklin Roosevelt, F-69500 Bron (FR). **RICCETTI, Tony** [FR/FR]; 231 Grande rue de Bulliez, F-01150 Lagnieu (FR).

(74) Agent: **FAUCHEUX, Jerome**; GTT - Legal & Corporate IP /TER E70 2 12, Renault Trucks, 99, route de Lyon, F-69806 St Priest (FR).

(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, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, 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, 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.

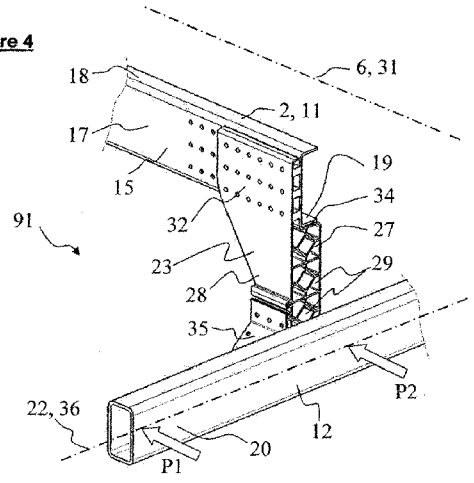
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, 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, ML, MR, NE, SN, TD, TG).

Published:

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

(54) **Title**: UNDERRUN PROTECTION STRUCTURE AND METHOD FOR MANUFACTURING AND ASSEMBLING THE SAME.

Figure 4



(57) **Abstract**: The underrun protection structure is for a vehicle having a vehicle chassis frame (2). This underrun protection structure (91) comprises at least one underride guard (12) having an elongated shape and at least two support brackets (23, 24). Each support bracket extends according to a main bracket direction (33) between a first end (25) where is fixed said underride guard (12) and a second end (26) for the fixation of the underrun protection structure (91) under the vehicle chassis frame (2). Each support bracket (23, 24) has a hollow body (27), side walls (28) delimiting said hollow body (27) and inner walls (30) dividing the hollow body (27) into cavities (29). The inner walls (30) and the cavities (29) extend in parallel straight lines inside each support bracket (23, 24) and according to a direction (31) that is transverse to the main bracket direction (33) of the support bracket (23, 24) and that is perpendicular to the underride guard (12).

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UNDERRUN PROTECTION STRUCTURE AND METHOD FOR MANUFACTURING AND ASSEMBLING THE SAME

Field of the invention

The present invention relates to an underrun protection structure designed to be arranged near the lower parts of a vehicle, especially at the rear and under a truck frame or a trailer frame. The invention also relates to a method for manufacturing a support bracket and assembling it between a vehicle chassis frame and an underride guard.

Technological background

It is known that high ride height vehicles such as trucks and trailers are equipped with an underrun protection structure to avoid in case of collision with a low ride height vehicle, such as a passenger car, the low ride height vehicle going under the high ride height vehicle.

Underrun protection structure could have the form of guards arranged at the rear, at the front or at the sides of a truck or a trailer. Today, it is considered that the most critical collision occurs when the passenger car moving in the forward direction collides with the rear of a truck or a trailer or with the front of a truck.

A widely known rear underrun protection structure, that is depicted in figures 2 and 3, is a bolted construction that uses steel brackets, formed with U shape profiles which are oriented vertically to fix a rear underride guard to the rear end of a truck frame.

Unfortunately, such a structure is not resistant enough and may break in case of violent collision with a passenger car or may be deformed in such a manner that a passenger car is not prevented from going under the truck. For many years several attempts have been made to modify the

underrun protection structure in order to increase its resistance, to make it able to absorb impact due to a collision between a truck and a passenger car and therefore limit consequences of such a collision. Unfortunately when the new designed structures are able to absorb and to resist a heavy rear end collision the weight of the structure is in return considerably increased.

It is also known in the car industry to use an extruded aluminium profile having a hollow structure to fix a front bumper to a crossbar of the vehicle. Such a solution is disclosed for instance in FR 2 966 103. Due to the design and particular arrangement of each aluminium profile, the solution disclosed in the FR 2 966 103 has the advantages of absorbing pedestrian impacts and is also lighter than steel brackets. Unfortunately even if these extruded aluminium profiles were re-sized to be used in a rear underrun protection structure for trucks, in case of a rear-end-collision with a passenger car, it is not possible, without a significant weight increase of the rear underrun protection structure, to sufficiently limit the deformation of the extruded aluminium profiles to avoid the passenger car going under a truck.

It therefore appears that there is room for improvement in underrun protection structure and especially to improve rear underrun protection structures of trucks or trailers.

Summary

It is an object of the invention to provide an improved underrun protection structure which can overcome the drawbacks encountered in traditional vehicles and which can increase safety of passenger car occupants in case of collision with a high ride height vehicle, especially with the rear end of a truck or a trailer or the front end of a truck, with a limited increase in weight or preferably with a decrease in weight.

More particularly, an object of the invention is to provide an underrun protection structure of a vehicle having a vehicle chassis frame, wherein the underrun protection structure comprises :

a. at least one underride guard having an elongated shape that extends along a main guard direction ;
b. at least two support brackets, each of them extending, according to a main bracket direction, between a first end where is fixed said underride guard and a second end for the fixation of the underrun protection structure under the vehicle chassis frame and each of the support brackets having a hollow body, side walls delimiting said hollow body and inner walls dividing the hollow body into cavities.

Inside each support bracket said inner walls and said cavities extend in parallel straight lines and extend according to a cavity direction that is transverse to the main bracket direction of the support bracket and that is perpendicular to the main guard direction of the underride guard.

The term "main bracket direction" refers to the direction of the support bracket that extends between the first and the second ends of the support bracket. In the operative position of the underrun protection structure, i.e. when it is fixed under the vehicle chassis frame, the main bracket direction of the support bracket corresponds substantially to a vertical direction. A " direction that is transverse to the main bracket direction" refers to a direction that is perpendicular to the main direction of the support bracket. In the operative position of the underrun protection structure, the transverse direction of the support bracket or a direction that is transverse to the main bracket direction corresponds substantially to a horizontal direction.

In the operative position of the underrun protection structure, the main guard direction of the underride guard corresponds substantially to a horizontal direction and when the underride guard is a front or a rear one, the main guard direction is transverse to the longitudinal axis of the vehicle.

Thus, the invention provides underrun protection structure wherein the support brackets have a hollow body divided into cavities which are formed by side walls and inner walls. Thanks to this arrangement, the support brackets

are lighten and therefore the weight of the underrun protection structure is globally decreased.

The inner walls and the cavities extend according to a direction ("cavity direction") that is perpendicular to the underride guard. A rear or front underride guard is generally disposed under the vehicle chassis frame to be impacted, in case of collision with another vehicle, in a direction that is perpendicular to the main guard direction. That means that, the inner walls and the cavities are oriented in a direction that is substantially the same as the direction of the impact in case for instance of rear or front end collision.

To the contrary, in prior art such as disclosed in FR 2 966 103, it is known that the support bracket, having a hollow body, has to be oriented so that the direction of the inner walls and the cavities is substantially perpendicular and not parallel to the direction of impact. Such a configuration is sufficiently deformable to absorb pedestrian impacts but unfortunately lacks a robustness and stiffness in order to withstand a more severe impact such, for example, the impact due to a collision with another vehicle.

