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Longitudinal girder for the transition area of a car body side wall to the car body roof of a rail vehicle car body

The invention relates to a longitudinal girder for the transition area of a car body side wall to the car body roof of a rail vehicle car body to which different car body roof sections can be attached in a simple fashion, a side wall for a rail vehicle car body, a car body and a rail vehicle comprising such a side wall or such a longitudinal girder, and also to a method for the production of a rail vehicle car body with different roof sections.

Rail vehicle car bodies can have both arched roof areas, which are also called contoured roof areas, and flat roof areas or less steep roof areas. Compared to the roof level in the arched roof areas, the roof level in the flat roof areas is lower. For example, air-conditioning units, pantographs, energy stores or drive equipment are installed on the flat roof sections. Arranging such installations on flat roof areas prevents them from projecting beyond the height level of the arched roof sections or, at least, makes them project less far.

Hitherto, the flat roof areas of car bodies have been implemented for example in the form of a roof trough. Such a roof trough has a horizontal, or basically horizontal, floor that forms the roof area and rising side walls. A roof trough may be connected to a contoured roof. For example, a rectangular opening is made in a contoured roof into which a roof trough is welded.

EP 1839989 A2 describes a car body for rail vehicles with a lowered flat roof area. To insert such a flat roof area, a side construction body arranged at the upper end of the side wall is cut short to create a connection point for a trough-shaped lowered flat roof area. The disadvantage of a solution is that a part of the side construction body has to be severed to make a connection point accessible at which a flat roof area can be attached.

One objective of the present invention is to facilitate the fastening of different roof areas with different heights, and in particular to facilitate the fastening of flat roof areas.

The solution proposed by the invention is a longitudinal girder and a side wall as specified in the enclosed patent claims. Especially advantageous embodiments of a longitudinal girder and a side wall are specified in the dependent claims. Likewise specified is a rail



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vehicle car body with roof areas of different heights and a method for the production of such a rail vehicle car body.

The invention relates to a longitudinal girder for a rail vehicle car body, comprising

- a first connection point for a first roof section which in installed position points upward vertically or at an angle;
- a second connection point for a second roof section which in installed position points in the direction of the car body inner side and which is arranged under the first connection point;
- a third connection point for a car body side wall which in installed position points downward or downward at an angle;

with the longitudinal girder designed to be one single piece.

In this description, the term "car body inner side" is used to denote the car body inner side of a side wall or of a fictitious extension of a side wall in upward direction. The wording "in the direction of the car body inner side" does not necessarily mean that a connection point, or a protrusion which will be described below, points towards the interior of the car body because this is not the case at least where a roof section is attached to the connection point or the protrusion. That is, the wording "in the direction of the car body inner side" does not necessarily mean "in the direction of the car interior". The following examples are provided for clarification: If the longitudinal girder is arranged above a side wall which is on the right side in direction of travel, then "in the direction of the car body inner side" means that the second connection point points towards the left side in direction of travel. If the longitudinal girder is arranged above a side wall which is on the left side in direction of travel, then "in the direction of the car body inner side" means that the second connection point points towards the right side in direction of travel. This applies by analogy to a first connection point or a first or second protrusion (described below), where their direction is defined in relation to a car body inner side. A further explanation of car body inner side and car body outer side is provided in the description of the illustrations.

The longitudinal girder is a supporting element of the car body and runs in longitudinal direction of the car between side wall and roof. In other words, it is located in the transition area between the side wall and the roof. A girder according to the invention is also called "top chord". The longitudinal girder may be a part of a car body of integral construction design or be intended for a car body of integral construction design.

According to a fundamental idea of the invention, the longitudinal girder has a connection point onto which a first roof section can be placed and affixed, for example an arched roof section, and a further connection point onto which a second roof section, for example a flat roof section, can be placed and affixed. Due to this, different roof sections can be affixed to the longitudinal girder as required and, for example, different roof sections can be created alternately on one and the same rail car. The terms "first roof section" and "second roof section" mean different roof types which can be arranged in succession on the longitudinal girder in longitudinal direction of the car. The difference between the first roof section mentioned and the second roof section mentioned is in particular that the first roof section protrudes upward beyond the second roof section. This means in particular that in its highest point the first roof section is higher than the second roof section. A further difference is that preferably only the second roof section is intended to receive installations such as air-conditioning units, energy stores, drive equipment or pantographs, but not the first roof section. The cross-sectional shape of a roof or a roof section may vary along its extension in longitudinal direction of the car.

When installed in the car body, the longitudinal girder extends along the longitudinal direction of the car body, and preferably over the entire length of the car body. The connection points for the side wall and the first and second roof sections extend over the entire length of the girder, preferably over the entire length of the car body. In particular, the cross-sectional shape of the longitudinal girder is basically the same along the entire length. Therefore, in particular, the surfaces that define the connection points have the same width and, possibly, the same cross-section profile over the entire length.

The longitudinal girder according to the invention is made as one piece, for example as an extruded section, and it extends in longitudinal direction of the car body preferably from the front end of the car body to the rear end of the car body. A special preference is that the longitudinal girder is a metal extruded section, preferably of aluminium or an aluminium alloy. A special preference is that the longitudinal girder is an extruded profile with a hollow chamber structure, in particular made of aluminium, in which the chambers may be separated by walls running in longitudinal direction.

