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(54) Railway vehicle bodies and methods of manufacturing them.

(57) A railway vehicle body has an underframe (3) with a pair of bogie bearings at B adjacent opposite ends of the body, two side structures (2) each including a plurality of window openings in a row, a roof structure (4) and two end structures (5). The side structures (2) each comprising a plurality of laminated panels (10) welded to each other and each having a pair of metal face sheets sandwiching a metal core, the face sheets being joined to the core by metal-to-metal bonding. The body including a longitudinally continuous extruded metal eave panel (20) having inner and outer plates connected together by longitudinally extending webs. The eave panel is welded at one side to a continuous row of the panels (10) of the adjacent side structure. The eave panel (20) extends continuously at least between bogie bearing points B. High rigidity and simplicity of construction are achieved.

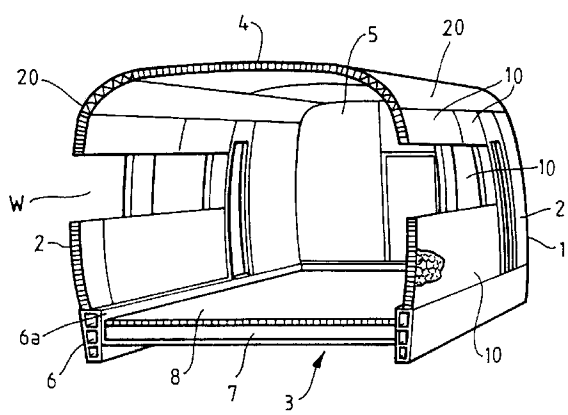

FIG. 1

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The present invention relates to railway vehicle body structures for railway rolling stock, particularly to body structures of lightweight rolling stock for high speed passenger trains. The invention also relates to methods of manufacturing such body structures.

A body structure constructed of brazed laminated panels of a light metal alloy has been proposed for a lightweight railway vehicle, suitable for high speed trains. The laminated panel is constructed by sandwiching a metal core, particularly a honeycomb construction, between a pair of metal face sheets and joining these components by brazing. These components are preferably formed of an aluminum alloy. Joining members, e.g. extruded metal sections, are arranged along the peripheries of the face sheets and serve as reinforcing members. They also are joined by brazing to the face sheets. The joining members of the adjacent laminated panels are joined together by welding to construct side structures and a roof structure, and the side structures and the roof structure are joined together to construct a body structure. Such a body structure is disclosed in, for example, EP-A-579500. Such laminated panels are used in embodiments of the present invention.

The recent progressive increase in the travelling speed of railway trains has entailed problems, such as increase in the impact of rolling stock on the rails, increase in noise generated by travelling rolling stock, increase in the power consumption of the rolling stock and increase in energy consumed by braking to stop the rolling stock. In view of such problems, rolling stock of a lightweight construction is a necessity. It is essential when constructing a lightweight vehicle to construct the body structure, which has a mass amounting to a majority of the mass of the vehicle, in a lightweight construction.

As is generally known, the external pressure acting on body structure changes suddenly when the train travels through a tunnel at a high speed. Particularly, when trains travelling in opposite directions meet in a tunnel, the pressure changes sharply and a large pressure acts on the body structure. As is generally known, the magnitude of the pressure is dependent on the travelling speed and is proportional to the square of the travelling speed. Therefore, the rigidity and strength against pressure of the body structure must be enhanced. However, the enhancement of the rigidity and the strength of the body structure is contradictory to the desired reduction of the weight of the body structure and hence is difficult to achieve.

The present inventors have noted the following problems.

Particularly the eave structure serving as a connection joining together the roof structure and the side structure has a curved surface having a small radius of curvature. Therefore, the fabrication and the processing of a laminated panel as described above for the eave structure is troublesome. Furthermore, since a stress concentration occurs at the eave structure, the eave structure may require many reinforcing members, which increases the amount of labour for fabrication.

A high stress is induced in portions of the side structure surrounding windows and hence these portions may require to be reinforced with reinforcing members, which increases the cost and the weight of the side structure. Since laminated panels disposed between windows as pier panels are comparatively small, the relative cost of these laminated panels is liable to be high.

EP-A-474510 shows a body having side structures formed of laminated panels as described above, in which the panels each extend the full height of the side structure and surround the window openings. The roof is also formed of laminated panels. The roof and side structures are joined by eave panels (also called frieze boards) which are extruded aluminum alloy members extending the full longitudinal length of the body. The extruded member has an outer plate and a plurality of inner reinforcing ribs of T-section.

EP-A-260200 illustrates a similar construction in which there are frame members of extruded box construction located behind an eave sheet and connected indirectly to the roof. This body is not intended for a high speed train.

US-A-4993329 shows a body which does not include the laminated described above, but has extruded metal eave panels having inner and outer plates joined by transverse webs to form longitudinally extending cells in the eave panel. These eave panels provide the upper edges of the window openings. FR-A-2635064 describes a similar construction in a double-deck railway body. The frame members at the eave and the middle deck level provide the upper edges of the window openings.

EP-A-354436 shows, in a commuter train type body, a complex construction at the eave level, having sloping laminated panels joining extruded profiles.

US-A-5042395 discloses a body construction, also of commuter train type, in which body panels are of laminate construction using non-metallic materials. At the eaves, a large roof panel has sharp curvature.

There are also proposals for bodies made entirely of extruded hollow members, for example in JP-A-2-246683. The maximum width of such extruded members is restricted, and the cost is high.

EP-A-579500 referred to above is mentioned here as disclosing the upward curvature or camber applied to the body during assembly, as in embodiments of the present invention described below.

Accordingly, it is an object of the present invention to provide a lightweight, highly rigid body structure for a railway vehicle, that can be fabricated at a comparatively low manufacturing cost.

One object of the present invention is to provide an eave structure serving as a joint for joining together a roof structure and a side structure at a comparatively low manufacturing cost.

Another object of the present invention is to provide portions of a side structure surrounding window openings at a comparatively low manufacturing cost.

A further object is to provide simple manufacturing methods of such bodies.

According to the invention in a first aspect there is provided a railway vehicle body having

(i) an underframe with a pair of bogie bearings adjacent opposite ends of the body,
(ii) two side structures each including a plurality of window openings in a row,
(iii) a roof structure and
(iv) two end structures,
(v) the side structures each comprising a plurality of laminated panels welded to each other, the laminated panels each having a pair of metal face sheets sandwiching a metal core, the face sheets being joined to the core by metal-to-metal bonding,
(vi) the body including a longitudinally continuous metal eave panel located at the junction of each side structure and the roof structure and having inner and outer plates connected together by longitudinally extending webs defining longitudinally extending cells, the eave panel being welded at one side to a continuous row of a plurality of the welded-together laminated panels of the adjacent the side structure,
(vii) wherein the laminated panels of said continuous row have lower edges which are not lower than the upper edges of the window openings of said row thereof and
(viii) the eave panel and the continuous row of laminated panels extend continuously over at least the length of said body between the bogie bearings.

Preferably the eave panel is at least one extruded member having its direction of extrusion in the longitudinal direction of the body and extending continuously over at least the length of the body between the bogie bearings. The eave panel may be a pair of extruded members welded together along adjacent longitudinal edges.

Preferably the eave panel has an outer surface which is smoothly curving, as seen in transverse section, in an arc from the side structure to which it is welded to the roof structure.

Since the eave structure of the body can be made with a curved shape of small radius of curvature and is an integral extruded shape, the material cost of the body structure is comparatively low and complex fabrication work at the eave is avoided. The body structure has a high out-of-plane bending rigidity and a lightweight construction and can be fabricated at a comparatively low manufacturing cost.

In a second aspect, the invention provides a railway vehicle body having

(i) an underframe,
(ii) two side structures,
(iii) a roof structure and
(iv) two end structures,
(v) both of the side structures comprising a plurality of laminated panels welded to each other, the laminated panels each having a pair of metal face sheets of thickness in the range 0.8 to 1.6 mm sandwiching a metal core, the face sheets being joined to the core by metal-to-metal bonding,
(vi) the body including, at the junction of each side structure and the roof structure, an eave structure having as seen in transverse section a radius of curvature less then that of the side structures and the roof structure,
(vii) the eave structure comprising at least one longitudinally extending metal eave panel formed by parallel curved inner and outer plates each having a thickness greater than said thickness of said face sheets and longitudinally extending webs interconnecting the inner and outer plates and defining, as seen in transverse section, a plurality of longitudinally extending cells,
(viii) the eave panel having an overall thickness from the outer face of the outer plate to the inner surface of the inner plate which is not less than the corresponding thickness of the laminated panels of the side structure and not more than the thickness of the laminated panels of the side structure plus the average thickness of the inner and outer plates of the eave panel,
(ix) the inner and outer plates of the eave panel being directly welded respectively to the inner and outer face sheets of at least one said laminated panel of the adjacent said side structure.

This aspect of the invention provides a simple, compact and easily assembled construction.

In a third aspect, the invention provides a railway vehicle body having

(i) an underframe,
(ii) two side structures each including a plurality of window openings in a row;
(iii) a roof structure and
(iv) two end structures,
(v) both of the side structures each comprising a plurality of laminated panels welded to each other, the laminated panels each having a pair of metal face sheets sandwiching a metal core, the face sheets being joined to the core by metal-to-metal bonding,
(vi) each side structure including a plurality of pier portions each located between an adjacent pair of window openings, each pier portion comprising at least one metal pier panel formed by spaced inner and outer plates which are connect-

ed together by webs defining elongate interior cells thereof. Preferably each pier panel is an extruded panel whose direction of extrusion is the longitudinal direction of the elongate cells thereof. This provides a construction which is strong, yet can be of low manufacturing cost.

In a fourth aspect, the invention provides a railway vehicle body having

(i) an underframe,
(ii) two side structures,
(iii) a roof structure and
(iv) two end structures,
(v) the roof structure comprising a plurality of laminated panels each having a pair of metal face sheets sandwiching a metal core, the face sheets being joined to the core by metal-to-metal bonding, said laminated panels being welded to each other to form a first roof portion,
(vi) the roof structure further comprising a second roof portion comprising at least one extruded metal panel formed by spaced inner and outer plates which are connected together by webs defining elongate interior cells thereof,
(vii) the second roof portion being joined by welding to the first roof portion.

The second roof portion is particularly suitable to carry heavy roof fixtures, such as electrical power equipment.

In a fifth aspect, the invention provides a railway vehicle body having

(i) an underframe,
(ii) two side structures,
(iii) a roof structure and
(iv) two end structures,
(v) the underframe having at each side thereof an extruded metal side beam member extending longitudinally of said body and joined to the respective said side structure,
(vi) the body including a longitudinally extending extruded metal eave panel located at the junction of each side structure and the roof structure and joined to the respective side structure and roof structure,
(vii) each side beam member and each eave member having, integrally extruded therewith at its interior side with respect to the body, at least one fixing rail for attachment of internal fixtures of said body.

The fixing rails take up little space and allow strong, easy and compact attachment of interior fixtures.

Particularly, it is preferred that an interior facing board is secured to both the fixing rails.

In a sixth aspect, the invention provides a method of manufacturing a railway vehicle body having an underframe, two side structures and two end structures mounted on the underframe and a roof structure mounted on the side and end structures, the body having at each side a longitudinally continuous metal eave panel connecting the respective side structure and the roof structure, the method including the steps of

(i) bending each eave panel to produce a predetermined upward curvature along the longitudinal direction of the panel, and
(ii) welding each eave panel at one edge thereof to a plurality of generally rectangular metal panels of the adjacent side structure, and welding the plurality of generally rectangular panels to each other to form at least part of the side structure, the side panels having shapes before welding together such that when they are welded to the eave panel and to each other, the side structure has a predetermined overall upward curvature,

whereby the upward curvature of said side structure of said body is at least partly removed by flexure of the body when subjected to the expected normal working load.

In a seventh aspect, the invention provides a method of manufacturing a railway vehicle body, including the steps of

(i) assembling two side structures of said body each comprising a plurality of welded-together metal side panels and a transversely curved metal first eave panel extending longitudinally along an upper edge of the side structure and welded at a first longitudinal edge thereof to a plurality of the side panels,
(ii) assembling a roof structure comprising a plurality of welded-together metal roof panels and a pair of transversely curved metal second eave panels extending longitudinally along respective side edges of the roof structure and each welded at a first longitudinal edge thereof to a plurality of said roof panels, and
(iii) after said steps (i) and (ii), assembling the roof and two side structures together by welding second longitudinal edges of said first eave panels to second longitudinal edges of said second eave panels.