Considering a support bracket that is used to fix an underride guard under a vehicle chassis frame, the inventors have found that in such a configuration, a hollow support bracket having cavities separated by inner walls offers a better robustness and stiffness in case of impact when inner walls and cavities are oriented according to the invention.

In comparison to a traditional underrun structure using support brackets made of steel profile having a U section shape, a structure according to the invention, having the same weight or being lighter than a traditional structure, is able to withstand a force generated by a car passenger impact that is at least 50 % more than a traditional underrun structure is able to withstand in similar conditions.

In addition, when a force is applied on the underride guard, the support brackets can have a tendency to bend, thanks to the specific orientation of the cavities and inner walls of the support brackets with respect to the underride guard orientation, side and inner walls of the support bracket, that

are oriented vertically or substantially vertically, have a tendency to undergo a buckling deformation. Thanks to that, the inventors have found that it is easier to deal with the global deformation of the support bracket and to limit the bending of the support brackets in case of impact on the underride guard by another vehicle.

According to advantageous but optional features, considered on their own or in any technically feasible combination :

- The vehicle chassis frame comprises two parallel frame rails and each support bracket is fixed to one frame rail at an end part of the vehicle chassis frame, preferably et the rear part of the vehicle chassis frame, so that the main guard direction of the underride guard is oriented perpendicularly to the frame rails and the cavity direction is parallel to the frame rails.
- The cavities open onto at least one side of each support bracket along the cavity direction.
- The cavities are through cavities having cylindrical shapes and that open on both sides of each support bracket along the cavity direction. The term "cylindrical shape" refers to a shape that is generated by the displacement of a straight line according to a closed curve while said straight line remains parallel to itself during said displacement. The section of the cylindrical shape can therefore be circular, rectangular, triangular or can be a more complex shape.
- The side and inner walls are integrally formed with the support brackets.
- The support brackets are made of light material, preferably of light alloy. The light material can also be a composite material or a plastic material and a preferred light alloy is an aluminium alloy.
- The support brackets are extruded parts which are oriented so that their direction of extrusion is along the cavity direction. In other

words the direction of extrusion is perpendicular to the main guard direction in the underrun protection structure.

- Each support bracket has a fastening extension integrally formed with the support bracket, that extends from said second end according to the main bracket direction and that is designed to fix the underrun protection structure onto a vertical side surface of each frame rail.
- Each support bracket comprises an abutment surface integrally formed with the support bracket and that is arranged to contact a lower surface of a frame rail at least in case of impact on the underride guard. In other words, the lower surface of the frame rail is either permanently contacted by the abutment surface of the support bracket or is contacted by the abutment surface only in case of impact by another vehicle on the underride guard. Thanks to this abutment surface of the support bracket, the mechanical stress of the fastening means, which results from an impact on the underride guard, is reduced. Particularly, when fastening means are nut and bolt assemblies, shear stress of bolts is considerably reduced when the underride guard is impacted by another vehicle.
- Each fastening extension has a thickness that is at least twice the thickness of the side walls of the support brackets. When the support bracket is made of light alloy, the inventors have determined that this minimum thickness is necessary to avoid a tearing of the fastening extension when the underride guard is impacted by another vehicle. Preferably, the thickness of the extension is comprised between twice and six times the thickness of the side walls.
- Each support bracket comprises at least one transversal extension which extends from the support bracket, along the underride guard and in a direction that is parallel to the main guard direction of the underride guard.

According to a second aspect, the invention relates to a vehicle having a vehicle chassis frame, having a longitudinal axis and comprising at least one underrun protection structure that comprises :

- at least one underride guard having an elongated shape ;
- at least two support brackets, each of them extending between a first end where is fixed said underride guard and a second end for the fixation of the underrun protection structure under the vehicle chassis frame and each of the support brackets having a hollow body, side walls delimiting said hollow body and inner walls dividing the hollow body into cavities ;

Inside each support bracket inner walls and said cavities extend in parallel straight lines. The underrun protection structure is fixed under the vehicle chassis frame. Said inner walls and said cavities extend according to a cavity direction that is parallel to the longitudinal axis of the vehicle and the underride guard extends in a transverse direction of the vehicle.

The term "longitudinal axis of the vehicle" refers to the axis that extends from the front to the rear of the vehicle and the term "transverse direction of the vehicle" refers to a direction that extends over the width of the vehicle and perpendicularly to the longitudinal axis of the vehicle.

In the vehicle, the underrun protection structure is preferably fixed at an end part of the vehicle chassis frame and more preferably at the rear part of the vehicle chassis frame.

The vehicle chassis frame preferably comprises two frame rails that are parallel to the longitudinal axis of the vehicle and each support bracket has a fastening extension integrally formed with the support bracket. The fastening extension extends upwards from said second end of the support bracket and extends along a vertical side surface of a frame rail. Each support bracket is fixed onto said vertical side surface via its fastening extension. Each fastening extension can be glued or welded onto the vertical side surface of a frame rail,

but preferably, it is used fastening means such as several nut and bolt assemblies to fasten each support bracket onto the side surface of a frame rail.

In the vehicle, each support bracket comprises an abutment surface integrally formed with the support bracket and that is arranged to contact a lower surface of a frame rail at least in case of impact on the underride guard. Said abutment surface extends along a lower surface of a frame rail and each support bracket extends globally in a vertical direction under said lower surface.

According to a third aspect, the invention relates to a method for manufacturing and assembling a support bracket between a vehicle chassis frame and an underride guard having an elongated shape and that is designed to be disposed under the vehicle chassis frame. The method comprises the following steps :

a. Providing an initial support bracket having a hollow body, extending according to a main bracket direction between a first end for the fixation of said underride guard on the support bracket and a second end for the fixation of the support bracket on the vehicle chassis frame, having :
    - side walls integrally formed with the support bracket and delimiting said hollow body,
    - inner walls, integrally formed with the support bracket and that divides the hollow body into several cavities.

   Said cavities extend inside the support bracket in parallel straight lines and according to a cavity direction that is transverse to the main bracket direction.
b. Locking said second end in order to avoid displacements of said second end. For instance the locking step can consist of fixing said second end onto a vehicle chassis frame or onto a support.
c. Applying a force on the first end of the initial support bracket. Said force is determined to be oriented according to a direction that is substantially parallel to said cavity direction.

d. Identifying at least one zone of buckling deformation on at least one side or inner wall.
e. Providing a new support bracket with at least a new inner wall that extends from said zone of buckling deformation until at least one another inner wall, side wall or intersection of walls of the support bracket.
f. Assembling the new support bracket between said underride guard and said vehicle chassis frame in such order that said cavity direction is perpendicular to the underride guard.

In a preferred implementation of the method, the zone of buckling deformation is identified on at least one side or inner wall that extends according to the main bracket direction. When the support bracket is assembled in an underrun protection structure that is itself fixed under the vehicle chassis frame, this side or inner wall corresponds to a vertical or substantially vertical side and inner wall of the support bracket.

Thanks to this method the design of the support bracket and its arrangement in an underrun protection structure can be optimized in order to limit the buckling deformation of the vertical or substantially vertical side and inner walls of the support bracket and to limit the global deformation of the support bracket when the underrun protection structure is mounted under the vehicle chassis frame and in case of impact on the underride guard.

Preferably, the zone of buckling deformation corresponds to a zone where the amplitude of the buckling deformation has reached a maximum amplitude.