The advantage of the longitudinal girder according to the invention is that no mechanical work has to be done on it to attach different roof sections. Over its entire length, preferably

the entire length of the car, the longitudinal girder may have the same design and also retain the same design, irrespective of whether a first or a second roof section is attached to it. The existing connection points are available, optionally the first and the second connection point. Following the attachment of a first roof section at the first connection point, the unused second connection point in this section may remain on the girder, and following the attachment of a second roof section at the second connection point, the unused first connection point in this section may remain on the girder.

A car body side wall can be attached at the longitudinal girder at the third connection point that points downward vertically or at an angle and be connected to the longitudinal girder. A longitudinal girder according to the invention is in particular arranged both above the left and the right side wall of a car body, both seen in the direction of travel. The longitudinal girders are arranged in mirror image to each other referred to a symmetry plane between the side walls. The different roof sections in particular each extend from longitudinal girder to longitudinal girder and in this way span the space between the side walls. In the completed car body, the longitudinal girders are arranged in the transition area between the side wall and the roof of the car body.

A further advantage of the longitudinal girder according to the invention is that in particular at its second connection point at least one transverse stiffening element can be affixed, for example by welding, as an alternative to a second roof section, which extends across the car body and is fastened preferably at the second connection point of a further longitudinal girder according to the invention installed at the other side of the car body. Such transverse stiffening elements may be attached for example in places of the car body where a first roof section is located and where the second connection points of the longitudinal girder at either side (right and left) of the car body are not used to affix a second roof section. In that case, a transverse stiffening element extends below a first roof section from the second connection point of a longitudinal girder on the one side of the car body to the second connection point of a longitudinal girder on the other side of the car body. Preferably, the transverse stiffening element is made of metal, preferably aluminium. Attaching such transverse stiffening elements can improve the car body's vibration behaviour, in particular in the case of car bodies the parts of which are likewise produced in aluminium integral construction design.

Preferably, the first roof section is an arched roof section. In this description, an arched roof section is also called "contoured roof" or "arched roof". The term "arched" encompasses all conceivable radii of curvature and arch shapes. The radius of curvature may also vary and/or the cross-section profile may include angles. When looking at the cross-section of a car body, the contoured roof may e.g. run upward, starting from the right (or left, if looked at from the other side) side wall, reach a highest point, a highest area or highest points and then run downward to the left (or right, if looked at from the other side) side wall. Preferably, the contoured roof is mirror-symmetric to a symmetry plane imagined halfway between the side walls. The second roof section may likewise be an arched roof section which, however, in particular does not protrude upward beyond the second roof section.

In a further variant, the first roof section is a roof section with a horizontal plateau which is located higher than the side edges of the first roof section which are connected to the first connection point. The second roof section may likewise have a horizontal plateau which is located higher than the side edges of the second roof section which are fastened at the second connection point, provided that the first roof section does not protrude upward beyond the second roof section.

Preferably, the second roof section is a horizontal, or basically horizontal, roof section. Such a roof section is also referred to as "flat roof" in this description. When looking at the cross-section of a car body, the flat roof runs horizontally, or basically horizontally, between the right and the left side wall. The flat roof attached to the second protrusion of the longitudinal girder needs not necessarily run exactly horizontally, which is expressed by using the term "basically". Such a roof may have a small inclination, in particular of up to 5° against the horizontal, running from the two car body side walls in the direction of the car body centre, with the roof being inclined either upward from both car body side walls or downward from both car body side walls. At identical angles of inclination, the angled roof areas of such a second roof section meet at the centre of the car body.

Most preferably, the second roof section is a horizontal flat roof running from the second connection point of a longitudinal girder on the one side of the car body (for example, the left side of the car body) to the second connection point of a longitudinal girder on the other side of the car body (for example, the right side of the car body) taking the shortest possible route.

The connections between the roof sections and the longitudinal girder and of the side wall and the longitudinal girder preferably are join connections that require heating of the parts to be joined. The connection most preferred is a welded or soldered connection. However, other joining technologies such as gluing or riveting are in principle also conceivable.

The connection points of the longitudinal girder preferably have profiled surfaces to which the intended roof sections of the car body can be connected. An example is a projecting lip. In the case of the first connection point, the profiled surface is used to connect a first roof section. In the case of the second connection point, the profiled surface is used to connect a second roof section. Roof sections may likewise have a profiled surface at their edges the shape of which is complementary to a profiled surface at a connection point. After placing a roof section onto the connection points, join connections can be made between the longitudinal girder and the roof section, preferably welded connections.

A special embodiment of the first connection point has a projecting lip onto which a first roof section can be placed and which can be connected to the first roof section by means of a welded connection. In a further special embodiment, the second connection point has a projecting lip onto which a second roof section can be placed and which can be connected to the second roof section by means of a welded connection.