In this method the pre-assembled side and roof structures are given high rigidity and fixed shape by the eave panels, and the eave panels are easily joined along their second longitudinal edges.

Embodiments of the invention will now be described by way of non-limitative example with reference to the accompanying generally diagrammatic drawings, in which:

Fig. 1 is a sectional perspective view of a body structure of a first embodiment according to the present invention.

Fig. 2 is a general perspective view of the body structure of Fig. 1.

Fig. 3 is a sectional view of a laminated panel employed in the body structure of Fig. 1.

Fig. 4 is a transverse sectional view of a portion, including the panel, of the body structure of Fig. 1.

Fig. 5 is a sectional perspective view of a body structure of a second embodiment according to the present invention.

Fig. 6 is a sectional view on line 6-6 in Fig. 5.

Fig. 7 is a side view taken from the left side in Fig. 6.

Fig. 8 is a fragmentary sectional view taken on line 8-8 in Fig. 7.

Fig. 9 is a transverse sectional view of a body structure of a third embodiment according to the present invention.

Fig. 10 is a sectional view taken on line 10-10 in Fig. 9.

Fig. 11 is a view taken in the direction of the arrows 11 in Fig. 10.

Fig. 12 is a graph showing the dependence of the specific rigidity of railway bodies on the travelling speed of the rolling stock.

Fig. 13 is a graph showing the dependence of the specific withstand pressure of railway bodies on the travelling speed of the rolling stocks.

Fig. 14 is a sectional perspective view of a body structure of a fourth embodiment according to the present invention.

Fig. 15 is a fragmentary perspective view of a roof structure included in the body structure of Fig. 14.

Fig. 16 is a partial sectioned view on line 16-16 of Fig. 15.

Fig. 17 is a partial sectional view showing an extruded eave member employed in the body structure of Fig. 14.

Fig. 18 is a partial sectional view of the body structure of Fig. 14 fitted with interior fittings.

Fig. 19 is a view showing the layout of panels forming a side structure, in the assembly of the embodiment of Figs. 1 to 4.

Fig. 20 shows the panels of Fig. 19 on a jig.

Fig. 21 shows panels of the roof structure of Figs. 14 to 18 being assembled on a jig.

In the drawings, corresponding parts have the same reference numbers.

A body for a railway passenger vehicle, in a first embodiment according to the present invention, will be described with reference to Figs. 1 to 4. The body 1 comprises two side structures 2 provided with window openings W, an underframe 3, a roof structure 4 and two end structures 5. The side structures 2 and the roof structure 4 are each formed by welding together a plurality of laminated panels 10, which will be described later. The end structures are formed conventionally, and can be made of similar laminated panels, but are not described here since the invention does not essentially concern them. Each side structure 2 comprises a row of laminated panels 10 forming a wainscot extending under the window openings W, a row of laminated panels 10 forming window headers extending over the window openings W, and laminated panels 10 forming pier panels between the window openings W.

The underframe 3 comprises side beams 6 extended longitudinally along the opposite sides of the body, a plurality of cross beams 7 extending widthwise of the body transversely to the side beams 7, and floor panels 8 on the cross beams 7. Body bolsters (not shown) are attached in conventional manner to portions of the underframe 3 at which the body structure is supported on bogies, these bogie bearing points being indicated by arrows B in Fig. 2. A longitudinal middle beam (also not shown) extends between the opposite longitudinal ends in conventional manner and is connected to the body bolsters. Couplers (not shown) are provided on the middle beam, and compressive load applied through the couplers to the middle beam is transmitted to the body bolsters, and the compressive load is distributed through the body bolsters to the underframe.

The side structures 2 are joined to the side beams 6. The side beams 6 are hollow extruded shapes of -light alloy having a closed cross section, i.e. having longitudinally extending closed cells. The cross beams 7 are welded to the side surfaces of the side beams 6. The cross beams 7 are arranged parallel to each other at intervals longitudinally of the body. The floor panels 8 are laminated panels, which will be described later, and are joined to the body bolsters so that the upper surfaces of the floor panels 8 are flush with the upper surfaces of the body bolsters. The thickness of the face sheets of the floor panels 8 joined directly to the body bolsters is greater than that of the face sheets of the other floor panels 8 to enhance the buckling strength of the floor panels 8 against a load acting on the floor panels 8 parallel to the surfaces thereof.

Referring to Fig. 3, each of the laminated panels 10 forming the side structures 2, the roof structure 4 and the floor panels 8 comprises a pair of face sheets 11 and 12, honeycomb cores 13 of aluminum alloy sandwiched between the face sheets 11 and 12 with the longitudinal direction of the honeycomb cells perpendicular to the face sheets 11, 12, extruded metal strength members 14 disposed between the cores 13 at intervals, and extruded metal joining members 15 extending along the peripheries of the face sheets 11 and 12. These components forming the laminated panel 10 are all formed of a light alloy, such as an aluminum alloy, and are joined together by brazing. The joining members 15 and the face sheets 11, 12 of each panel are welded to the corresponding parts of the adjacent laminated panels, to the side beams 6 and to eave panel members 20, to be described later, to construct the body structure. The face sheets are 1.2 mm thick.

Each side structure 2 has a window header panel block 2a extending over the window openings W, a wainscot panel block 2b extending under the window openings W, pier panels 2c disposed between the adjacent window openings W, and doorway panels 2d defining doorways. The window header panel block 2a is constructed by contiguously arranging rectangular laminated panels 10 as described above longitudinally of the body structure and welding together the adjacent laminated panels 10. The joining parts of the laminated panels 10 are finished by machining to a high accuracy before joining the laminated panels 10 together. Each of the laminated panels 10 of the side structure 2 is formed in a substantially trapezoidal shape so as to conform to the desired cambered shape of the body structure, in which the middle portion with respect to the longitudinal direction of the body structure is raised in a curve; that is, each laminated panel 10 has a quadrilateral shape, i.e., a trapezoidal shape, having its upper side, when set in place to form the structure, longer than its lower side. Therefore, the window header panel block 2a formed by contiguously arranging and joining together the plurality of laminated panels 10 has a cambered shape with respect to the longitudinal direction with the middle portion thereof being curved convexly upwardly. The camber of the window header panel block 2a for a 25 m long body structure is in the range of about 20 to 30 mm.

The wainscot panel block 2b, similarly to the window header panel block 2a, is formed in a cambered shape by contiguously arranging and joining together a plurality of the laminated panels 10. The pier panels 2c are disposed between the window header panel block 2a and the wainscot panel block 2b at intervals equal to the width, i.e. the dimension along the longitudinal direction of the body structure, of the window openings W. The pier panels 2c are welded to the window header panel block 2a and the wainscot panel block 2b. Each window opening W is defined by the two pier panels 2c, the window header panel block 2a and the wainscot panel block 2b. The pier panels 2c, the window header panel block 2a and the wainscot panel block 2b are joined together by welding.

The roof structure 4 is constructed by longitudinally arranging and welding together a plurality of the laminated panels 10. The roof structure 4 has a transverse curvature. The radius of curvature of the roof structure 4, similarly to that of the side structures, is comparatively large.

Each eave panel member 20 is continuous at least between the bearing points B and in this embodiment extends the full length of the body 1 and is a hollow extruded one-piece shape of light alloy such as aluminum alloy having a closed cross section, and serves for joining the side structure 2 and the roof structure 4 together. It has spaced inner and outer plates 20b, 20d connected by internal webs 20g to define a plurality of closed cells 20h within the member 20. The extrusion direction is parallel to the longitudinal direction of the body, and in transverse cross-section the member 20 has the shape of a circular arc.

The outer plate 20b of the extruded eave member 20 is joined to the side structure 2 and the roof structure 4 so that the outer surface 20a thereof merges smoothly into the outer surfaces of the side structure 2 and the roof structure 4 with the least possible step or angle at the joint. One side portion 20c of the outer plate 20b adjacent the side structure 2 is welded to the window header panel block 2a so that the outer surface thereof merges smoothly into that of the window header panel block 2a in a smooth, continuous surface; that is, the face plates of the laminated panels forming the window header panel block 2a and the adjacent side portion 20c of the extruded member 20 are welded together so as to form a smooth, continuous surface. The window header panel block 2a is curved in the shape of a circular arc, and the side portion 20c of the eave member 20 is curved in a curvature approximately equal to that of the window header panel block 2a.

The other side portion 20i of the outer plate 20b adjacent the roof structure 4 is curved in a curvature approximately equal to that of the laminated panels forming the roof structure 4. The side portion 20i overlaps the edges of the laminated panels forming the roof structure 4 and is welded to the roof structure 4. The plate 20b and the outer face sheets of the laminated panels of the roof are welded together so as to form a smooth surface. One flange 20e of the inner wall 20d on the side of the side structure 2 overlaps and is welded to the joining members and the face sheets of the laminated panels of the window header panel block 2a so as to form a smooth, continuous surface with the least possible step at the joint. Another flange 20f of the inner plate 20d on the side of the roof structure 4 overlaps and is welded to the edges of the laminated panels forming the roof structure 4. The flange 20f is welded to the joining members and the face sheets of the laminated panels 10 so as to form a smooth surface with the least possible step at the joint.

Substantially the entire length of the extruded member 20 is welded to the window header panel block 2a of the side structure 2 and the roof structure 4 by continuous welding. Therefore, the outer plate 20a and the inner plate 20d of the extruded member 20 are welded directly to the outer face panels and the inner face panels of the laminated panels 10 of the window header panel block 2a respectively.

Since the side structure 2 and the extruded eave member 20 are joined together continuously along their entire length, stress concentration is not induced in the joint between the side structure 2 and the extruded member 20 when pressure load acts on the body structure 1 due to the variation of the external pressure or the vertical load acting on the body structure 1. Since the extruded member 20 is longer than the distance between the support points B at which the body structure 1 is supported on the bogies, the extruded member 20 serves as a beam to carry the vertical load applied to the vehicle. In this respect, the extruded member 20 is effective in preventing stress concentration. Since the window header panel block 2a of the side structure 2 and the extruded member 20 are joined together by welding together the face plates 11, 12 and the joining members 15 of the laminated panels 10 and the outer plate 20b and the inner plate 20d, force can smoothly be transferred between the window header panel block 2a and the extruded member 20. Forces acting in different directions are transferred smoothly between the outer plate 20b of the extruded member 20 and the outer sheets of the laminated panels 10, and between the inner plate 20d of the extruded member 20 and the inner sheets of the laminated panels 10. Accordingly, problems attributable to stress concentration do not occur in the joint between the side structure 2 and the extruded member 20, so that the wall thicknesses of the component members can be reduced and, consequently, the body structure 1 can be formed with a lightweight construction.

The side beams 6, and the extruded shapes 20 serving as the eave members have as mentioned, closed cell cross sections, very high torsional rigidities and very high bending rigidities. Since the body 1 is constructed by joining the side structures 2 and the underframe 3 to the side beams 6, and joining the side structures 2 and the roof structure 4 to the extruded shapes 20, the body 1 has a very high rigidity.

The thicknesses of the portions of currently available extruded members are large as compared with those of the face plates of the laminated panels. Therefore, the strength and the rigidity of the extruded members are higher and their weight is larger than those of the laminated panels. Since the body structure 1 has the window openings W, the strength and the rigidity of a portion of the body structure 1 formed with the pier panels 2c are lower than those of the extruded member 20. The body structure 1 is provided with the window header panel block 2a formed by continuously and longitudinally arranging and joining together the adjacent laminated panels 10 between the pier panels 2c and the extruded member 20 which has a high strength and a high rigidity, and hence the extruded member 20 and the pier panels 2c are spaced apart from each other on the body structure. In this body structure 1, strength and rigidity vary stepwise in order of the extruded member 20, the window header panel block 2a and the pier panels 2c. Therefore, strength and rigidity do not change sharply at the junction of the adjacent members, so that stress concentration can be prevented.