In an advantageous design of the new support bracket, the new inner wall is inclined with an angle lower than 30°, preferably lower than 10°, with respect to a direction that is perpendicular to the portion of the side or inner wall where the zone of buckling deformation has been identified.

These and other features and advantages will become apparent upon reading the following description in view of the drawing attached hereto representing, as non-limiting examples, embodiments of a vehicle according to the invention.

Brief description of the drawings

The following detailed description of several embodiments of the invention is better understood when read in conjunction with the appended drawings, it being however understood that the invention is not limited to the specific embodiments disclosed.

Figure 1 is a side view of a vehicle equipped with an underrun protection structure.

Figure 2 is a rear view of a rear portion of a vehicle chassis frame showing a rear underrun protection structure of the prior art.

Figure 3 is a perspective view of the underrun protection structure of figure 2.

Figure 4 is a perspective view of an underrun protection structure according to a first embodiment of the invention ;

Figure 5 is a perspective view of the support bracket of the underrun protection structure of figure 4 ;

Figure 6 is a side view of the underrun protection structure of figure 4 ;

Figure 7 is a rear view of an underrun protection structure according to a second embodiment of the invention ;

Figure 8 is a perspective view of an underrun protection structure according to a third embodiment of the invention ;

Figures 9.a to 9.b represent different steps of a method according to the invention.

Detailed description of the invention

The invention relates to an underrun protection structure which is designed to be arranged near the lower parts of a vehicle and to be fixed onto the vehicle chassis frame.

As illustrated in Figure 1, such a vehicle 1 can comprise a chassis frame 2 supported by wheels 3 as well as a cab 4 and a container 5 having the shape of a parallelepiped. The vehicle 1 has a longitudinal axis 6 that extends from the front 7 to the rear 8 of the vehicle 1. The longitudinal axis 6 defines a longitudinal direction of the vehicle 1.

Traditionally, the vehicle 1 is equipped with a first underrun protection structure 9 arranged at the rear part 8 of the vehicle 1 and fixed under the chassis frame 2 as well as a second underrun protection structure 59 arranged at the front part 7 of the vehicle 1 and that can also be fixed under the chassis frame 2. The vehicle 1 can also be equipped with a pair of third underrun protection structures 10 arranged on each side of the vehicle 1.

Even if the underrun protection structure according to the invention can be fixed at the front part 7 or on the sides of the vehicle 1, the underrun protection structures hereinafter described are especially designed to be arranged and to be fixed at the rear part 11 of the chassis frame 2 of a vehicle such as a truck or a trailer (hereinafter the "rear underrun protection structure").

Reference is now made to figures 2 and 3 which illustrate an underrun protection structure 9 of the prior art. Such a rear underrun protection structure 9 comprises a rear underride guard 12 that is arranged under the rear part 11 of the chassis frame 2. The rear underride guard 12 is fixed to the chassis frame 2 via two vertical support brackets 13, 14 that extend generally in a vertical direction.

The chassis frame 2 of a truck or trailer comprises generally two parallel left and right C-shaped frame rails 15, 16 that have a vertical web 17 and two horizontal upper and lower flanges 18, 19. The left and right frame rails

15, 16 are inwardly open towards each other; the vertical web 17 of each front frame rail 15, 16 therefore forms the outward surface of the vehicle chassis frame 2.

The rear underride guard 12 is an elongated part that can be a bar, a tube or an extruded profile with a more complex section shape such as depicted in figure 8. The rear underride guard 12 extends between two free ends 20, 21, according to a main axis 22 and in a transverse direction of the vehicle 1. The term "transverse direction of the vehicle" refers to a direction that is perpendicular to the longitudinal axis 6 of the vehicle 1.

Figures 4-9 illustrate different embodiments of the invention. Reference is now made to figures 4-6 which illustrate a first embodiment of the invention. For the sake of clarity and because the chassis frame 2 and the rear underrum protection structure 91 can be considered symmetrical, figures 4 and 5 illustrate only the left C-shaped frame rail 15 of the vehicle frame chassis 2 and the left part of the rear underrun protection structure 91.

Rear part 11 of the frame chassis and the underride guard 12 can be unchanged compared to prior art such as depicted in figures 2 and 3, that's why for this elements it is hereinafter allotted the same reference number.

The rear underrun protection structure 91 depicted in figures 4, 6 is fixed under the rear part 11 of a vehicle chassis frame 2 and comprises a rear underride guard 12 that extends between two free ends 20, 21, according to its main guard direction 22 and in a transverse direction of the vehicle 1.

The rear underrun protection structure 91 further comprises support brackets 23, 24 to fix the rear underride guard 12 under the chassis frame 2. Each support bracket 23, 24 extends according to a main bracket direction 33 between a first end 25 designed for the fixation of the underride guard 12 on each support bracket 23, 24 and a second end 26 designed for the fixation of each support bracket 23, 24 on the chassis frame 2. In an operative position of the underrun protection structure 91, means that when the rear underrun protection structure 91 is mounted on the vehicle chassis frame 2, each support bracket 23, 24 extends globally in a vertical direction and under the lower

flange 19 of a frame rail 15, 16; the first end 25 corresponds to a lower end of the support bracket 23, 24; and the second end 26 corresponds to a top end of the support bracket 23, 24.

Each support bracket 23, 24 has a hollow body 27 delimited by side walls 28 and divided into several cavities 29. The cavities 29 are separated inside the support bracket by inner walls 30. The cavities 29 and the inner walls 30 extend inside the support bracket 23, 24 in parallel straight lines. In other words the cavities have cylindrical shapes with sections that can be rectangular, triangular, circular or can be of any other shape. The term "cylindrical shape" refers to a shape that is generated by the displacement of a straight line according to a closed curve while the straight line remains parallel to itself during said displacement.

As depicted in figures 4, 6-8, said inner walls 30 and said cavities 29 extend according to the cavity direction 31 that is transverse to the main bracket direction 33 of the support bracket and that is perpendicular to the underride guard 12. In other words, they extend according to a direction that is perpendicular to the main guar direction 22 of the underride guard 12 so that when the underrun protection structure 91 is, for instance, a rear one mounted on the vehicle chassis frame 2 the inner walls 30 and the cavities 29 extend according to cavity direction 31 that is parallel to the longitudinal axis 6 of the vehicle 1. Consequently, the direction 33, according to which the inner walls 30 and the cavities 29 extend, is substantially the same as the direction P2 of an impact on the underride guard 12 due to a rear end collision.

The support brackets 23, 24 are made of light material and they are preferably made of aluminium alloy. Advantageously, the side walls 28 and the inner walls 30 are integrally formed with the support brackets 23, 24. For instance support brackets 23, 24 are obtained by an extrusion process and the extruded profile (not depicted) is cut into portions to obtain the final shape of the bracket 23 such as, for instance, depicted on figure 5. The support brackets 23, 24 can also be obtained by injection moulding or by die casting process.

Each support bracket 23, 24 preferably comprises a fastening extension 32 that is also integrally formed with the support bracket 23, 24 and that extends along the vertical web 17 of the frame rail 15, 16. Each support bracket 23, 24 is fastened onto the vertical web 17 via the fastening extension 32 and it is preferable to use fastening means such as several nut and bolt assemblies (not depicted) to fasten each support bracket 23, 24 onto the vertical web 17.