In a special embodiment, the invention provides a longitudinal girder, comprising

- a section which in installed position is at the bottom and comprises the third connection point;
- a first protrusion which in installed position projects upward vertically or at an angle with a free end that comprises the first connection point for the first roof section; and/or
- a second protrusion which in installed position projects in the direction of the car body inner side, is arranged under the first protrusion and has a free end that comprises the second connection point for the second roof section.

The following description relates to the case in which two protrusions exist. However, it applies by analogy to cases in which only the first protrusion or only the second protrusion exists.

The protrusion or the protrusions and the lower section extend in particular over the entire length of the girder in longitudinal direction of the car or at least over a longitudinal section in which different roof sections are fastened to the longitudinal girder. In the cross-section of the longitudinal girder, the lower section preferably has a larger cross-sectional area compared to that of each of the protrusions. As an alternative or in addition, the width of the lower section preferably is larger than the width of the protrusions. The width is determined in a direction transverse to the longitudinal direction. In assembled condition of the car body, the lower section is arranged above the side wall. The side wall is fastened to the lower section at the third connection point. The third connection point is preferably located at the lower end of the lower section. The side wall and the longitudinal girder may also form an integral part.

The connection point for the first roof section is located at the end of the first protrusion and the connection point for the second roof section is located at the end of the second protrusion. Due to this, a first roof section can be attached to the first protrusion of the longitudinal girder and a second roof section can be attached to the second protrusion of the longitudinal girder as required, so that different roof sections can be created on a car body.

On this special longitudinal girder, each of the protrusions can be accessed for welding in case of a join connection by means of welding without the need to cut off the protrusion not required. This means e.g. that the second protrusion at the longitudinal girder in a longitudinal section may remain unused if a first roof section is welded to the first protrusion in the longitudinal section, and vice versa.

Hence, if a second roof section is attached, then in particular the first protrusion of the longitudinal girder that points upward vertically or at an angle remains. It may be used as a side shield for devices installed on the second roof section such as air-conditioning units, energy stores, drive equipment or pantographs and wholly or partly cover such devices or their fastening points. In addition to acting as a shield against impact from the side such as dust and dirt, the first protrusion may also act as a visual cover. Where the visual covering or shielding of devices on a second roof section is not necessary, the first protrusion may also itself be used as a fastening point for devices.

In addition, the first protrusion may be used as a side roof rim in the area of a second roof section, in particular in the area of a flat roof section, that prevents water from flowing over the edge of the roof. In this way, the first protrusion in the area of a flat roof section may for example prevent rainwater or water from an air-conditioning unit installed on the flat roof from flowing over the side edges of the roof and down the car body. In addition to acting as a rim, the first protrusion may also itself be used to drain water, as explained further below.

Preferably, the special-design longitudinal girder described above is an extruded section made of metal, especially preferably of aluminium. A special preference is that the longitudinal girder is an extruded profile with a hollow chamber structure, in particular made of aluminium. Preferably, such a profile may have an outer (in relation to the inside of the car body) and an inner plate-shaped area which are connected by means of additional chamber walls. Each protrusion and the lower section of the longitudinal girder according to the invention may have an outer and an inner plate-shaped area which are connected by means of additional chamber walls. Likewise, however, the protrusions may be formed of a single chamber of a hollow chamber profile. The protrusions are preferably closed at their ends, for example by a transverse wall.

In a special embodiment of the longitudinal girder, the first protrusion has a drainage duct inside. The purpose of the drainage duct is to drain water from a roof section, preferably a second roof section. Preferably, the drainage duct extends in longitudinal direction of the car. A drainage duct extending in longitudinal direction of the car may extend along the entire length of the first protrusion or just along a part of the protrusion. The first protrusion has at least one inlet opening and at least one outlet opening between which the drainage duct extends. The inlet opening(s) can be accessed from the second roof section, for example by being arranged at the side of the protrusion facing the second roof section. The outlet opening can be arranged at different places, for example at a long-side end of the protrusion located at the front end or the rear end of a car body in the direction of travel. A nozzle or a drain pipe may be attached to the outlet opening.

The embodiment described above can be combined to particular advantage with an embodiment in which the first protrusion is formed of one or more than one chambers of a hollow chamber profile. In that case, such a chamber serves as a drainage duct.

The protrusions may in principle be dimensioned at will.

The length of a protrusion is defined by the length of the longitudinal girder in longitudinal direction of the car. The depth of a protrusion corresponds to its extension from a basis of the longitudinal girder, in particular from the lower section, to its free end.

In a cross-sectional view (transverse to the longitudinal direction of the car body) through the longitudinal girder, the ratio of width to depth of the protrusions may, independent of each other, be greater than 1 or smaller than 1. The width of a protrusion may vary in the depth direction. For example, at least one of the protrusions may taper in the direction of its free end.

At their ends, the protrusions preferably have a profiled surface onto which the car body components intended for the purpose can be placed. In the case of the first protrusion, the profiled surface is used to put on a first roof section. In the case of the second protrusion, the profiled surface is used to put on a second roof section. The roof sections may have a profiled surface at their edges the shape of which is complementary to a profiled surface at the end of an associated protrusion. After placing a roof element on, a join connection can be made between the end of the relevant protrusion and the roof element, preferably a welded connection.