Since each laminated panel 10 is formed by joining the cores 13 to the entire surfaces of the face plates 11 and 12, the laminated panel 10 has a high out-of-plane bending rigidity. The fixed distance desired between the side beam 6 and the extruded member 20 can rigidly secured by the laminated panels 10 having a high out-of-plane bending rigidity. The laminated panels 10 have sufficient strength and sufficient rigidity against load acting in a direction perpendicular to the direction of their thickness. Therefore, the side structure 2 or the body structure 1 has an enhanced equivalent bending rigidity (EI). In the conventional body structure constructed by joining together shell plates and framing members, the shell plates are deformed in the direction of their thickness. When this body structure is loaded, the body structure becomes strong and rigid when the shell plates are deformed so that force can effectively transferred between the shell plates and the framing members. In constructing the conventional body structure by the general rolling stock manufacturing method, it is difficult to prevent out-of-plane deformation. Therefore, the shell plates having different degrees of out-of-plane deformation bear different loads and hence stress concentration is liable to occur in the body structure. Since the laminated panel 10 is formed by connecting the pair of face plates with the core members, the out-of-plane deformation of the laminated panel 10 is very small. Therefore, force can be transferred uniformly through the joint between the laminated panel 10 and the extruded member 20 and the laminated panel 10 is not deformed uselessly. Accordingly, reduction in the strength of the conventional body structure due to the deformation of the shell plate does not occur in the body structure of the. present invention.

The floor board 8 consisting of the laminated panels 10 is joined to the inner side surfaces of the side beams 6 in addition to the cross beams 7. Since each of the joints of the side beams 6 and the floor panels 8 is above the middle of the height of the side beam 6, the floor panels 8 enhance the bending rigidity of the side beams 6. The floor panels 8 enhance also the bending rigidity of the cross beams 7. Therefore, the height and the width of the side beams 6 may be smaller than in a conventional body structure, and hence the body structure 1 can be formed with a lightweight construction.

The height of the cross section of the extruded eave member 20, namely, the distance between the exterior surface of the outer wall 20b and the exterior surface of the inner wall 20d, is approximately equal to the thickness of the laminated panels 10 of the side structure 2 and the roof structure 4. Therefore, the body structure 1 is uniform in strength and rigidity, and the outer surface of the body structure 1 can be formed with a smooth surface.

Since the pair of side structures 2, the underframe 3 and the roof structure 4 are joined to the side beams 6 and the two extruded members 20, stress concentration at the joints can be prevented and, therefore, the thicknesses of the component members of the pair of side structures 2, the underframe 3 and the roof structure 4 may be comparatively small and the body structure can be formed with a lightweight construction.

The flanges 20e, 20f along the sides of the extruded member 20 overlap part of the laminated panels of the window header panel block 2a and the side portions of the laminated panels of the roof structure 4 respectively. Since the portions of the component members forming the welded joints overlap each other, the members can easily be positioned relative to each other in preparation for welding.

The thickness of the extruded eave members 20 may be equal to those of the panels 10 of the side structures 2 and the roof structure 4, which are joined to the extruded shapes 20 or only the thickness of the connecting flanges 20e and 20f may be increased so that the surfaces of the connecting flanges 20e and 20f are continuous with those of the side structures 2 and the roof structure 4 to enhance the smoothness of the body 1. Alternatively the thickness of the eave member 20 may be slightly greater than that of the panels 10, with the face plates of the member 20 either abutting or lying on the face sheets of the panels 10 so that strong welded joints can be made.

Thus, the side structures 2, the underframe 3, the roof structure 4, the side beams 6 and the eave members 20 each have a lightweight construction and, consequently, the body overall has a lightweight construction. Since each extruded eave member 20 is formed by extrusion as an integral member, the number of the component parts including the side structures 2 and the roof structure 4 of the body structure 1 is far smaller than the number of components of a conventional body structure. The extruded members 20 can be easily formed with a small radius of curvature if desired. Honeycomb panels formed by brazing members and having a curved shape having a small curvature cannot be fabricated or, even they can be fabricated, tend to be expensive.

Since the outer surface of each extruded eave member 20 merges smoothly into the outer surfaces of the side structure 2 and the roof structure 4, and the inner and outer plates 20b and 20d have the shapes of circular arcs, local stress concentration scarcely occurs, which contributes to the strength of the body.

The inner plate 20d of each extruded eave member 20 having a curved circular shape is advantageous in providing a pressure-proof structure capable of withstanding variation of the external and internal pressure.

Particularly the feature whereby the eave members 20 extending in this case over the full length of the body are joined to the continuous row 2a laminated panels 10 providing the upper edges of the window openings, provides a strong and easily assembled construction. This row 2a of panels 10 extends the full length of the body side between end door panels, i.e. more than the length between the bogie bearing points B.

The eave member 20 having the closed cross section is in this embodiment a light metal extruded shape which is formed in a one-piece unit having no welded division over the whole length of the body, at least between the bearings B. The hollow member 20 may be fabricated by joining together a plurality of longitudinally extending parts, and particularly can be made of a plurality of extruded shapes each extending at least between the bearings B and joined along longitudinal edges.

A procedure for constructing the body structure 1 will be described with reference to Figs. 19 and 20. The basic components of the body structure 1, i.e. the laminated panels 10, are fabricated and the peripheries of the laminated panels 10 are finished by machining. When assembling the side structure 2, first the window header panel block 2a and the wainscot panel block 2b are fabricated. The plurality of laminated panels 10 are arranged longitudinally and the adjacent laminated panels 10 are joined together to form the window header panel block 2a and the wainscot panel block 2b. When completed, the window header panel block 2a and the wainscot panel block 2b have curved shapes. The window header panel block 2a and the wainscot panel block 2b are set on a jig G1, and then the plurality of pier panels 2c are disposed between the window header panel block 2a and the wainscot panel block 2b. The extruded member 20 is arranged alongside the window header panel block 2a on the side of the roof structure 4. The extruded member 20 is formed in a straight shape and, when arranged alongside the window header panel block 2a, is curved forcibly by binding it to the jig G1 so as to conform to the shape of the curved window header panel block 2a. In this state, the extruded member 20 is bound to the support surface of the jig G1 with cramps Ga attached to the jig G1. Then, the window header panel block 2a, the wainscot panel block 2b, the plurality of pier panels 2c and the door panels 2d are welded together, and then the curved extruded member 20 is welded to the window header panel block 2a and the door panels 2d.

The jig G1 has support surfaces conforming to the shapes of the outer surfaces of the side structures 2 and the extruded members 20 of the body structure 1 respectively. When assembling the side structure 2, the window header panel block 2a, the wainscot panel block 2b, the plurality of pier panels 2c and the extruded member 20 are bound to the support surfaces.

Similarly, the roof structure 4 is assembled by binding the plurality of laminated panels 10 to a roof structure assembling jig and welding together the laminated panels. The roof structure assembling jig has support surfaces conforming to the shape of the outer surface of the roof structure.

When assembling the underframe 3, first the plurality of cross beams 7 are arranged between the pair of side beams 6 and the cross beams 7 are welded to the side beams 6. Then, floor panels 8 are placed on a frame formed by welding the cross beam 7 to the side beams 6, and then the adjacent floor panels 8 are welded together and the floor panels 8 are welded to the side beams 6 and the cross beams 7 to complete the underframe 3.

When assembling the end structure 5, outer panels and framing members are arranged on and bound to a jig, and the outer panels and the framing members are welded together. Since the strength and the rigidity of the end structure 5 need not be as high as those of the side structure, the outer panels need not be the laminated panels 10.

A procedure for assembling the pair of side structures 2, the underframe 3, the roof structure 4 and the pair of end structures 5 will be explained. First, the pair of side structures 2 are held opposite to each other, the pair of end structures 5 are disposed at the opposite longitudinal ends of the side structures 2 respectively, and the roof structure 4 is placed above the side structures 2 and the end structures 5. In this state, the respective positions of the structures relative to each other are adjusted and then the structures are bound. The roof structure 4 is fixed in a curved shape conforming to the curved shapes of the side structures 2 and the extruded members 20. The pair of side structures 2 and the pair of end structures 5 are welded together, and then the roof structure 4 is welded to the side structures 2 and the end structures 5.

The five-sided structure thus constructed is placed on the underframe 3, and then the pair of side structures 2 and the pair of end structures 5 are welded to the underframe 3. When welding the side structures 2 and the end structure 5 to the underframe 3, the underframe 3 is curved so as to conform to the curved shapes of the side structures 2.

Since each window header panel block 2a and each wainscot panel block 2b are formed in curved shapes respectively and the window header panel block 2a, the wainscot panel block 2b and the pier panels 2c are bound to the jig G1 when joining together the same, the assembling work can easily be accomplished. Since the extruded member 20 is bound to the jig G1 so as to conform to the curved shape of the window header panel block 2a, the window header panel block 2a and the extruded member 20 can easily and accurately be positioned on the jig G1. The extruded member 20 bound in a curved shape to the jig G1 is welded to the window header panel block 2a by longitudinally continuous welding. Since the window header panel block 2a and the extruded member 20 are welded together by continuous welding, a uniform welded joint is formed and the reliability is enhanced. Since the hollow member is bound fixedly to the jig G1 in a curved shape conforming to the camber of the body structure 1, the hollow member 20 can be welded to the side structure 2 with a high dimensional accuracy.

A second embodiment according to the present invention will be described with reference to Figs. 5 to 8. In this, the laminated panels 10 described above form the side structure 2 and the eave structure, as well as the roof structure 4, except that the portions of the side structure 2 serving as the pier panels 30 between the window openings are extruded shapes. The pier panels 30 are welded to the panels 10 of the wainscot and window headers. Each pier panel 30 consists of two extruded shapes 31a and 31b which are joined together by welding. Each of the extruded shapes 31a and 31b is a one-piece integral aluminum alloy extrusion having a closed cross section formed by a plurality of cells partitioned by partition webs joining inner and outer plates. The outer surface 30a of each pier panel 30 merges smoothly into the window header and the wainscot of the side structure 2. For example, when the surface of the side structure has a shape having a contour of a circular arc, the outer surface 30a of the pier panel 30 is a circular arc shape of curvature equal to that of the surface of the side structure. Since the extrusion direction of the extruded shape 31a, 31b is parallel to the longitudinal direction of the body 1, the extruded shape can be easily formed in the contour of a circular arc.

In Fig. 7, indicated at L is the overall length of the extruded shapes 31a and 31b. The corners 31c and 31d of the pier panel 30 contiguous with the window headers and the wainscot are rounded to prevent stress concentration.

As Fig. 8 shows, some of the partition walls extending between the inner outer plates of the extruded shapes 31a and 31b are cut to form a groove 31e for receiving a window therein. A reinforcing plate 32 is welded to the extruded shapes 31a and 31b so as to form the base of the groove 31e. The outer plate of the extruded shape 31a, 31b is longer than the inner plate so that the end 31f of the outer plate projects into the window opening W more than the end 31g of the-inner plate, to facilitate the installation of the window.

In this embodiment, the pier panels in which a comparatively high stress is induced are strong extruded shapes, so that the body structure overall has a lightweight construction and can be fabricated at a reduced manufacturing cost.

Each pier panel 30 may be a single extruded shape instead of the composite extruded shape formed by welding together the two extruded shapes 31a and 31b, if the size of the window permits.

The eave structure shown in Figs. 1 to 4 can be combined with the pier panel structure of Figs. 5 to 8, or with the pier panel structure of Figs. 9 to 11 now to be described.

A body in a third embodiment according to the present invention is shown in Figs. 9 to 11. In this embodiment, the pier panels 30 are extruded aluminum alloy shapes 35 having a flat shape and a closed cross-section of cells separated by webs as seen in Fig. 10. The extruded shapes 35 have their extrusion direction vertical in the body structure. The corners 35c and 35d of each extruded shape 35 adjacent to a window are rounded to prevent stress concentration. The relation between the respective edges 35f and 35g of the extruded shape 35 are the same as that of the edges 31f and 31g of Fig. 8. The respective positions of partition webs 35k adjacent the window openings W are determined so that grooves for receiving the side edges of the window are formed.