The fastening extensions 32 have preferably a thickness "**T**" that is more than twice the thickness "**t**" of the side walls 28 of the support bracket. The thickness **T** of the fastening extensions 32 is preferably comprised between twice and six times the thickness **t** of the side walls 28 and for example is about four times the thickness **t** of the side walls 28. The minimum thickness is necessary to avoid a tearing of the fastening extension 32 when the underride guard 12 is impacted by another vehicle and the maximum thickness is required for compactness and lightness of the underrun protection structure 91. The fastening extensions 2 may be formed by at least two parallel and vertical walls 71, 72 (figure 5) forming cavities between them. The vertical walls 71, 72 are preferably linked together by horizontal inner walls 73 having a thickness that is sufficient to form through-holes 74 through the horizontal inner walls 73 and in order to allow the passage of bolts (not depicted) for the fixation of each support bracket onto a frame rail 15, 16. The thickness of horizontal inner walls 73 can be comprised between 20 and 80 mm.

Each support bracket can also comprise an abutment surface 34, integrally formed with the support bracket 23, 24, that extends along and under the lower flange 19 of a frame rail 15, 16. To be more precise and when the underrun protection structure is assembled onto the vehicle, the abutment surface 34 is horizontal. In the present embodiment each support bracket 23, 24 is mounted onto a frame rail 15, 16 in such a way that the abutment surface 34 permanently contacts said lower flange 19. Alternatively each support bracket 23, 24 can be designed and arranged so that the abutment surface 34 contacts the lower flange 19 only in case of impact on the underride guard 12.

Thanks to this abutment surface 34 formed on the support bracket, the mechanical stress of the fastening means, resulting from an impact on the underride guard 12, is reduced. Particularly when fastening means are nut and bolt assemblies, shear stress of bolts is considerably reduced when the underride guard 12 is impacted by another vehicle.

By comparison to a traditional underrun protection structure 9 such as depicted in figures 2, 3 and that uses support brackets 13, 14 made of steel profile having a U section shape, a structure 91 according to the invention, having the same weight or being lighter than the traditional structure, is able to withstand a force generated by a car passenger impact that is at least 50 % more than the traditional underrun protection structure 9 is able to withstand in similar conditions.

For instance, a rear underrun protection structure 91, designed and arranged according to the invention and having a weight of about 47 kg, has been tested and compared to a prior art structure 9 having a weight of 68 kg and arranged such as illustrated in figures 2 and 3. Both underrun protection structures have been tested according to the same conditions and according to the homologation protocol described in the Regulation N°58 of the Economic Commission for Europe (ECE R58) relative to the rear underrun protection. Efforts have been applied on different points of the underride guard 12 and in particular on the point P2 that is facing each support bracket 13, 14 (prior art) and 23, 24 (invention). Considering a maximum amplitude of deformation on the point P2, the effort applied on P2 has been increased to assess mechanical resistance of each structure 9, 91. For instance, for a maximum amplitude of deformation of 30 mm, the results of the testing have showed that the rear underrun protection structure 91 according to the invention is able to withstand an effort of about 180 kN. To the contrary, the prior art structure 9 is only able to withstand an effort of 100 kN within the same amplitude of deformation.

A dynamic test has also been performed. In this test the underride guard 12 has been impacted by a passenger car having a weight of 1400 kg. The results have shown that the underrun protection structure 91 according to

the invention is able to withstand an impact when the speed difference between both vehicles is more than 40 km/h whereas in the same conditions the prior art structure 9 collapses when the speed difference is only about 25 km/h.

The inventors have determined that resizing a prior art structure 9, such as depicted in figure 2, in order to obtain the same results as with the present invention, causes an increase in weight of the prior art structure, this weight can exceed 75 kg.

Each support bracket 23, 24 may also comprise one or several transversal extensions 35 that extend from a vertical side wall 28 and according to a direction 36 that is parallel to the underride guard 12. The transversal extensions 35 are integral with support bracket 23, 24, i.e. they are part of the extruded profile such as obtained by an extrusion process. These transversal extensions 35 can be used to fix additional equipment such as for instance lights or hydraulic actuators for a tailgate lift (not depicted). As represented on figure 4, a transversal extension 35 extends preferably along the underride guard 12 and outwards on the underrun protection structure 91. In other words, each transversal extension 35 extends preferably along the underride guard 12 and towards one of the ends 20, 21. Thanks to this configuration of the transversal extensions 35, the bending of the underride guard, due to a rear impact P1 localized near one of its ends 20, 21, is reduced.

It is noticed that each support bracket 23, 24 extends mainly under its abutment surface 34 and therefore under a frame rail 15, 16 so that, in an operative position, the width of each support bracket is partially covered by the width of a frame rail 15, 16. Therefore, a better compactness and a better integration of the inventive structure 91 under the vehicle chassis frame 2 results from this configuration.

Reference is now made to figure 7 which illustrates a second embodiment of the invention. This embodiment differs from the embodiment of figures 4-6 mainly by the fact that the fastening extension 32 of each support bracket 23, 24 extends along the vertical web 17 from the inside 36 of each

frame rail 15, 16 instead of extending along the vertical web 17 at the outside of the frame rail such as depicted in figures 4-6 and 8.

This configuration promotes a greater compactness of the underrun protection structure 91 and a better integration of the underrun protection structure 91 under the vehicle chassis frame 2.

Figure 8 represents a third embodiment of the invention wherein each radial extension 35 of the first embodiment (figures 3-5) has been replaced by two add-on reinforcement bars 37. Each reinforcement bar 37 is fixed between a vertical side wall 28 of a support bracket 23, 24 until an end part 20, 21 of the underride guard 12.

Each reinforcement bar 37 can be fixed onto a support bracket 23, 24 via a groove 38 of the support bracket that extends in the same direction 31 as cavities 29, i.e. according to the direction that is perpendicular to the underride guard 12. It is noticed that, thanks to the direction of extrusion of the support brackets, the grooves can be easily formed into each support bracket 23, 24 and can be used to fix reinforcement bars 37 or to fix additional equipment (not depicted).

A method for manufacturing and assembling a support bracket 23, 24 according to the invention is now described by reference to the figures 9.a-9b. For example, the method is implemented for a support bracket 124 similar to that of figure 8 is chosen.

Such a method comprises the following steps :

- A first step (a) consists of providing an initial support bracket 124 such as represented in figure 9.a.
- A second step (b) consists of locking the second end 26 of the support bracket 24 in order to avoid motions of said second end 26. In a practical manner this step can be performed, for instance, by fixing the second end 26 of the support bracket 24 onto a vehicle frame 2 or onto a support (not represented).

- A third step (c), such as represented in figure 9.b, consists of applying a force "F" on the first end 25 of the initial support bracket 124 according to a direction that is substantially the same as the cavity direction 31 according to which the cavities 29 and the inner walls 30 extend inside the support bracket. In other words and when the support bracket 124 is obtained thanks to an extrusion process the force F is applied in a direction that is substantially parallel to the direction of extrusion. The force F can be applied directly on the the first end 25 or via an intermediate component such as an underride guard 12.
- A fourth step (d), also represented in figure 9.b, consists of identifying at least one zone 40 of buckling deformation on at least one wall 28, 30 that extends substantially in the main direction 33 of the support bracket 124. In other words and when the underrun protection structure 91 is in its operative position, the fourth step (d) consists of identifying at least one zone 40 of buckling deformation on at least one wall 28, 30 that is substantially vertical. In the present case and such as depicted in figure 9.b, a buckling deformation 40 is observed on a top vertical side wall 28 and another buckling deformation is observed on a top vertical inner wall 30.
- A fifth step (e), such as represented in figure 9.c, consists of designing a new support bracket 224 with at least a new inner wall 291, 292 that extends from said zone 40 of previously observed buckling deformation until at least another inner wall 30, side wall 28 or intersection of walls 41 of the support bracket 224. As depicted in figure 9.c, two inner walls 291, 292 have been added. The first one 291 extends horizontally from the vertical inner wall 30 where the buckling deformation has been observed until a vertical side

wall 28. The second one 292 extends in a direction that is inclined with respect to a horizontal plane and extends from the vertical side 28 wall where the buckling deformation has been previously observed until an intersection 41 of inner walls inside the support bracket 224.