In a special embodiment, the first protrusion has a projecting lip at its free end onto which a first roof section can be placed and which can be connected to the first roof section by means of a welded connection. In this embodiment, preferably the first roof section also has a projecting lip at its end, which end is connected to the free end of the first protrusion, and the lip is put onto the first protrusion when the roof section is placed onto the lip of the protrusion and can, in turn, be joined to the first protrusion by means of a welded connection. To create a flat junction point, the first protrusion may have a deepening at the contact point with the supported lip of the first roof section into which the lip of the first roof section is inserted and fits.

In a further special embodiment, the second protrusion has a projecting lip at its free end onto which a second roof section can be placed and which may be connected to the second roof section by means of a welded connection. In this embodiment, preferably the second roof section also has a projecting lip at its end, which end is connected to the free

end of the second protrusion, and the lip is put onto the second protrusion when the roof section is placed onto the lip of the protrusion and can, in turn, be joined to the second protrusion by means of a welded connection. To create a flat junction point, the second protrusion may have a deepening at the contact point with the supported lip of the second roof section into which the lip of the second roof section fits.

At the third connection point, the lower section of the longitudinal girder may have, for example, two opposing lips bent towards each other towards the inner side of the lower section at which two lips projecting from the end of a side wall element are supported and where a welded connection between the side wall and the longitudinal girder can be established at the transition points of the lips abutting on each other.

The first protrusion of the longitudinal girder may run upward vertically or at an angle. "At an angle" means that in the cross-section (transverse to the longitudinal direction of the car body) the first protrusion rises towards the inner side of the car. The first protrusion may run towards its free end in a straight or a curved line. The protrusion may also be straight on one side (inside or outside) and curved on the other side (inside or outside). The curvature may connect to the curvature of the contoured roof. A special preference is that the first protrusion extends upward at an angle.

A preferred angle of the straight-line extension of the first protrusion towards an imagined horizontal line is in particular  $20^{\circ}$  to  $70^{\circ}$ . At a protrusion running upward at an angle, a first roof section can be attached to advantage which runs downward at an angle at its side ends. In particular, the angle of the first protrusion which runs upward at an angle and the angle along the roof section are each identical at the end of the roof section, referred to the horizontal line.

The second protrusion points towards the car body inner side. In the cross-section (transverse to the longitudinal direction of the car body), it preferably runs horizontal, or basically horizontal. The second protrusion may run towards its free end in a straight or a curved line, the straight shape being preferred. With reference to the second protrusion, basically horizontal means that it may run upward by up to  $10^{\circ}$  or downward by up to  $10^{\circ}$  referred to an imagined horizontal line.

In a special embodiment, the second protrusion projects beyond the first protrusion in horizontal direction in the direction of the car body inner side. In other words, this means that, when looking at the longitudinal girder from above, the free end of the second protrusion is visible and not covered by the first protrusion. This embodiment allows for especially good accessibility for welding of the second protrusion from above because the welding location is not hidden by the first protrusion.

In a special variant, the depth of the first protrusion and the depth of the second protrusion, in a cross-sectional view, are dimensioned in such a way that an imagined connecting line from the free end of the first protrusion to the free end of the second protrusion forms an angle of  $40^{\circ}$  to  $50^{\circ}$  against the horizontal. In the case of a projecting lip, the free end is defined by its free end. Otherwise, e.g. an outer wall of a hollow chamber profile is located at the free end.

The advantage of this embodiment is that the free end of the first protrusion can be used as a guide for a welding torch when a second roof section is welded to the second protrusion. In the process, the welding torch, in particular its nozzle, is supported at or leaned against the free end of the first protrusion and the welding torch nozzle is pointed at the free end of the second protrusion at which the second roof section to be joined is supported. A welding torch aligned in this way can be guided along the free end of the first protrusion in longitudinal direction of the car and a weld seam can be produced between the free end of the second protrusion and the abutting flat roof part. In this process, the welding torch remains optimally aligned, in particular optimal to create a lap weld between the second protrusion and the second roof section.

In yet another embodiment, the second protrusion of the longitudinal girder has at its underside a means for fastening an interior panelling or other components or assemblies. In this embodiment, the second protrusion of the longitudinal girder has a double function, namely to act as a connecting point for a second roof section and to act as a fastening point, e.g. for an interior panelling such as an interior ceiling or other component such as cable ducts and air-conditioning unit elements.

A preferred example of a fastening means is a fastening rail, in particular a C-profile rail. The fastening means may be a fastening means attached at the second protrusion or the

fastening means may be manufactured as an integral part of the second protrusion, for example as an area of the extruded section.

The longitudinal girders described above may be joined with one or more than one first and/or second roof sections to form a component which is used in the production of car bodies as an assembly unit or as a pre-assembled component. Therefore, the invention also relates to a component for a rail vehicle car body comprising or consisting of previously described longitudinal girders and one or more than one first and/or second roof sections affixed to the longitudinal girders.

Regarding a further aspect, the invention relates to a side wall for a rail vehicle car body which at its upper end comprises

- a first connection point for a first roof section which in installed position points upward vertically or at an angle;
- a second connection point for a second roof section, arranged under the first connection point, which in installed position points in the direction of the car body inner side.