The relation between the travelling speed, the rigidity and the pressure-withstanding characteristic of a railway vehicle will be discussed below with reference to Figs. 12 and 13. In Fig. 12, the maximum working speed of a high speed train is given on the horizontal axis and the specific rigidity, i.e., the ratio of the rigidity of the body structure to the mass of the body structure, is given on the vertical axis. Solid circles represent the specific rigidities of currently used vehicles, and an unfilled triangle represents the specific rigidity of vehicle having the body structure in the foregoing embodiments. In Japan, the weight of railway vehicles must be reduced to permit increase of the possible travelling speed, in view of many restrictions on the construction of tracks and on effects of high-speed travel of trains, such as noise, vibration, and environmental effects. The weight of both the body structure and the equipment of the vehicle must be reduced, in order to construct a lightweight vehicle. On the other hand, the rigidity of the body structure must be at a certain level to provide a vehicle that is safe and comfortable to ride in. As shown in Fig. 12, the specific rigidity, i.e. (rigidity of the body structure)/(mass of the body structure), of existing vehicles is a linear function of travelling speed. As is apparent from Fig. 12, the specific rigidity of vehicles that are expected to travel at speeds in the range of 300 to 350 km/hr must be at least 0.3 GN·m^2/ton, preferably in the range of 0.3 to 0.4 GN·m^2/ton.

Fig. 13 shows the dependence of the specific withstand pressure (i.e., the ratio of pressure load that acts on the body structure of a vehicle when trains travelling respectively in opposite directions pass each other or when trains run into a tunnel to the mass of the body structure) on maximum working speed. The specific withstand pressure is given on the vertical axis, and travelling speed is given on the horizontal axis. In Fig. 13, solid circles represent the specific withstand pressure of existing vehicles, and a blank triangle represents the specific withstand pressure of a vehicle having the body structure as in the foregoing embodiments. As mentioned above, increase in the travelling speed of railway vehicles has entailed increase in fluctuating pressure load that acts on the vehicles when trains travelling in opposite directions pass each other or when trains run into a tunnel, and the fluctuating pressure load is proportional to the square of travelling speed as shown in Fig. 13. Accordingly, the pressure withstanding capacity of the body structure must be enhanced to enable the body structure to obtain a safe strength. As is apparent from Fig. 13, the specific withstand pressure of rolling stocks expected to travel at speeds in the range of 300 to 350 km/hr must be in the range of 1.5 to 3.0 kPa/ton.

A body in a fourth embodiment according to the present invention will be described hereinafter with reference to Figs. 14 to 18. In this, the side structure 52 comprises laminated panels 10 forming a wainscot, laminated panels 10 forming a window header, pier panels 64 disposed between window openings W and interconnecting the laminated panels 10, and an extruded eave member 60 having a closed cross section and disposed on the laminated panels 10 forming the window header, as in Figs. 1 to 4. Each of the laminated panels 10 forming the wainscot and the window header regions is generally rectangular but has a slight deviation from exact rectangular shape so as to be trapezoidal with a longer upper side and a shorter lower side. The effect is that the side structure 52 when assembled has a slight upward curvature, i.e. a cambered shape, as discussed above for Figs. 1 to 4. The extruded members 60 extend the full longitudinal length of the body and are given an upward curvature when being welded to the adjacent laminated panels 10 to form the complete cambered side structure 52. The laminated panels 10 are as described above.

The periphery of each doorway is defined by a doorway panel 52a formed by joining extruded metal shapes together. The doorway panel 52a is joined by welding to the laminated panels 10 and the extruded eave member 60, and has a generally rectangular shape. A side wall 52b of a utility room, contiguous with the doorway panel 52a may be formed by assembling extruded shapes to facilitate the arrangement of interior fixtures.

The extruded eave member 60 will be described with reference to Fig. 17. It has a small radius of curvature with a comparatively large width in the range of about 800 to about 1000 mm and hence, in view of the state of the art of extrusion, must be formed in parts. As shown in the embodiment, the member 60 is formed by joining and welding together two extruded shapes 60h and 60l. The radius R2 of curvature of portions of the member 60 near the opposite longitudinal sides is greater than the radius R1 of curvature of the central portion, to increase the volume of the interior of the vehicle body. It is preferable to weld the extruded shapes 60h and 60l together before joining the member 60 to the laminated panels 10 because the extruded shapes 60h and 60l can in either case be satisfactorily and accurately welded together. The member 60 thus formed is suitable for bearing high stress.

Fixture holding rails 60r for holding interior fixtures are formed integrally with the extruded shapes 60h and 60l on their inner surfaces along one longitudinal side of each of the extruded shapes 60h and 60l. The rails 60r are used for holding parcel racks, interior face boards, ducts for air conditioning and ceiling panels, which will be described later.

The extruded shapes 60h and 60l are formed in a closed cross section, i.e. a cross section having hollow cells, to secure rigidity and to achieve a lightweight construction. The hollow cells are formed in a high density in portions of the extruded shapes 60h and 60l having smaller radii of curvature so that the extruded member 60 has a sufficiently high strength and can withstand positive and negative bending loads.

As shown in Fig. 14, the pier panels 64, similarly to the extruded shape 60, are formed with a closed cross section by extrusion (see Figs. 5 to 8 also), and a fixture holding rail 60r is formed integrally with each of the pier panels 64 on the inner surface of the pier panel 64.

An underframe 53, substantially similar to those of the foregoing embodiments, is formed by cross beams 7 and extruded side beams 62, with floor panels 8 on the cross beams 7 and the side beams 62. A fixture holding rail 62r is formed integrally with each side beam 62 at a position above the junctions of the side beam 62 and the cross beams 7. The lower side of an interior face board 81 (see Fig. 18) covering the inner surface of the window header panels, areas around the windows and the wainscot panels is fastened to the holding rail 62r with bolts and the like. The upper side of the interior face board is hooked to the interior fixture holding rail 60r of the extruded shape 60l, and the middle part of the interior face board is pressed against the interior fixture holding rail 64 of the pier panels 64. The interior face board is curved in a radius of curvature smaller than that of the inner surface of the side structure 52. The upper and the lower side of the interior face board are thus fixed and the middle part of the same is pressed against the pier panels 64. The space between the side structure 52 and the interior face board is filled up with a resilient thermal insulating material for heat-insulation and for the prevention of vibration of the side interior face board. The thermal insulating material is urethane foam or the like.

The roof structure 54 (see Figs. 15 and 16) is constructed by arranging a plurality of laminated panels 70 (of the same construction as the panels 10) longitudinally of the body structure and joining together the adjacent laminated panels 70. The opposite longitudinal ends of each laminated panel 70 are slightly inclined to the vertical so that the lower side of the panel is shorter than the upper side of the panel, so that the roof structure is formed in a cambered (upwardly curved) shape with respect to the longitudinal direction of the body when the laminated panels 70 are joined together by welding.

Some vehicle bodies are designed to support current collecting equipment or insulators for supporting high tension cables on the roof. A portion of the roof structure supporting such heavy equipment is formed by an extruded member 60S having a closed cross section with inner and outer plates joined by webs to define cells, at the end of the roof, as shown in Figs. 15 and 16. The member 60S is constructed by arranging a plurality of extruded metal shapes across the width of the body structure and joining together the adjacent shapes by welding. Support members for supporting current collecting equipment, such as support rails, may be formed integrally with the extruded shape 60S.

Fig. 17 shows a part of the body structure around the junction of the roof structure 54 and the extruded members 60 of the side structures 52, the lower part of the side structures 52 being omitted. As described above the laminated panels 10 are shaped so that the side structures 52 have a cambered (upwardly curved) shape and curved extruded members 60 are joined to the laminated panels 70. Since the roof structure 54 is also cambered, the side structure 52 and the roof structure 54 can be accurately and comparatively easily joined together. Thus the extruded member 60 provides a continuous, longitudinal beam extending along the junction of the side structure 52 and the roof structure 54, to reinforce the body structure against vertical bending load; that is to say, the laminated panels 70 of the roof structure are joined along weld lines extending across the width of the body structure, and hence it is advantageous to provide the longitudinal beam extending perpendicularly to the weld lines for securing reliability in strength.

The cambers of the side structure 52 and the roof structure 54 can comparatively easily be formed as compared with forming a camber by processing the laminated panels 10 or the laminated panels 70 to bend the plurality of extruded shapes. It is advantageous that the extruded members 60 extend longitudinally of the body structure between the bearing points B (Fig. 2) in respect of the reliability in strength of the weld zones. The combination of the side structure and the roof structure of the illustrated embodiments of Figs. 1 and 14 provides a structure having both advantages.

The side structure 52 is fabricated by a procedure similar to that for fabricating the side structure in the embodiment of Figs. 1 to 4. When assembling the side structure 52, the window header panel block, the wainscot panel block, the pier panels and the hollow member 60l are arranged on and bound to a jig, and then those components are welded together. The extruded member 60l is bound to the jig in a curved shape conforming to the camber of the body structure.

When assembling the roof structure 54, first the roof panel block 70a is fabricated, and then the two extruded members 60h are welded to the lateral sides of the roof panel block 70a respectively. First, the roof panel block 70a is fabricated by longitudinally arranging the plurality of laminated panels 70 and the panel 60S if provided, and welding together the adjacent laminated panels. As mentioned, when the laminated panels 70 thus formed are welded together, the roof panel block 70a is formed in a curved shape conforming to the camber of the body structure. Then, as shown in Fig. 21, roof panel block 70 and the extruded members 60h are placed on and bound to a jig G2 having support surfaces conforming to the shape of the outer surface of the roof structure 54. The support surfaces are formed so as to curve the roof panel block 70a and the extruded members 60h in a shape conforming to the camber of the body structure. When bound to the jig G2, the roof panel block 70a and the hollow members 60h are curved so as to conform to the camber of the body structure. The roof panel block 70a and the extruded members 60h thus curved are welded together.

The pair of side structure 52, the roof structure 54 and the pair of end structures are positioned relative to each other, and then those structures are welded together. When joining together each side structure 52 and the roof structure 54, the longitudinal joint of the respective sides of the extruded members 60h and 60l is welded by continuous welding. Although the side structures 52 and the roof structure 54 have curved shapes, respectively, conforming to the camber of the body structure, the joining work can easily be carried out because the side structures 52 and the roof structure 54 are fabricated accurately using the jigs. Since the extruded members 60h are attached to the opposite lateral sides of the roof structure 54, the rigidity of the roof structure is higher than that of a roof structure constructed by assembling only laminated panels, which facilitates the work for handling the roof structure 54 including moving and turning over the roof structure 54.

The extruded eave members 60 may be included in the roof structure. In such a case, first the extruded members 60 and the extruded members 60S are joined together and a camber applied to them if desired, and then a plurality of laminated panels 70 joined together in a unit is joined to the extruded members 60 and 60S.

Arrangement of interior fixtures and fittings on the structures will be described with reference to Fig. 18. An interior face board 81 covers an area from the connection of the eave member 60 to the side panels 10 to the upper part of the side beam 62. The interior face board 81 covers the inner surfaces of the window headers, areas surrounding the windows and the wainscot. The board 81 is fabricated by shaping an aluminum alloy plate by pressing and coating the formed aluminum alloy plate with a resin sheet. The board 81 is curved with a radius of curvature smaller than that of the side structure 52. The upper side of the board 81 is fastened to the rail 60r of the extruded member 60 and the lower side of the board 81 is fastened to the rail 62r of the side beam 62. The space between the side structure 52 and the board 81 is filled with a thermal insulating material 85. The middle portion, with respect to the height of the board 81 is pressed against the rails 64r of the pier panels 64 because the curvatures of the side structure 52 and the board 81 are different from each other.

The board 81 is fastened to the rails 64r of the pier panels 64 with screws screwed in the fixture holding rails 64r from the interior of the passenger compartment or by hooking fixtures attached beforehand to the board 81 to the fixture holding rails 64r. If necessary, vertical reinforcing members (not shown) are attached adhesively to the outer side of the board 81.

The lower end and the upper end of a parcel rack 82 are fastened to the rails 60r of the extruded member 60 with fastening bolts. The lower end of the parcel rack 82 fastened to the rail 60r covers the upper edge of the board 81. The parcel rack 82 is provided with a hinged front lid 82a and the fastening bolts fastening the parcel rack 82 to the fixture holding rails 60r are arranged within the parcel rack 82. Therefore, the fastening bolts are not exposed to the passenger compartment.