- A sixth step (f), consists of assembling the new support bracket 224 between an underride guard 12 and a vehicle frame 2 in such a manner that the cavity direction 31 according to which the cavities 29 and the inner walls extend inside the support bracket is perpendicular to the underride guard. In other words, when the support bracket 224 is obtained thanks to an extrusion process and when the underride guard is, for instance, a rear one, the new support bracket 224 is assembled so that the direction of extrusion is perpendicular to the transverse direction of the vehicle.

The first five steps (a-e) can be repeated several times until the global bending deformation of the support bracket 124 falls below a threshold value or until the displacement of the first end 25 due to the global deformation of the support bracket 124 becomes lower than a maximum authorized displacement.

The first five steps (a-e) can be implemented thanks to a computer modelling tool or can be implemented thanks to full-scale prototype tests.

In step d), it is preferable to identify a zone 40 corresponding to a zone where the amplitude of displacement due to the buckling deformation reaches a maximum amplitude. Then, in step e) the new support bracket 224 is designed so that the the new inner walls 291, 292 extend from the zone 40 where the amplitude of the buckling deformation has reached a maximum until at least another inner wall 30, side wall 28 or intersection 41 of walls of the support bracket.

The new inner walls are preferably inclined with an angle lower than 30° and more preferably lower than 10° with respect to a direction that is perpendicular to the portion of the side or inner wall 28, 30 where the zone 40 of buckling deformation has been observed. In other words and when the underrun protection structure 91 is in an operative position, new inner walls are preferably inclined with an angle lower than 30° and more preferably lower than 10° with respect to a horizontal plane.

It is well understood that support brackets 23, 24 are also designed according to the usual rules and principles for designing hollow parts obtained for instance by extrusion processes.

The invention is of course not limited to the embodiments described above as examples, but encompasses all technical equivalents and alternatives of the means described as well as combinations thereof.

CLAIMS

1. An underrun protection structure for a vehicle (1) having a vehicle chassis frame (2), wherein the underrun protection structure (91) comprises :
    a. at least one underride guard (12) having an elongated shape that extends along a main guard direction (22);
    b. at least two support brackets (23, 24), each of them extending, according to a main bracket direction (33), between a first end (25) where is fixed said underride guard (12) and a second end (26) for the fixation of the underrun protection structure (91) under the vehicle chassis frame (2) and each of the support brackets (23, 24) having a hollow body (27), side walls (28) delimiting said hollow body (27) and inner walls (30) dividing the hollow body (27) into cavities (29) ;

    wherein said inner walls (30) and said cavities (29) extend in parallel straight lines inside each support bracket (23, 24),
    characterized in that said inner walls (30) and said cavities (29) of each support bracket (23, 24) extend according to a cavity direction (31) that is transverse to the main bracket direction (33) of the support bracket (23, 24) and that is perpendicular to the main guard direction (22) of the underride guard (12).

2. The underrun protection structure according to claim 1, wherein the vehicle chassis frame (2) comprises two parallel frame rails (15, 16) and each support bracket (23, 24) is fixed to one frame rail (15, 16) at an end part (11) of the vehicle chassis frame (2) so that the main guard direction (22) of the underride guard (12) is oriented perpendicularly to the frame rails (15, 16) and the cavity direction (31) is parallel to the frame rails (15, 16).

3. The underrun protection structure according to any one of the preceding claims, wherein said cavities (29) open onto at least one side (51, 52) of each support bracket (23, 24) along the cavity direction (31).

4. The underrun protection structure according to claim 3, wherein said cavities (29) are through cavities having cylindrical shapes and that open on both sides (51, 52) of each support bracket (23, 24) along the cavity direction (31).

5. The underrun protection structure according to any one of the preceding claims, wherein the side and inner walls (28, 30) are integrally formed with the support brackets (23, 24).

6. The underrun protection structure according to any one of the preceding claims, wherein the support brackets (23, 24) are made of light material, preferably of light alloy.

7. The underrun protection structure according to any one of the preceding claims, wherein the support brackets (23, 24) are extruded parts which are oriented so that their direction of extrusion is along the cavity direction (31).

8. The underrun protection structure according to any one of the preceding claims in combination with claim 2, wherein each support bracket (23, 24) has a fastening extension (32) integrally formed with the support bracket (23, 24), that extends from said second end (26) according to the main bracket direction (33) and that is designed to fix the underrun protection structure (91) onto a vertical side surface (17) of each frame rail (15, 16).

9. The underrun protection structure according to the claim 8, wherein each support bracket (23, 24) comprises an abutment surface (34) integrally formed with the support bracket (23, 24) and that is arranged to contact a lower surface (19) of a frame rail at least in case of impact on the underride guard (12).

10. The underrun protection structure according to claim 8 or 9 in combination with claims 6 and 7, wherein each fastening extension (32) has a thickness (T) that is at least twice the thickness (t) of the side walls (28) of the support brackets (23, 24).

11. The underrun protection structure according to any one of the preceding claims, wherein each support bracket (23, 24) comprises at least one transversal extension (35) which extends from the support bracket (23, 24), along the underride guard (12) and in a direction (36) that is parallel to the main guard direction (22) of the underride guard (12).

12. A vehicle having a vehicle chassis frame (2), having a longitudinal axis (6) and comprising at least one underrun protection structure (91) that comprises :

- at least one underride guard (12) having an elongated shape ;
- at least two support brackets (23, 24), each of them extending between a first end (25) where is fixed said underride guard (12) and a second end (26) for the fixation of the underrun protection structure (91) under the vehicle chassis frame (2) and each of the support brackets (23, 24) having a hollow body (27), side walls (28) delimiting said hollow body (27) and inner walls (30) dividing the hollow body (27) into cavities (29) ;

wherein said inner walls (30) and said cavities (29) extend in parallel straight lines inside each support bracket (23, 24),

wherein said underrun protection structure (91) is fixed under the vehicle chassis frame (2),
characterized in that said inner walls (30) and said cavities (29) extend according to a cavity direction (31) that is parallel to the longitudinal axis (6) of the vehicle and in that the underride guard (12) extends in a transverse direction of the vehicle (1).

13. A vehicle, according to claim 12, wherein said underrun protection structure (91) is fixed at an end part (11) of the vehicle chassis frame (2).

14. A vehicle, according to claim 12 or 13, having a vehicle chassis frame (2) that comprises two frame rails (15, 16) that are parallel to the longitudinal axis (6) of the vehicle, wherein each support bracket (23, 24) has a fastening extension (32) integrally formed with the support bracket (23, 24) that extends upwards from said second end (26) of the support bracket (23, 24) and along a vertical side surface (17) of a frame rail (15, 16), and wherein each support bracket (23, 24) is fixed onto said vertical side surface (32) via its fastening extension (32).