In contrast to the longitudinal girder described above, the side wall now itself has connection points for attaching different roof areas. Refer to the above disclosure regarding the connection points. In other words, the side wall and the longitudinal girder form an integral, common component.

However, the invention also relates to a component for a rail vehicle car body comprising a previously described longitudinal girder and a side wall connected to the girder. This object is a side wall which is connected to a separately manufactured longitudinal girder to form an assembly unit or a pre-assembled component.

In a special embodiment, the side wall has the following elements:

- A first protrusion which in installed position projects upward vertically or at an angle and has a free end that comprises the first connection point for the first roof section; and/or
- A second protrusion, arranged under the first protrusion, which in installed position projects in the direction of the car body inner side and has a free end that comprises the second connection point for the second roof section.

The first and/or second protrusion may be designed as already described above. In particular, a side wall may be designed in such a way that the first protrusion, when looking at its cross-section, runs upward at an angle with a bend in relation to the car body side wall.

The side wall according to the invention together with the first and second protrusion may be made of extruded sections, preferably made of aluminium. With respect to this, also refer to the explanations above regarding extruded sections.

The side wall described may be joined with one or more than one first and/or second roof sections to form a component which is used in the production of car bodies as an assembly unit or as a pre-assembled component. Therefore, the invention also relates to a component for a rail vehicle car body comprising or consisting of previously described side walls and one or more than one first and/or second roof sections affixed to the side walls.

Furthermore, the invention relates to a car body for a rail vehicle which has a previously described longitudinal girder or a previously described side wall. In particular, the car body has at least one first roof section and at least one second roof section and, when looking at the car body in longitudinal direction, the first roof section projects upward beyond the second roof section. With respect to this, refer to the disclosure above regarding roof sections. A special preference is a car body on which the first roof section is an arched roof section and the second roof section is a horizontal, or basically horizontal, roof section.

Regarding yet another aspect, the invention relates to a rail vehicle which has a car body as previously described. Preferred rail vehicles are underground rail vehicles, commuter train vehicles, long-distance train vehicles, high-speed train vehicles and tramway vehicles. A special preference are integral construction rail vehicles.

The invention also relates to the use of a longitudinal girder as previously described or a side wall as previously described as a component for a rail vehicle car body.

Furthermore, the invention relates to a method for the production of a rail vehicle car body with at least one first roof section and at least one second roof section with, when looking at it in longitudinal direction, the first roof section projecting upward beyond the second roof section, and where in the method

- a) a single-piece longitudinal girder is arranged both above the area of the right car body side wall and above the area of the left car body side wall of a car body, the longitudinal girder comprising the following elements:
  - a first connection point for a first roof section pointing upward vertically or at an angle in the direction of the car body inner side;
  - a second connection point for a second roof section, arranged under the first connection point, which in installed position points in the direction of the car body inner side;
  - a third connection point for a car body side wall which in installed position points downward or downward at an angle;
- b) a right and a left car body side wall are joined to the third connection points of the two longitudinal girders;
- c) one or more than one first roof sections are joined to the first connection points of the two longitudinal girders and one or more than one second roof sections are joined to the second connection points of the two longitudinal girders, so that the first and second roof sections are arranged in longitudinal direction of the car and either just one first or just one second roof section is arranged in a longitudinal section of the longitudinal girder.

A longitudinal girder as already described above, including all special and preferred embodiments, can be used in the method. In step a) of the method, a longitudinal girder according to the invention can be used as a girder on the right side or the left side of the car body in the direction of travel.

In a variant of the method, a joining device, in particular a welding torch, is guided along the second connection point, in particular along a second protrusion, when one or more than one first roof sections are joined to the first connection point, in particular to a first protrusion.

In a further variant of the method, a joining device, in particular a welding torch, is guided along the first connection point, in particular along a first protrusion, when one or more

than one second roof sections are joined to the second connection point, in particular to a second protrusion.

The car body to be manufactured has at least one first roof section and at least one second roof section. The arrangement of the roof sections can in principle be chosen at will and there may be several first roof sections that alternate with one second roof section or more than one second roof section. It is also possible to connect at least one third roof section to the longitudinal girder at the first or the second connection point. In a special embodiment of a car body, flat roof sections are intended to be installed at the front and rear end of the car body, and between them a contoured roof section. The joining steps of the method are preferably carried out using a joining technology that requires heating of the components to be joined. A special preference is a welded or a soldered connection. However, gluing or riveting are also conceivable.

There may be an opening between a first roof section and a second roof section, provided that the first roof section does not already form a gable at the transition point. In an optional further step of the method, openings between first roof sections and second roof sections are closed. For example, a gable element such as a sheet or an appropriately shaped hollow section may be inserted into the opening and connected to the edge of the first roof section at its upper edge and to the edge of the second roof section at its lower edge, preferably by means of a joint connection, in particular by welding.