A ceiling board 83 extends between and is fastened to the rails 60r of the opposite extruded members 60. An air duct 84 for air conditioning extends in the space between the ceiling board 83 and the roof structure. The air duct 84 has one side fastened to the rail 60r and the other side fastened to a rail 70r attached to the internal reinforcing members of the laminated panels 70. The rail 70r is attached to the internal reinforcing members, i.e., shapes, by fixing members inserted in holes formed in the internal reinforcing members. Conditioned air is supplied from one end of the air duct 84 adjacent an end structure of the body and is blown out into the compartment through air outlets 84a provided on the ceiling board 84.

When fitting out the interior of the vehicle, the ceiling and the side walls are fitted first with fixtures, and then the parcel racks 85 are put on the side walls. The ceiling boards 83 are attached to the body structure after installing the air duct 84.

The interior face board 81 is attached after spreading the thermal insulating material 85 over the inner surface of the side structure 52. Then, the parcel racks 82 are fastened to the extruded members 60 so as to cover the junctions of the ceiling boards 83 and the boards 81 so that the interior of the rolling stock looks attractive. When the parcel rack 82 has one end to be hooked to the fixture holding rail 60r and the other end to be fastened to the other fixture holding rail 60r with fastening bolts, the parcel rack 82 can be installed easily.

The body structure thus constructed is provided with the longitudinal extruded members 60, i.e. shapes having a closed cross section, extending along the opposite upper corners, and the longitudinal side beams 62, i.e. shapes having a closed cross section, extended along the opposite lower corners, and the longitudinal extruded members 60 and the longitudinal side beams 62 are joined to the laminated panels 10 and 70. Accordingly, the body structure has a comparatively high bending rigidity (EI).

Since the laminated panels 10 and 70 are shaped so as to form cambers, the cambered body structure can easily be constructed by welding together the adjacent laminated panels 10 and 70. Combined use of the laminated panels 10 and 70, and the extruded members 60 improves the reliability in strength of the weld zones.

Since the outer surfaces of the laminated panels 10 and 70, and the extruded shapes 60 at their junctions are substantially flush with each other, the outer surface of the body can easily be finished with a smooth surface, and variable positive and negative pressures acting on the body structure can uniformly be distributed and hence stress concentration and the like can be prevented. Since the edges of the extruded shapes 60 are formed so that the longitudinal edges of the roof structure 54 can be easily placed and located on the side structures 52, the side structures 52 and the roof structure 54 can easily be joined together as compared with a side structure and a roof structure which must be held in their desired position relative to each other when joining them together.

The webs defining hollow cells in the curved portion of the extruded member 60 having a comparatively small radius of curvature are arranged at small intervals to enhance the rigidity of this curved portion and hence the size of the extruded member 60 may be comparatively small. Consequently, a passenger compartment having a comparatively large volume can be formed by using the extruded member 60 having a sufficiently high strength.

The thickness of the middle portion of the extruded member 60 in which stress concentration is liable to occur may be increased to enhance the rigidity of the extruded member 60.

Each pier panel 64 has an extruded shape having a closed cross section and a length corresponding to the height of the window. A longitudinally continuous, hollow cell extruded panel may be used instead of the pier panels 64, and openings corresponding to the windows may be formed in the longitudinally continuous, hollow extruded panel by machining; that is, a longitudinally continuous, hollow cell extruded panel provided integrally with window frames may be used instead of the pier panels 64, and the laminated panels 10 may be joined to the longitudinally continuous, hollow extruded panel to construct the body structure. A body structure thus constructed has an enhanced strength and lightweight construction because the window frames are formed integrally with the body structure.

The camber (upward curvature) applied to the body in the embodiments of Figs. 1 to 4 and Figs. 14 to 18 is of an amount such that, when the body is subjected to loads occurring in normal operation of the vehicle, e.g. the weight of internal fixtures, passengers etc. and particularly the weight of underfloor equipment mounted on the body, the body tends to flex downwardly at its centre so as approximately to eliminate the curvature applied during manufacture.

The features of the embodiment of Figs. 14 to 18 herein described can be applied also as appropriate to the other embodiments above.

While the invention has been illustrated by several embodiments, it is not limited to them and variations, modifications and improvements are possible within the scope of the inventive concept.

Claims

1. A railway vehicle body having

(i) an underframe (6,7,8) with a pair of bogie bearings (B) adjacent opposite ends of the body,

(ii) two side structures (2) each including a plurality of window openings (W) in a row,

(iii) a roof structure (4) and

(iv) two end structures (5),

(v) said side structures each comprising a plurality of laminated panels (10) welded to each other, said laminated panels (10) each having a pair of metal face sheets (11,12) sandwiching a metal core (13), the face sheets being joined to the core by metal-to-metal bonding,

(vi) said body including a longitudinally continuous metal eave panel (20,60) located at the junction of each said side structure (2) and said roof structure (4), and being welded at one side to a continuous row of a plurality of said welded-together laminated panels (10) of the adjacent said side structure (2), characterized in that

(vii) said eave panel has inner and outer plates (20b,20d) connected together by longitudinally extending webs (20g) defining longitudinally extending cells,

(viii) said laminated panels (10) of said continuous row have lower edges which are not lower than the upper edges of said window openings (W) of said row thereof and

(ix) said eave panel (20) and said continuous row of laminated panels (10) extend continuously over at least the length of said body between said bogie bearings (B).

2. A railway vehicle body according to claim 1 wherein said eave panel is at least one extruded member (20,60h,60l) having its direction of extrusion in the longitudinal direction of the body, and extending continuously over at least the length of said body between said bogie bearings.

3. A railway vehicle body according to claim 1 or claim 2 wherein said eave panel (20,60) has an outer surface which is smoothly curving, as seen in transverse section, in an arc from said side structure (2) to which it is welded to said roof structure (4).

4. A railway vehicle body according to claim 3 wherein said arc of said curving outer surface of said eave panel (20,60) has a single radius of curvature, or a first radius of curvature (R_1) at a central portion thereof and a second radius of curvature (R_2) larger than said first radius of curvature (R_1) at respective end portions thereof on opposite sides of said central portion.

5. A railway vehicle body according to claim 1 wherein said lower edges of said laminated panels (10) of said continuous row are welded to pier panels (30) which define side edges of said window openings, said pier panels being selected from

(a) laminated panels each having a pair of metal face sheets sandwiching a metal core, the face sheets being joined to the core by metal-to-metal bonding, and

(b) extruded metal members having inner and outer plates connected together by longitudinally extending webs defining longitudinally extending cells.

6. Railway vehicle body having an underframe (6,7,8), two side structures (2), a roof structure (4) and two end structures (5),

both of said side structures (2) comprising a plurality of laminated panels (10) welded to each other, each having a pair of metal face sheets (11) of thickness in the range 0.8 to 1.6 mm sandwiching a metal core (13), the face sheets being joined to the core by metal-to-metal bonding, wherein

(a) said body includes, at the junction of each said side structure (2) and said roof structure (4), an eave structure (20,60) having as seen in transverse section a radius of curvature less then that of said side structures and said roof structure,

(b) said eave structure comprising at least one longitudinally extending metal eave panel (20,60h,60l) formed by parallel curved inner and outer plates (20b,20d) each having a thickness greater than said thickness of said face sheets (11,12) and longitudinally extending webs (20g) interconnecting said inner and outer plates and defining, as seen in transverse section, a plurality of longitudinally extending cells,

(c) said eave panel has an overall thickness from the outer face of said outer plate (20b) to the inner surface of said inner plate (20d) which is not less than the corresponding thickness of said laminated panels (10) of said side structure and not more than said thickness of said laminated panels (10) of said side structure plus the average thickness of said inner and outer plates (20b,20d) of the eave panel,

(d) said inner and outer plates (20b,20d) of said eave panel are directly welded respectively to the inner and outer face sheets (11,12) of at least one said laminated panel (10) of the adjacent said side structure.

7. A railway vehicle body having an underframe (6,7,8), two side structures (2) each including a plurality of window openings (W) in a row, a roof structure (4) and two end structures (5), said side structures (2) each comprising a plurality of laminated panels (10) welded to each other, said laminated panels each having a pair of metal face sheets (11,12) sandwiching a metal core (13), the face sheets being joined to the core by metal-to-metal bonding,

characterized in that

each said side structure includes a plurality of pier portions (30) each located between an adjacent pair of said window openings (W), each said pier portion comprising at least one metal pier panel (30a,31a,31b) formed by spaced inner and outer plates which are connected together by webs defining elongate interior cells thereof.

8. A railway vehicle body according to claim 7 wherein each said pier panel (30a,31a,31b) is an extruded panel whose direction of extrusion is the longitudinal direction of said elongate cells and is either the longitudinal direction of said railway vehicle body or is perpendicular to the longitudinal direction of said railway vehicle body.

9. A railway vehicle body having an underframe (6,7,8), two side structures (2), a roof structure

(4) and two end structures (5), said roof structure (4) comprising a plurality of laminated panels (70) each having a pair of metal face sheets (11,12) sandwiching a metal core (13), the face sheets being joined to the core by metal-to-metal bonding, said laminated panels being welded to each other to form a first roof portion,
characterized in that
said roof structure further comprises at least one second roof portion comprising at least one extruded metal panel (60S) formed by spaced inner and outer plates which are connected together by webs defining elongate interior cells thereof, each said second roof portion being joined by welding to said first roof portion.

10. A railway vehicle body having an underframe (6,7,8), two side structures (2), a roof structure (4) and two end structures (5), said underframe having at each side thereof an extruded metal side beam member (6) extending longitudinally of said body and joined to the respective said side structure (2), said body including a longitudinally extending extruded metal eave panel (20,60) located at the junction of each said side structure and said roof structure and joined to the respective said side structure and said roof structure,
characterized in that
each said side beam member (6) and each said eave member (20,60) having, integrally extruded therewith at its interior side with respect to the body, at least one fixing rail (60r,62r) for attachment of internal fixtures of said body.

11. A method of manufacturing a railway vehicle body having an underframe (6,7,8), two side structures (2) and two end structures (5) mounted on said underframe and a roof structure (4) mounted on said side and end structures, said body having at each side a longitudinally continuous metal eave panel (20,60) connecting the respective said side structure and said roof structure, the method including the steps of
(i) bending each said eave panel (20,60) to produce a predetermined upward curvature along the longitudinal direction of the panel, and
(ii) welding each said eave panel at one edge thereof to a plurality of generally rectangular metal panels (10) of the adjacent said side structure, and
(iii) before or after step (ii) welding said plurality of generally rectangular panels to each other to form at least part of said side structure, said side panels (10) having shapes before welding together such that when they are welded to the eave panel and to each other, the side structure has a predetermined overall upward curvature,
whereby said upward curvature of said side structure of said body is at least partly removed by flexure of the body when subjected to the expected normal working load.

12. A method of manufacturing a railway vehicle body, including the steps of
(i) assembling two side structures (2) of said body each comprising a plurality of welded-together metal side panels (10) and a transversely curved metal first eave panel (60l) extending longitudinally along an upper edge of said side structure and welded at a first longitudinal edge thereof to a plurality of said side panels,
(ii) assembling a roof structure (4) comprising a plurality of welded-together metal roof panels (60S,70) and a pair of transversely curved metal second eave panels (60h) extending longitudinally along respective side edges of said roof structure and each welded at a first longitudinal edge thereof to a plurality of said roof panels, and
(iii) after said steps (i) and (ii), assembling said roof and two side structures together by welding second longitudinal edges of said first eave panels (60l) to second longitudinal edges of said second eave panels (60h).

13. A railway vehicle body for a vehicle for a railway train intended to travel at at least 300 km/h, having a specific rigidity (ratio of the rigidity of the body structure to the mass of the body structure) of not less than 0.3 GN·m^2/ton.

14. A railway vehicle body for a vehicle for a high-speed train intended to travel at a speed in the range of 300 to 350 km/hr, having a specific rigidity (ratio of the rigidity of the body structure to the mass of the body structure) in the range of 0.3 to 0.4 GN·m^2/ton, and a specific withstand pressure (ratio of a pressure load acting on the body structure to the mass of the body structure) in the range of 1.5 to 3.0 kPa/ton.