15. A vehicle, according to any one of claims 12 to 14, wherein each support bracket (23, 24) comprises an abutment surface (34) integrally formed with the support bracket (23, 24) and that is arranged to contact a lower surface (19) of a frame rail at least in case of impact on the underride guard (12), said abutment surface (34) extends along a lower surface (19) of a frame rail (15, 16) and each support bracket (23, 24) extends globally in a vertical direction under said lower surface (19).

16. A method for manufacturing a support bracket and assembling it between a vehicle chassis frame (2) and an underride guard (12) having an elongated shape and that is designed to be disposed under the

vehicle chassis frame (2) wherein the method comprises the following steps :

a. providing an initial support bracket (124) having a hollow body (27), extending according to a main bracket direction (33) between a first end (25) for the fixation of said underride guard (12) on the support bracket (124) and a second end (26) for the fixation of the support bracket (124) on the vehicle chassis frame (2), having :
   - side walls (28) integrally formed with the support bracket (141) and delimiting said hollow body (27),
   - inner walls (30), integrally formed with the support bracket (124), dividing the hollow body (27) into several cavities (29),

   wherein said cavities (29) extend inside the support bracket in parallel straight lines and according to a cavity direction (31) that is transverse to the main bracket direction (33);
b. locking said second end (26) in order to avoid displacements of said second end (26) ;
c. applying a force on the first end (25) of the initial support bracket (124), said force being oriented according to a direction that is substantially parallel to said cavity direction (31);
d. identifying at least one zone (40) of buckling deformation on at least one side or inner wall (28, 30) ;
e. providing a new support bracket (224) with at least a new inner wall (291, 292) that extends from said zone (40) of buckling deformation until at least one another inner wall (30), side wall (28) or intersection of walls (41) of the support bracket (224) ;
f. assembling the new support bracket (224) between said underride guard (12) and said vehicle chassis frame (2) in such

order that said cavity direction (31) is perpendicular to the underride guard (12).

17. The method according to claim 16, wherein the zone (40) of buckling deformation is identified on at least one side or inner wall (28, 30) that extends according to the main bracket direction (33).

18. The method according to claim 16 or 17, wherein the zone (40) of buckling deformation corresponds to a zone where the amplitude of buckling deformation reaches a maximum amplitude.

19. The method according to anyone of claims 16 to 18, wherein the new inner wall (291, 292) is inclined with an angle lower than 30°, preferably lower than 10°, with respect to a direction that is perpendicular to the portion of the side or inner wall (28, 30) where the zone (40) of buckling deformation is identified.