Embodiments of the invention are described below making reference to the attached drawings. The figures show the following:

Fig. 1a, 1b The car body of a rail vehicle in two different perspectives

Fig. 2 A cross-section of the car body as shown in Fig. 1b along the line I-I

Fig. 3 A magnification of detail X of Fig. 2 showing a longitudinal girder with an attached contoured roof

Fig. 4 An enlarged detail of Fig. 3 showing the transition from longitudinal girder to contoured roof

- Fig. 5a, 5b The production of a welded connection between contoured roof and longitudinal girder
- Fig. 6 A cross-section of the car body as shown in Fig. 1b along the line II-II
- Fig. 7 A magnification of detail Y of Fig. 6 showing a longitudinal girder with an attached flat roof
- Fig. 8 A detail of Fig. 7 showing the transition from a longitudinal girder to a flat roof
- Fig. 9 The production of a welded connection between a longitudinal girder and a flat roof element
- Fig. 10 A longitudinal girder in the area of a flat roof, the first protrusion featuring a drainage duct

Fig. 1a and 1b show a rail vehicle car body 1, with Fig. 1a showing a view from above at an angle and Fig. 1b showing a side view. The car body has a head structure which in the figure is located at the right end of the car body and the view in both figures is on the right side wall 2. At its front and rear end, the car body has a horizontal car body roof 3 as second roof section (flat roof). An arched car body roof 4 (contoured roof) as first roof section is located between this. Furthermore, Fig. 1a and 1b show window openings 5 and door openings 6 in the side wall. An opening 7 exists between the contoured roof 4 and the flat roofs 3.

Fig. 2 shows a cross-section of the car body der Fig. 1b along the line I-I. The cross-sectional view is of the area of the car body where a contoured roof is located. The right car body side wall 2, the left car body side wall 8, the car body bottom 9 and the contoured roof 4 are shown. The longitudinal girder according to the invention is arranged in the marked section X and explained with the help of Fig. 3. The car body bottom 9, the side walls 2, 8, the contoured roof 4 and the longitudinal girder are made of extruded sections with of a hollow chamber structure.

Fig. 3 shows the longitudinal girder according to the invention 10 with an attached right car body side wall 2 and an attached contoured roof 4. The longitudinal girder 10 is shown

as a dark-coloured hollow chamber profile to facilitate distinction from neighbouring components. This is merely a graphic representation and does not mean that the longitudinal girder 10 has to be made of a material different from that of a contoured roof 4 or a side wall 2. Preferably, all these parts are made of aluminium. The longitudinal girder 10, formed of a hollow chamber profile, has a first protrusion 11 that points upward at an angle and has a free end 12. The free end 12 forms the first connection point for a first roof section. In this embodiment, the arched car body roof 4 is welded on at the free end 12. Details of the welded connection are given in Fig. 4 below. Furthermore, the longitudinal girder 10 has a second protrusion 13 with a free end 14. The free end 14 forms the second connection point for a second roof section. The second protrusion 13 points horizontally in the direction of the car body inner side and is arranged under the first protrusion 11. The first protrusion 11 is formed of one single chamber of a hollow chamber profile and tapered in the direction of its free end 12. The second protrusion 13 is formed of two chambers of a hollow chamber profile and tapered in the direction of its free end 14. The free end 14 of second protrusion 13 is not occupied because no flat roof is attached in this area of the car body. The car body outer side is marked with the letter A and the car body inner side with the letter B. Together with the car body side wall, the broken line drawn in as an extension of the side wall 2 forms the borderline between car body inner side B and car body outer side A according to the definition of this invention. The broken line is an imagined upward extension of the side wall 2. A corresponding broken line is also shown in Fig. 7. It can be seen in Fig. 3 that the second protrusion 13 projects beyond the first protrusion 11 in horizontal direction and that it projects beyond the first protrusion in the direction of the car body inner side B. A fastening means 15 in the form of a C-profile rail which is open at its underside is provided in the bottom side of the second protrusion 13. The C-profile rail is an integral part of the extruded section. At its lower end 17 — which here is the third connection point — a lower section 16 of the longitudinal girder 10 is connected to the right side wall 2.

At its lower end, the lower section 16 has two lips 18 bent towards each other towards the inside at which two lips 19 projecting from the end of the side wall 2 are supported. The lips 18 and 19 are connected with each other by means of a weld, whereby the connection between the side wall 2 and the longitudinal girder 10, or its lower section 16, is made. In the embodiment shown, the side wall 2 also has a fastening means 20 in the form of a C-profile rail.