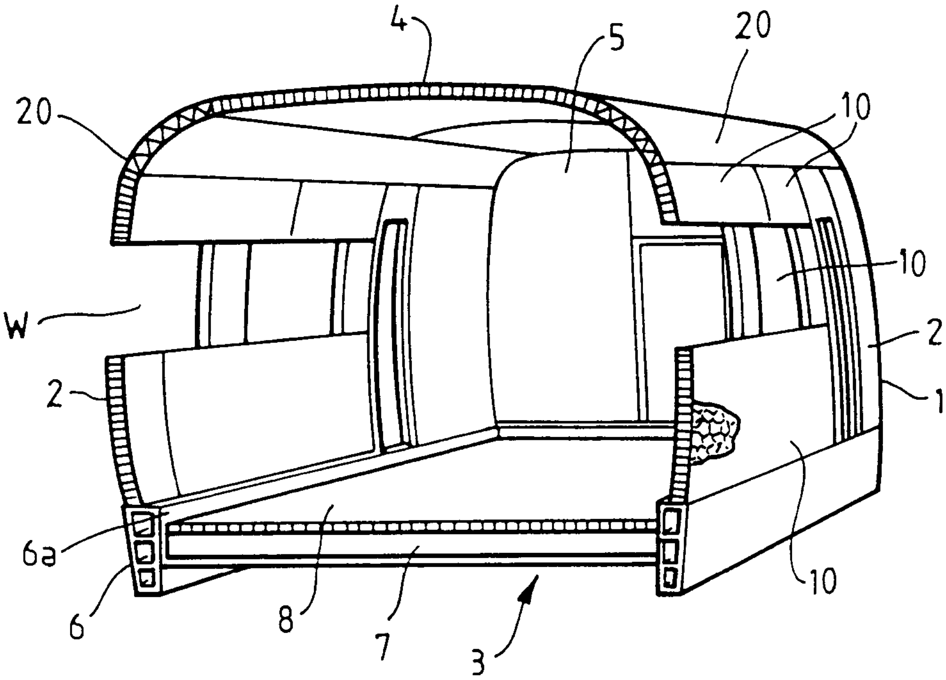


FIG. 1

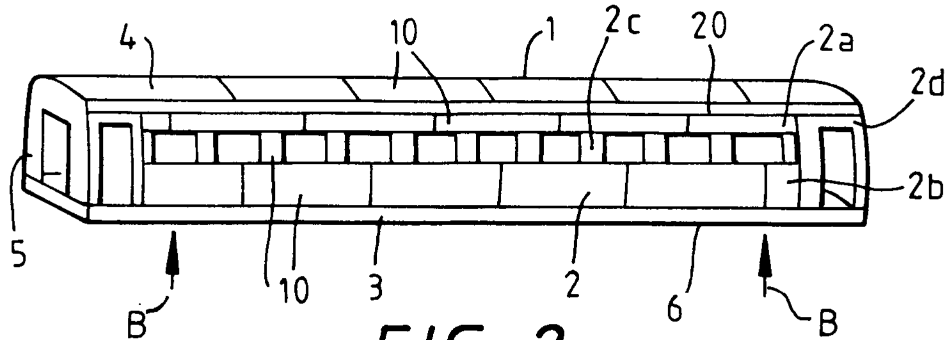


FIG. 2

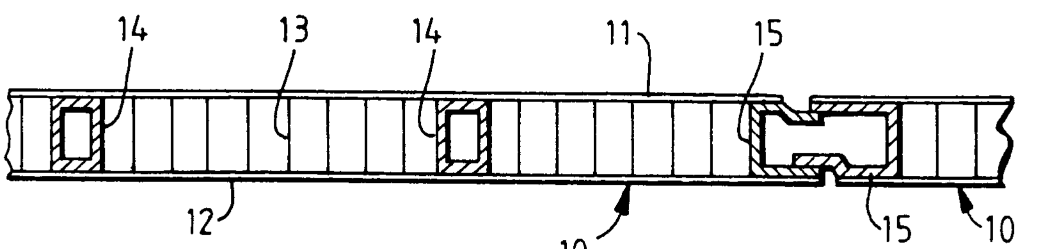
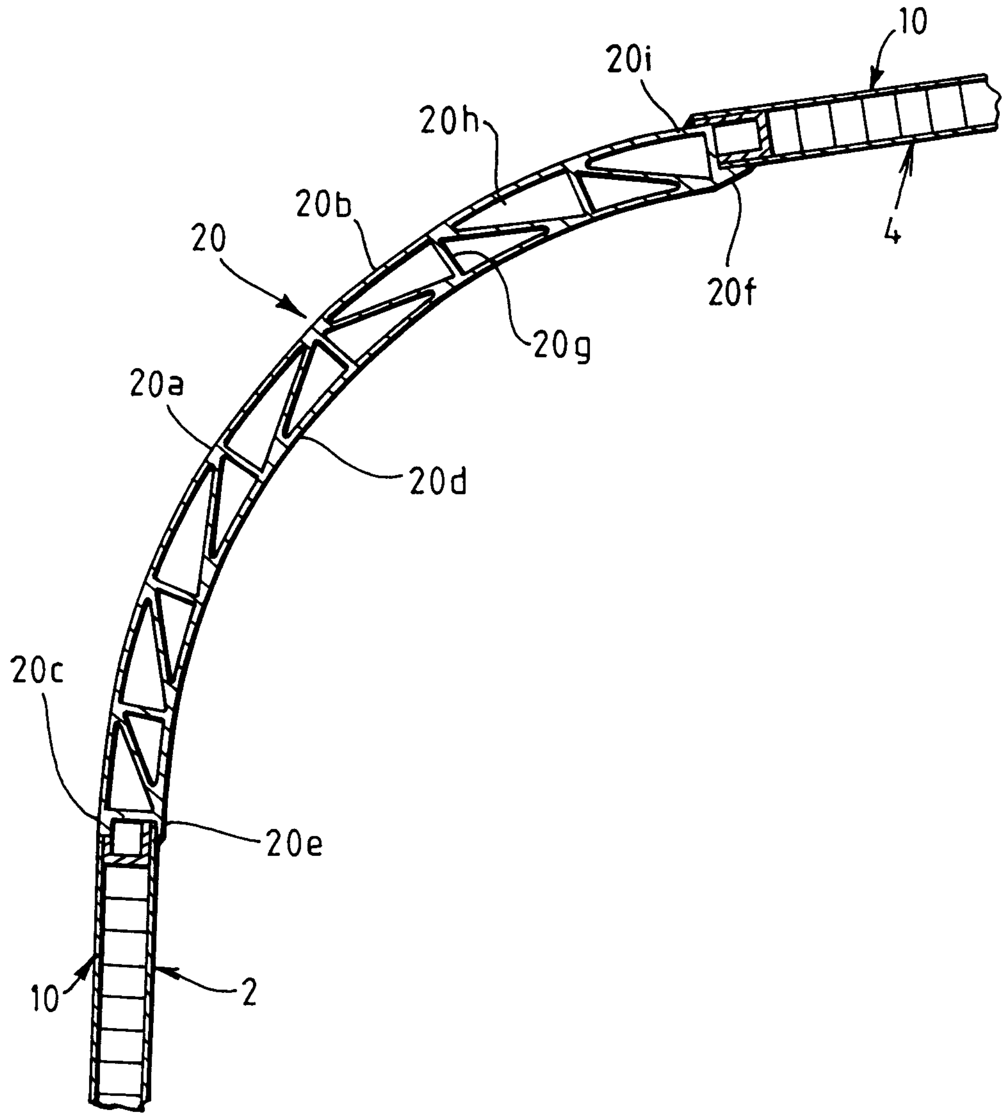


FIG. 3

FIG. 4



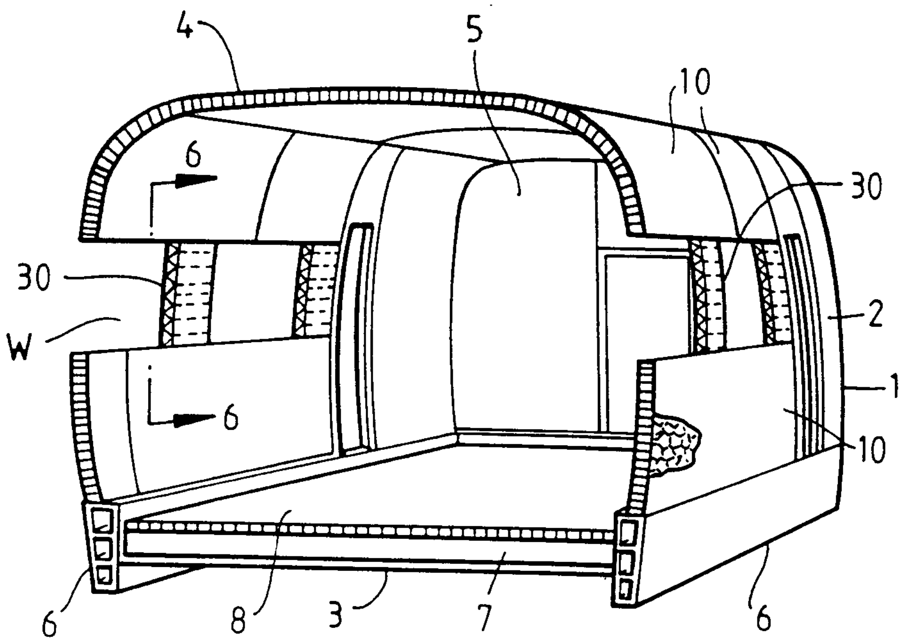


FIG. 5

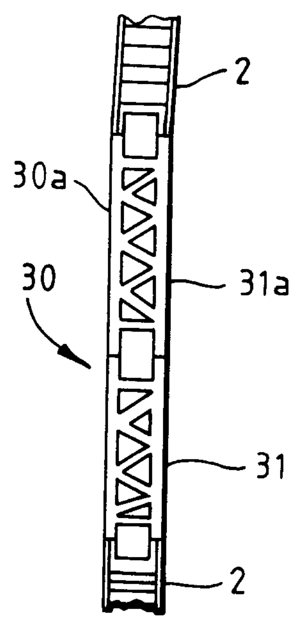


FIG. 6

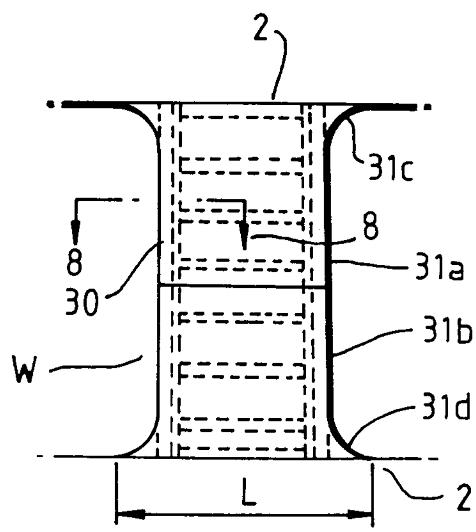


FIG. 7

FIG. 8

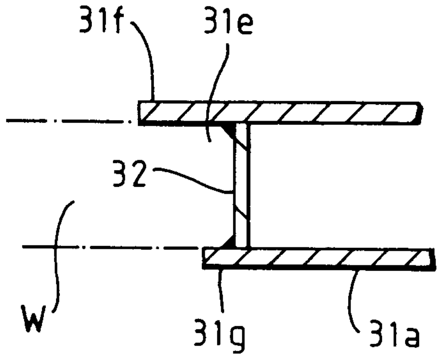
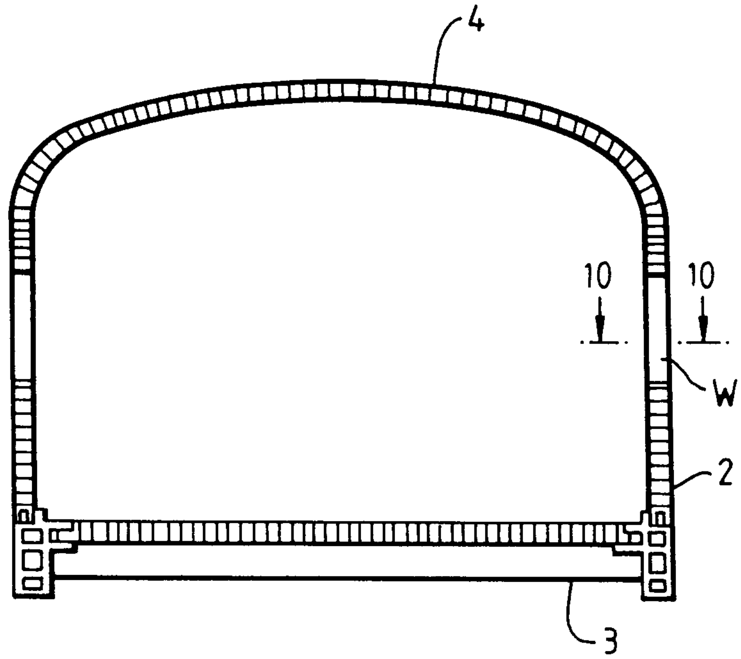