FIGURES

Figure 1

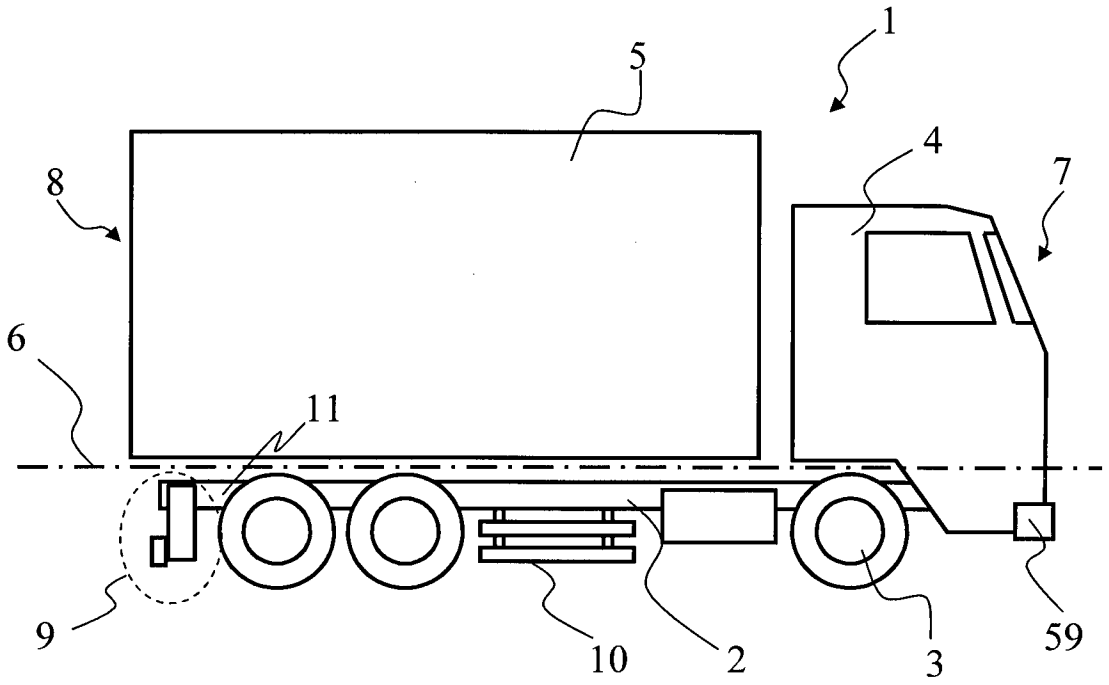


Figure 2

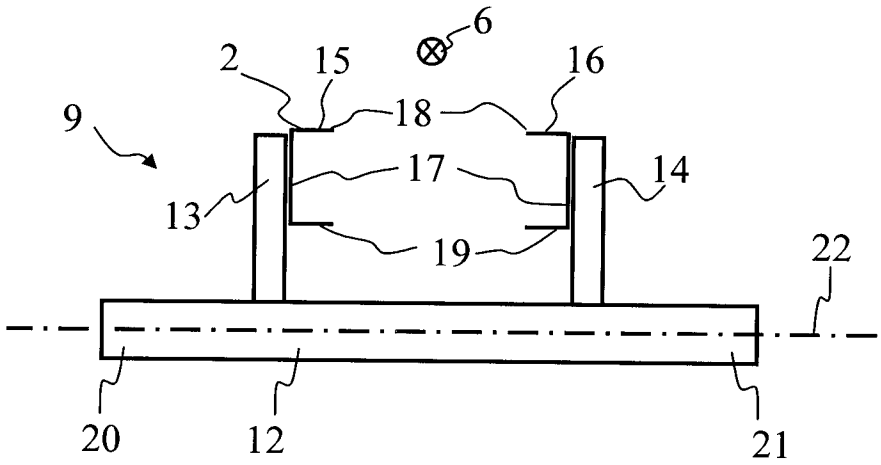


Figure 3

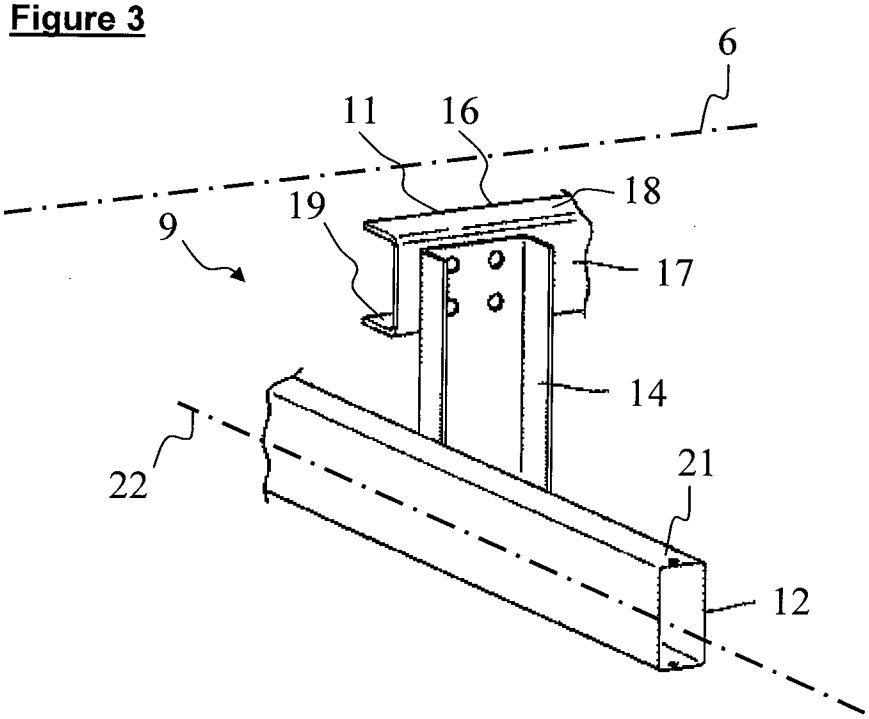


Figure 4

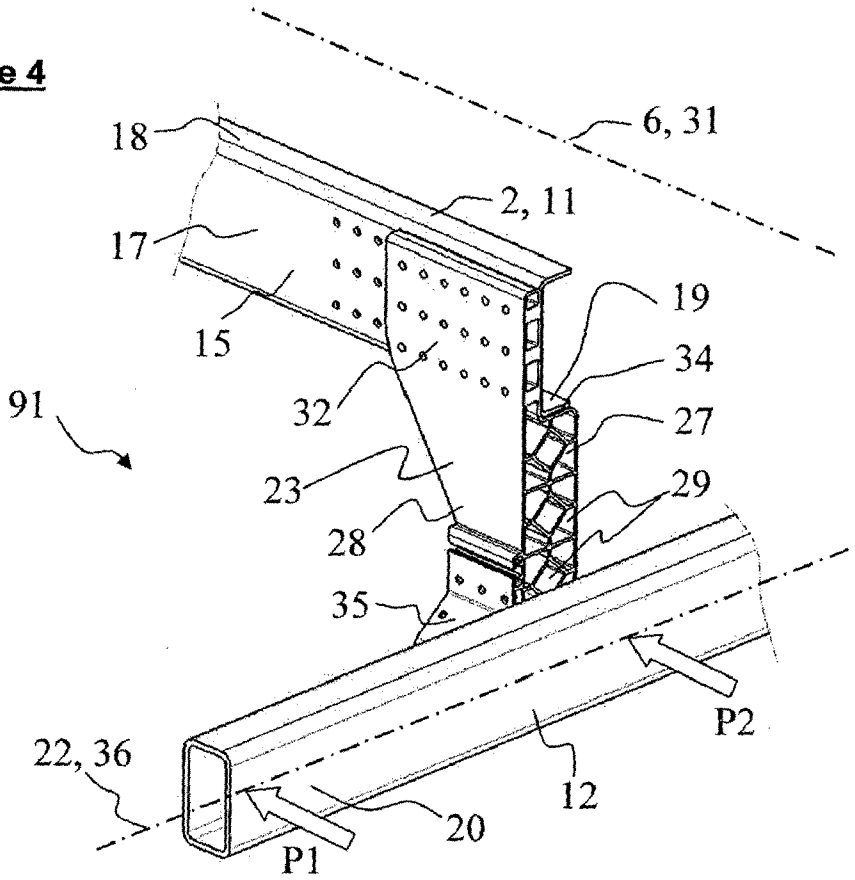


Figure 5

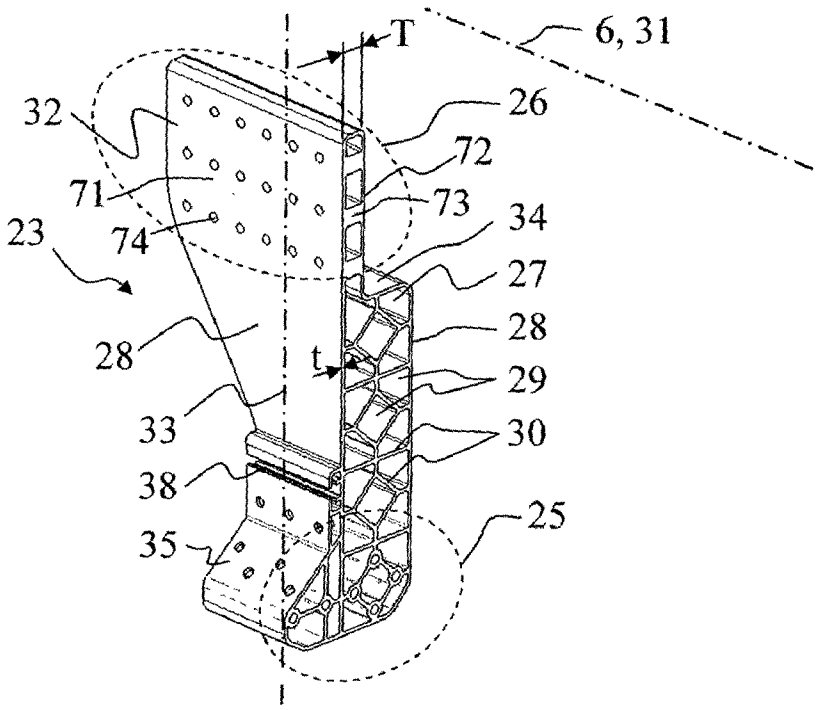


Figure 6

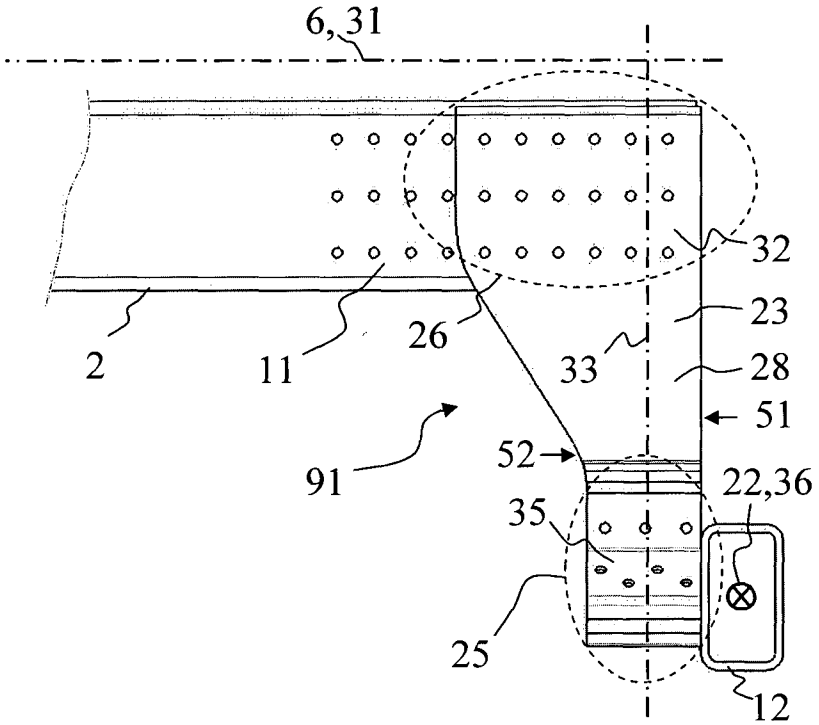


Figure 7

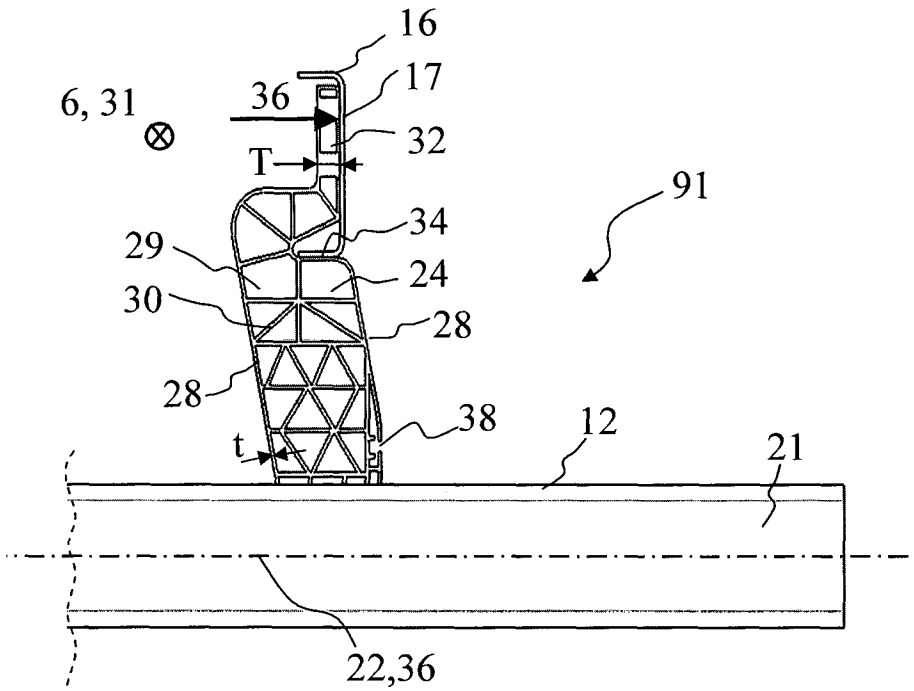


Figure 8

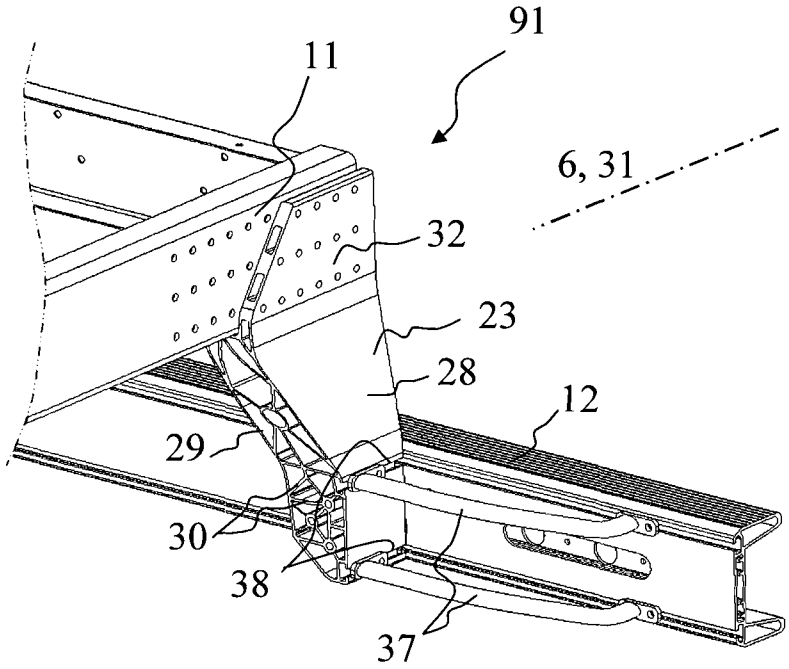


Figure 9.a

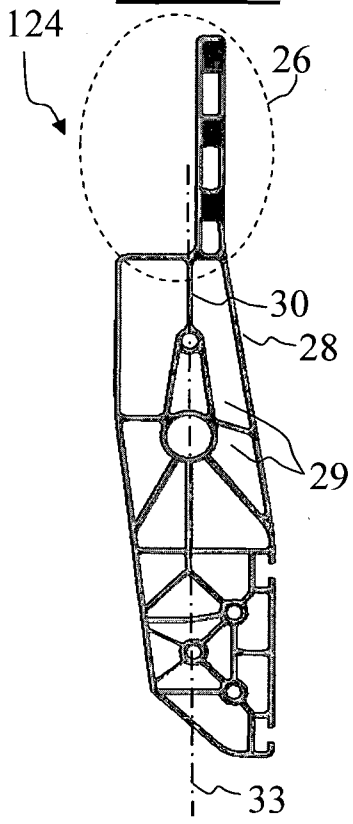


Figure 9.b

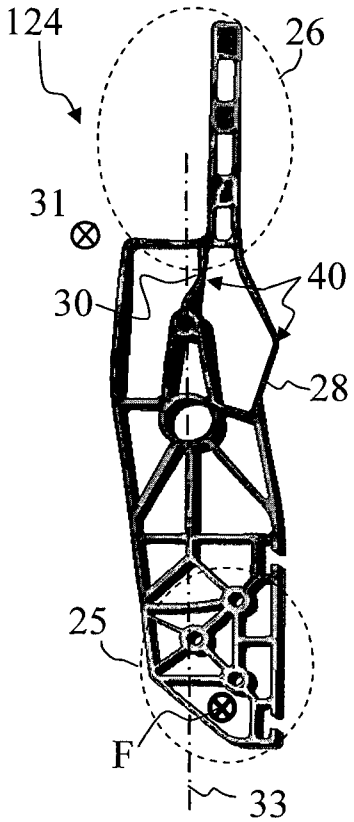
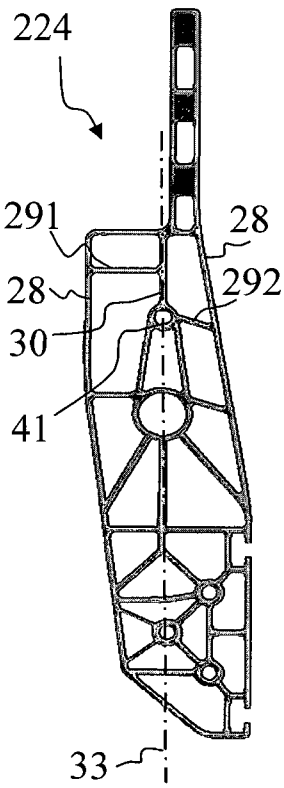


Figure 9.c



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2012/002999

A. CLASSIFICATION OF SUBJECT MATTER
INV. B62D21/15 B60R19/56
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60R B62D

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, PAJ, 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	EP 1 293 389 A1 (PLASTIC OMNIUM CIE [FR]) 19 March 2003 (2003-03-19) paragraph [0030] - paragraph [0063]; figures 1-6	1-13,15
X	FR 2 911 559 A1 (PLASTIC OMNIUM CIE [FR]) 25 July 2008 (2008-07-25) page 6, line 28 - page 10, line 5; figures 1-3	1-13,15
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 May 2013	24/05/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ekblom, Henrik

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2012/002999

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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