Fig. 4 shows an enlarged detail of Fig. 3 showing the connection point between the first protrusion 11 of the longitudinal girder 10 and the contoured roof 4. It can be seen in Fig. 4 that the first protrusion 11 of the longitudinal girder 10 has a projecting lip 30 at its free end 12 on which the contoured roof 4 is placed. At its end 31, the contoured roof 4 has a projecting lip 32 which is supported on the first protrusion 11 at the car body outer side. A gap to equalise production tolerances is formed between the end 31 of the contoured roof 4 and the end 12 of the longitudinal girder 10. At the contact point to the lip 32, the first protrusion 11 has a deepening 33 into which the lip 32 is fitted to create a flush transition from the contoured roof 4 to the longitudinal girder 10. Lap welds are produced at the end 34 of lip 32 of the contoured roof and at the end 35 of lip 30 of the longitudinal girder 10 to join the contoured roof 4 to the free end 12 of the first protrusion 11 of the longitudinal girder 10. The production of such a weld is shown in Fig. 5a and 5b. Moreover, Fig. 5a shows a detail of the extension of the longitudinal girder 10 in longitudinal direction of the car body in addition to a section through the longitudinal girder 10 and a side wall 2 in transverse direction. Fig. 5b only shows a section in transverse direction. It can be seen in Fig. 5a that the longitudinal girder 10 is one single piece, i.e. it extends without seam from one end of the car body, which is visible in Fig. 5a at the right border of the figure, to the other end of the car body, which is on the left side in Fig. 5a but not visible in the figure. The longitudinal girder 10 is arranged in the transition area of the side wall 2 to the roof 4 and is also called top chord. Fig. 5a and 5b show the accessibility of the first protrusion 11 for the production of a welded connection with the contoured roof 4. The welding torch 50 can be applied from the inner side of the car body to produce a weld seam. The first protrusion 11 is accessible for welding without the need to cut off the second protrusion 13. If necessary, the welding torch 50 may even be leaned against the second protrusion 13 and guided along the second protrusion 13 in longitudinal direction of the car body (in viewing direction in Fig. 5b).

Fig. 6 shows a section through a car body 1 along the line II-II shown in Fig. 1b. This is a section through an area of the car body 1 in which a flat roof 3 is affixed. The longitudinal girder according to the invention 10 connects the car body side walls 2, 8 to the flat roof 3. Apart from that, the explanations regarding Fig. 2 may be referred to for a further explanation of the figure.

Fig. 7 shows a magnification of detail Y of Fig. 6. A side wall 2 is attached to the third end 17 — which here is the third connection point — of the lower section 16 and a flat roof 3 is

attached to the free end 14 of the second protrusion 13. The free end 12 of the first protrusion 11 is not occupied and the protrusion 11 remains at the car body also in the flat roof area. The protrusion 11 projects beyond the level of the flat roof 3 and can be used as a side shield for devices (not shown) installed on the flat roof such as air-conditioning units. Depending on the dimensions of such a device and the protrusion 11, the protrusion may hide the device wholly or partly towards the car body outer side A when looking at it from the side (from left to right in the figure). Refer to Fig. 3 for an explanation of other features of Fig. 7.

Fig. 8 shows an enlarged detail of Fig. 7 in which the junction point of the flat roof 3 to the second protrusion 13 of the longitudinal girder 10 is shown in detail. At its end 14, the second protrusion 13 has a projecting lip 40 on which the contoured roof 3 is placed. At its end 41, the contoured roof 3 has a lip 42 on which the second protrusion 13 is supported. To create a flat junction point between the flat roof 3 and the second protrusion 13, the second protrusion 13 has a deepening 43 into which the lip 42 of the flat roof 3 fits. Lap welds are produced in longitudinal direction of the car (in viewing direction in this figure) at the end 44 of the lip 42 and at the end 45 of the lip 40 to join the flat roof 3 to the free end 14 of the protrusion 13.

Fig. 9 shows how the unoccupied first protrusion 11 can be used as guide for a welding torch 50. The welding torch 50 is guided along the protrusion 11 in longitudinal direction of the car (viewing direction) to produce a weld between the flat roof 3 and the second protrusion 13. The welding torch nozzle 51 of the welding torch 50 is supported at the edge of the projecting lip 30 at the free end 12 of the first protrusion 11 and the opening 52 of the welding torch nozzle 51 is pointed at the free end 14 of the second protrusion 13. By guiding the welding torch along the end of the lip 30 at the free end 12 of the first protrusion 11 in longitudinal direction of the car in such a way, the welding torch remains aligned at the optimal angle, which is about  $45^\circ$  in this case, to produce a lap weld between the flat roof 3 and the second protrusion 13. In the embodiment shown here, the welding torch nozzle 51 is supported at the end of the lip 30. In the embodiment shown here, the length of the first protrusion 11, including lip 30, and the length of the second protrusion 13 are dimensioned in such a way that an imagined connecting line from the end of the lip 30 to the free end 14 of the second protrusion 13 forms an angle of about  $45^\circ$  against the horizontal (here, for example, the roof line of the flat roof 3). The outermost point of the protrusion 11 is the end 35 of the lip 30. If no lip 30 is provided at

the free end 12 of the first protrusion 11, the end 12 — here in the form of a terminal profile web — forms itself the outermost point and the supporting point for the welding torch nozzle 51. In that case, the first protrusion 11 would ideally be dimensioned in such a way that an imagined connecting line from the free end 12 to the free end 14 would form an angle of  $45^\circ$  against the horizontal. Fig. 9 also shows the very good accessibility for welding of the junction point of the flat roof 3 with the second protrusion 13 of the longitudinal girder because the second protrusion 13 projects beyond the first protrusion 11 in horizontal direction (in this figure horizontally towards the left).