FIG. 9



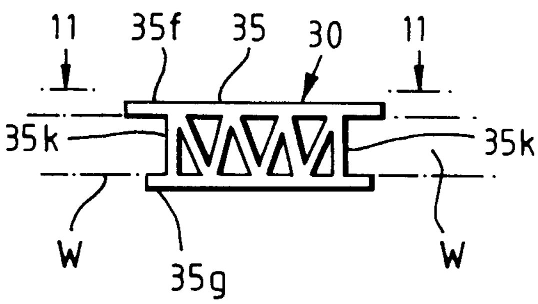


FIG. 10

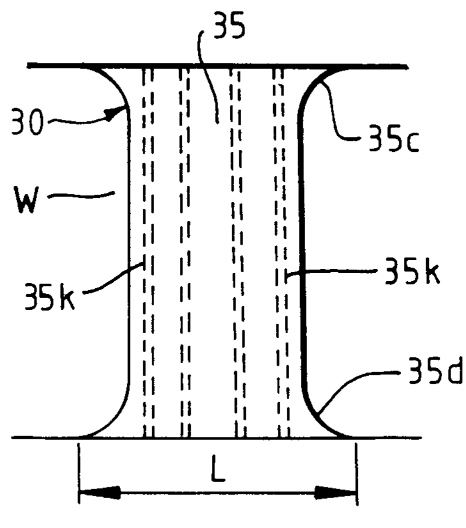


FIG. 11

FIG. 12

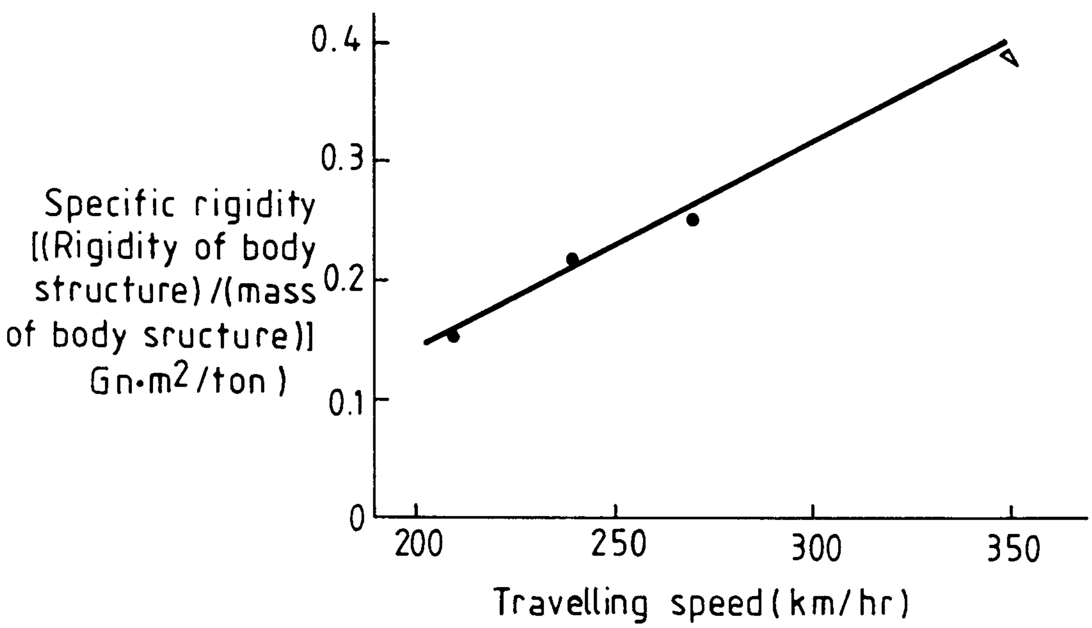
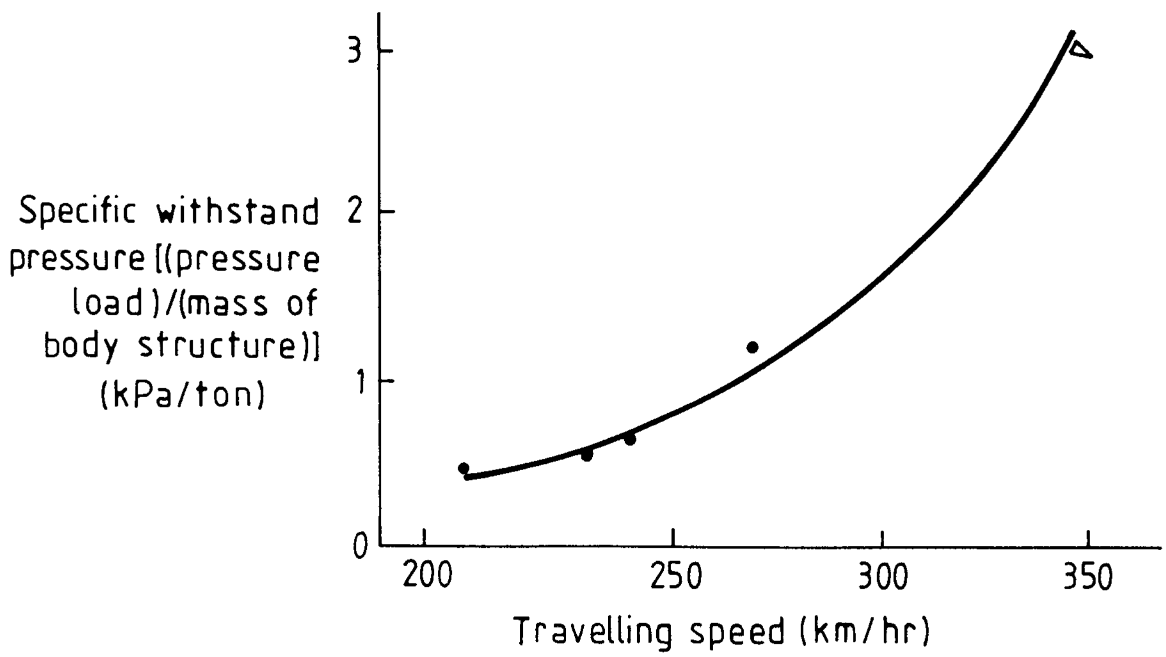

0.4
0.3
0.2
0.1
0
Specific rigidity [(Rigidity of body structure) /(mass of body sructure)] Gn•m2/ton)
200
250
300
350
Travelling speed (km/hr)

FIG. 13


3
2
1
0
Specific withstand pressure [(pressure load)/(mass of body structure)] (kPa/ton)
200
250
300
350
Travelling speed (km/hr)

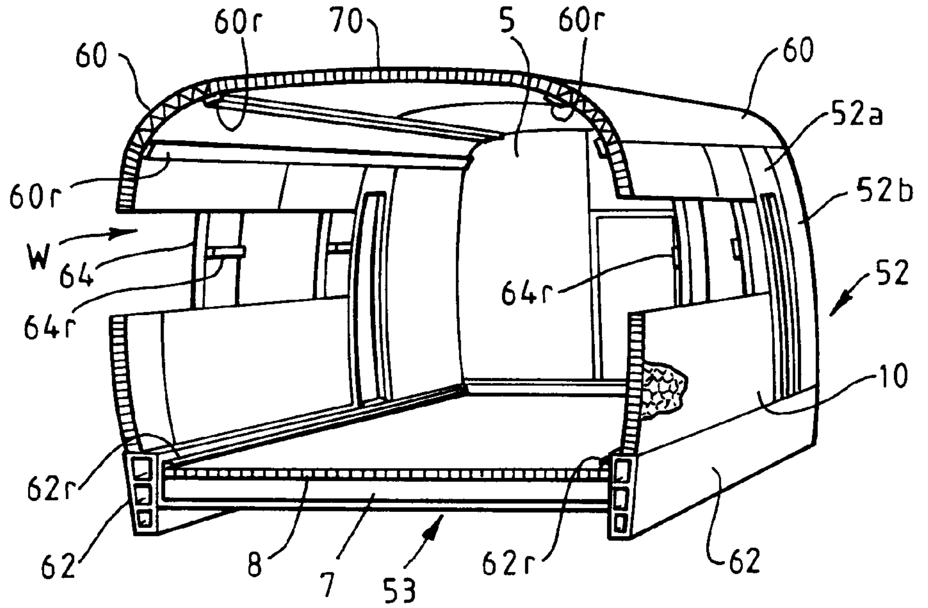

60r
70
5
60r
60
60
52a
52b
60r
W
64
64r
64r
52
10
62r
62
8
7
53
62r
62

FIG. 14

FIG. 15

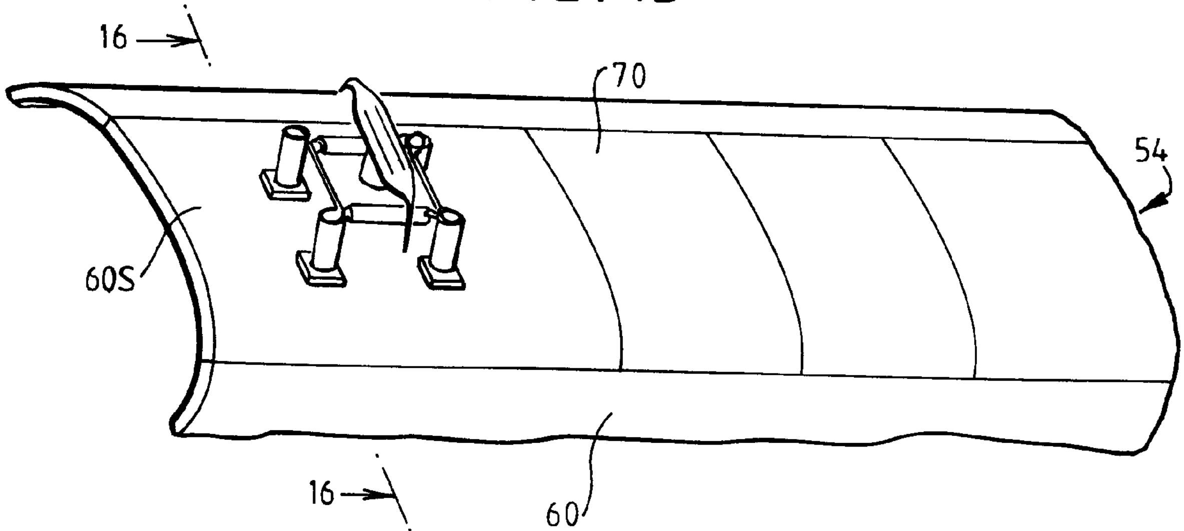
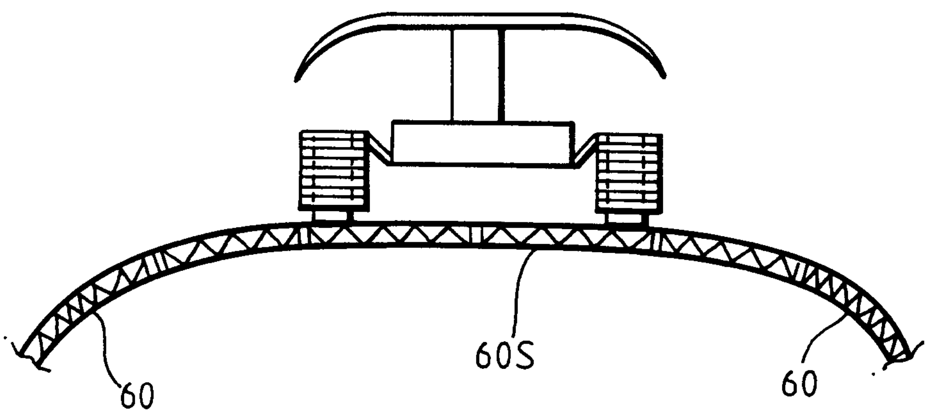

16
70
54
60S
16
60

FIG. 16



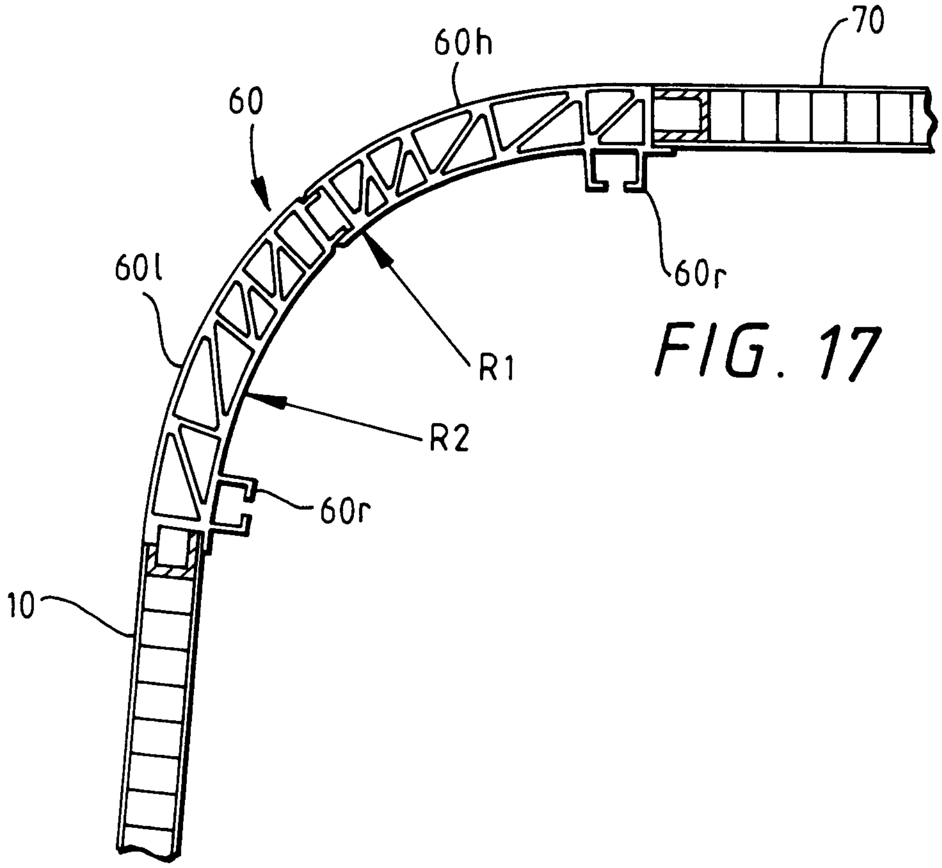


FIG. 17

FIG. 18

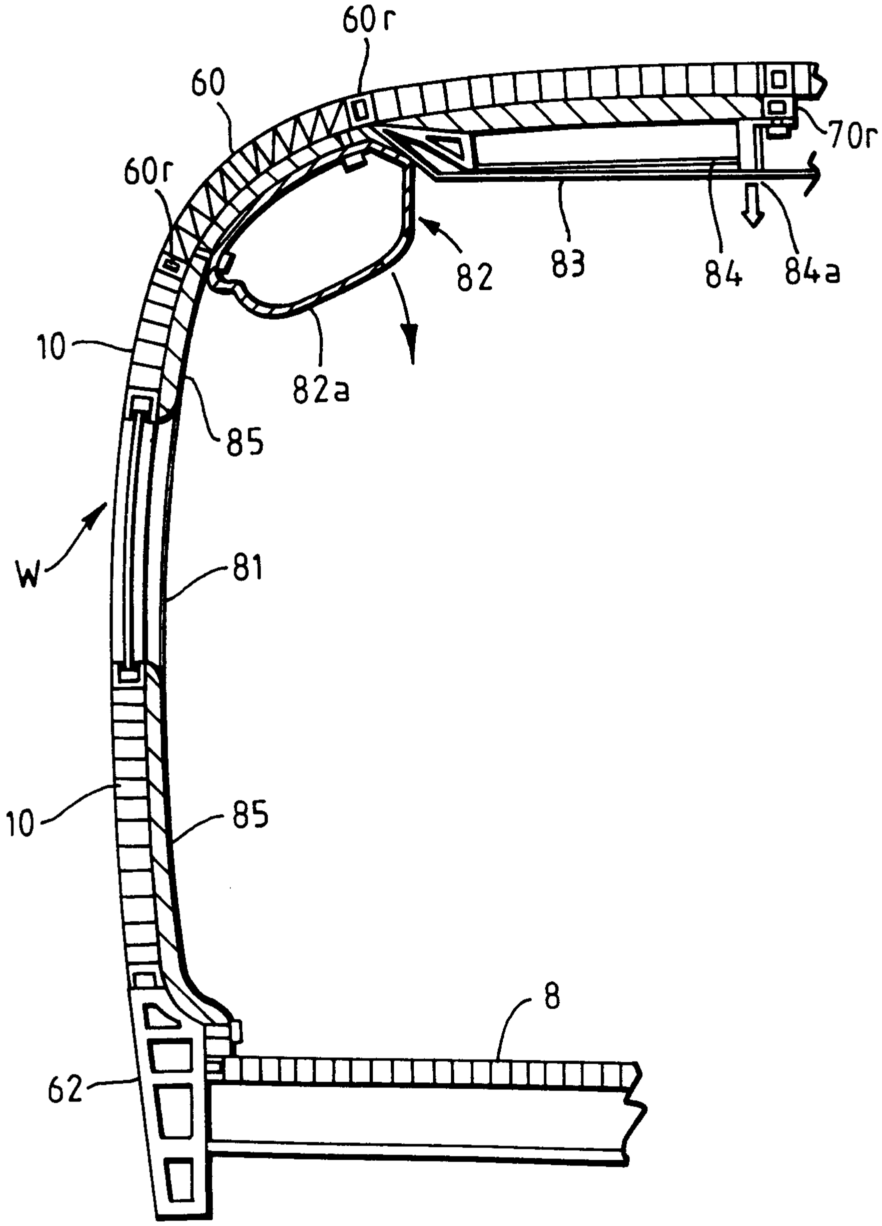


FIG. 19

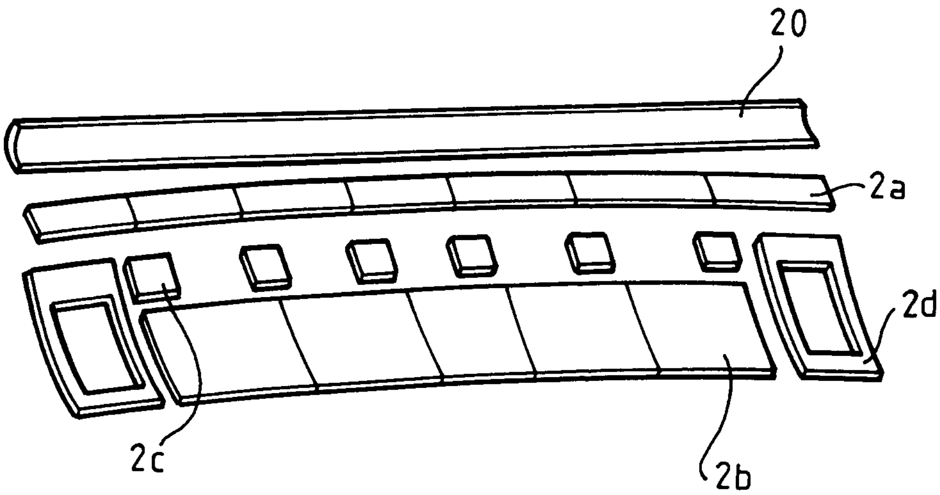


FIG. 20

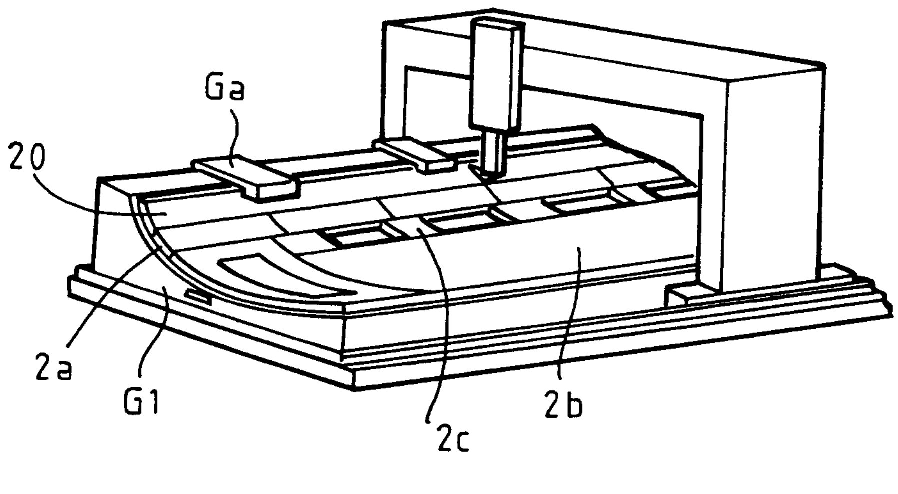
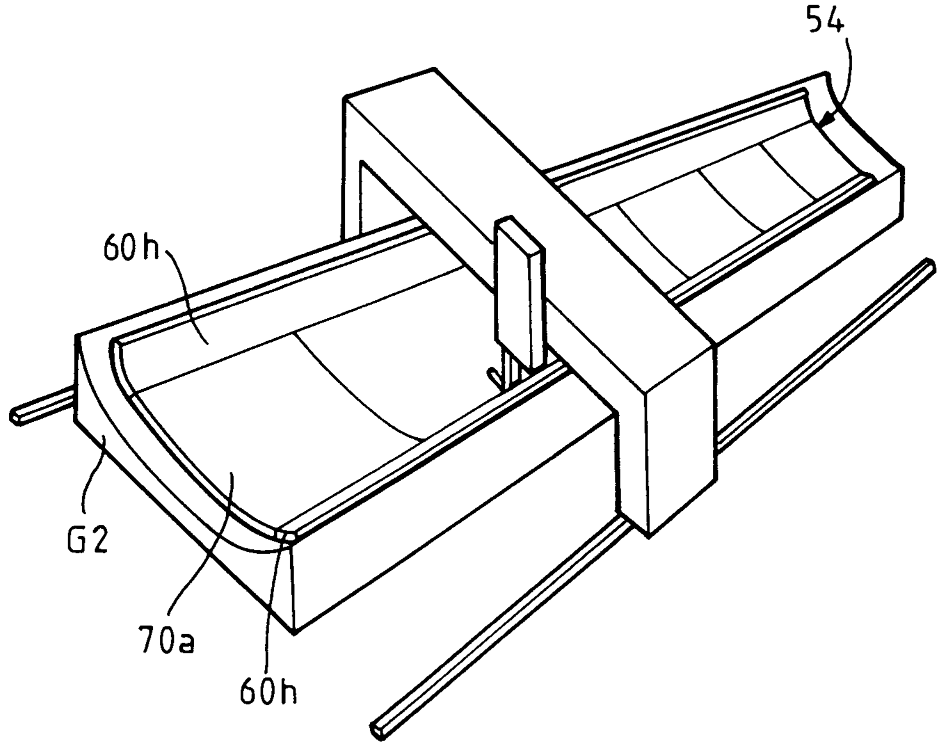


FIG. 21



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 30 1789

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	EP-A-0 495 429 (SUMITOMO LIGHT METAL IND ;HITACHI LTD (JP)) 22 July 1992 * column 11, line 10 - column 12, line 30; figures 1-3 *	1,6,9,10	B61D17/04 B62D31/02
Y	EP-A-0 345 962 (HITACHI LTD) 13 December 1989 * column 2, line 24 - column 4, line 15; figures 1-5 *	1,6,9,10	
A	EP-A-0 544 498 (HITACHI LTD) 2 June 1993 * column 6, line 41 - column 7, line 44; figures 1,2 *	1,5	
A	GB-A-720 177 (K. PRANGE) 15 December 1954 * page 2, line 81 - page 3, line 15; figures 9,10 *	1,6,9,10	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B61D B62D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 June 1995	Chlosta, P

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