Fig. 10 shows the draining of a flat roof area 3. The first protrusion 11 of a longitudinal girder 10 has a drainage duct inside. The first protrusion 11 consists of one single chamber of a hollow chamber profile as shown e.g. in Fig. 3 and 4 and this hollow chamber is used as a drainage duct. The drainage duct extends in longitudinal direction of the car and only along part of the protrusion 11. The drainage duct runs from an inlet opening 60 to an outlet opening 61. The inlet opening 60 can be accessed from a flat roof section 3. In the area of the inlet opening, the walls of the hollow profile chamber of the first protrusion 11 are partly removed, which has created a drainage niche. Areas of the hollow profile chamber of the first protrusion 11 in which a drainage duct is not intended are closed by a plate 64. The outlet opening 61 is located in the bottom area of the hollow profile chamber of the first protrusion 11 and located at the bottom at the long-side end 63 of the protrusion 11 and hence at the end of the car body 1. The profile chamber of the first protrusion is closed by a plate 65 at the long-side end 63, so that water flowing off is drained exclusively through the outlet opening 61 that points downward. In principle, it would be conceivable also to leave the profile chamber of the first protrusion open at the side and to drain water off through this opening. At the outlet opening 61, a pipe socket 62 is welded to the first protrusion 11. Further pipes can be connected to the pipe socket 62 to drain water flowing off to specific locations at the undercarriage (not shown) of the car body 1, for example to the centre of the track bed. The direction of flow of the water flowing off from the flat roof section 3 is marked by arrows. As indicated by the arrows, water is routed from the flat roof to the end of the car.

## Patent claims

1. Longitudinal girder (10) for a rail vehicle car body (1), comprising
  - a first connection point (12) for a first roof section (4) which in installed position points upward vertically or at an angle in the direction of the car body inner side, characterised by;
  - a second connection point (14) for a second roof section (3) which in installed position points in the direction of the car body inner side (B) and which is arranged under the first connection point (12);
  - a third connection point (17) for a car body side wall (2, 8) which in installed position points downward or downward at an angle;the longitudinal girder being one single part.
2. Longitudinal girder according to claim 1, comprising
  - a section (16) which in installed position is a lower section and comprises the third connection point (17);
  - a first protrusion (11) which in installed position projects upward vertically or at an angle in the direction of the car body inner side with a free end that comprises the first connection point (12) for the first roof section (4); and/or
  - a second protrusion (13) which in installed position projects in the direction of the car body inner side (B), is arranged under the first protrusion and has a free end that comprises the second connection point (14) for the second roof section (3).
3. Longitudinal girder according to claim 2, on which in installed position the second protrusion (13) projects beyond the first protrusion (11) in horizontal direction.
4. Longitudinal girder according to claim 3, on which the depth of the first protrusion and the depth of the second protrusion are dimensioned in such a way that an imagined connecting line from the free end of the first protrusion to the free end of the second protrusion forms an angle of 40° to 50° against the horizontal.
5. Longitudinal girder according to one of the previous claims, on which the second protrusion (13) has at its underside a fastening means (15) for fastening an interior panelling or other components or assemblies.

6. Longitudinal girder according to one of the previous claims, on which the first protrusion has a drainage duct inside.
7. Side wall for a rail vehicle car body which at its upper end comprises
  - a first connection point for a first roof section which in installed position points upward vertically or at an angle;
  - a second connection point for a second roof section, arranged under the first connection point, which in installed position points in the direction of the car body inner side.
8. Car body of a rail vehicle, comprising a longitudinal girder according to one of the claims 1 to 6 or a side wall according to claim 7.
9. Car body according to claim 8, comprising at least one first roof section and at least one second roof section, with the first roof section projecting upward beyond the second roof section.
10. Car body according to claim 9, on which the first roof section is an arched roof section and the second roof section is a horizontal, or basically horizontal, roof section.
11. Rail vehicle, comprising a car body according to one of the claims 8 to 10.
12. Method for the production of a rail vehicle car body with at least one first roof section and at least one second roof section, with the first roof section projecting upward beyond the second roof section, and where in the method
  - a) a single-piece longitudinal girder is arranged both above the area of the right car body side wall and above the area of the left car body side wall of a car body, the longitudinal girder comprising the following elements:
    - a first connection point for a first roof section which in installed position points upward vertically or at an angle in the direction of the car body inner side;
    - a second connection point for a second roof section, arranged under the first connection point, which in installed position points in the direction of the car body inner side;
    - a third connection point for a car body side wall which in installed position points downward or downward at an angle;

- b) a right and a left car body side wall are joined to the third connection points of the two longitudinal girders;
  - c) one or more than one first roof sections are joined to the first connection points of the two longitudinal girders and one or more than one second roof sections are joined to the second connection points of the two longitudinal girders, so that the first and second roof sections are arranged in longitudinal direction of the car and either just one first or just one second roof section is arranged in a longitudinal section of the longitudinal girder.
13. Method according to claim 12, characterised in that a joining device, in particular a welding torch, is guided along the second connection point when one or more than one first roof sections are joined to the first connection point.
14. Method according to claim 12 or 13, characterised in that a joining device, in particular a welding torch, is guided along the first connection point when one or more than one second roof sections are joined to the second connection point.
15. Use of a longitudinal girder according to one of the claims 1 to 6 or of a side wall according to claim 7 as a component for a rail vehicle car body.