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(71) Applicant: **Bombardier Transportation GmbH**
10785 Berlin (DE)

(72) Inventors:
- **Roe, M. Michael James**
  Weston on Trent
  Derby (GB)
- **Rhodes, Duncan**
  Breadsall
  DE 21 5LH (GB)
- **Mitchell, David**
  West Bridgford
  Nottingham NG2 5LE (GB)

(74) Representative: **Novagraaf IP**
122 rue Edouard Vaillant
92593 Levallois-Perret Cedex (FR)

(54) Rail vehicle car body and method of assembly

(57) A rail vehicle car body (10) includes two end modules (14), at least one of which is provided with a lateral access door (142), and a tubular module (18) extending from one of the two end modules to the other and mechanically fastened to the two end modules. The tubular module comprises a doorless shell made of aluminium alloy extruded longitudinal profiles extending from one of the two end modules to the other and longitudinally welded together. With such a structure, the interior outfit of the rail car can be installed through one of the open ends of the tubular module, after the longitudinal profiles of the shell have been welded together and painted. Similarly, refurbishment is simplified, since one of the end modules can be removed to give access to the interior of the tubular module.

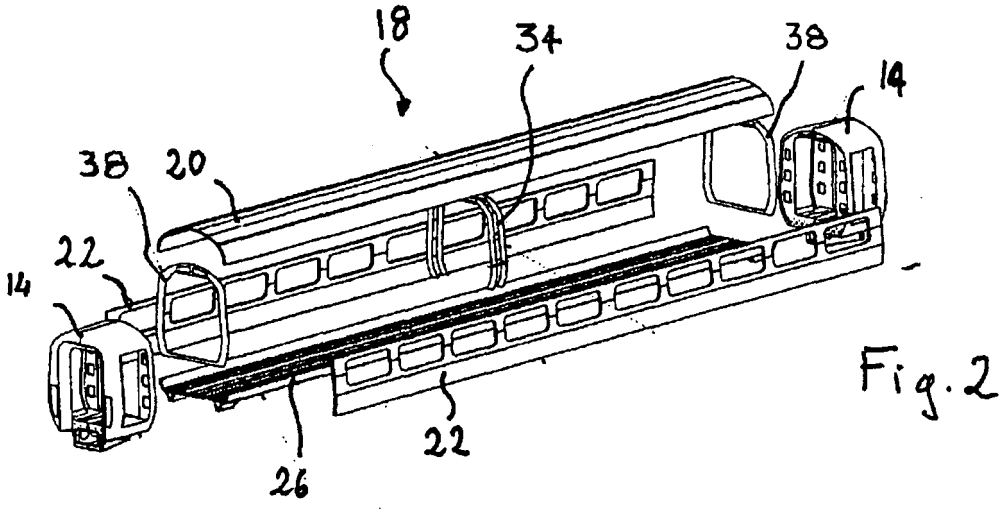

Fig. 2

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The invention relates to a method of assembly of a car body for a rail vehicle, and more particularly for an inter-regional or intercity train. It also relates to the resulting car body and a method of refurbishing such a car body.

BACKGROUND ART

[0002] A modular car body for a rail vehicle formed from a number of double-skin extruded panels extending along the length of the vehicle is known from EP 1 043 206. The extruded panels are welded edge to edge along all the length of the vehicle. Unlike riveting or bolting this method of assembly does not necessitate a substantial overlapping of the edge portions of the panels, which proves particularly beneficial in terms of weight. Practically, a gain of ca. 600 kg can be achieved for a conventional passenger carriage of 25500 mm.

[0003] When the assembly of the different constitutive parts of the car body shell involves welding operations, these welding operations have to be completed before painting of the inner part of the car body shell and/or the assembly of the inner outfit of the car body can start. When at least some of the panels which have to be welded extend the whole length of the vehicle, such as disclosed in EP 1 043 206, the welding operation impede the installation of the inner outfit as long as the whole car body shell has not been completed. With such a sequence of operations, the interior outfit of the rail car, which may include the ceiling, flooring, interior panels, cabling, lighting and insulation has to be inserted in the vehicle through the side doors of the car body.

[0004] In the case of a commuter train provided with wide door openings and large entry platforms regularly spaced at short intervals on each side of the car body, the installation of the interior outfit through the side openings does not present a difficulty.

[0005] In the case of inter-regional or intercity trains, however, the door openings are narrower and located at the ends of the rail car in order to minimise the entry space and to maximise the space allocated to the passenger area. Moreover, most elements of the interior outfit, notably the seats, are larger and heavier than for commuter trains. Thus, the installation of the interior outfit becomes particularly difficult and results in a considerable loss of time during assembly because of the limited space available through the side doors.

[0006] There is therefore a need for a more appropriate car body structure and method of assembly, which can simplify the installation of the interior outfit in a car body shell obtained by longitudinal welding of extruded aluminium panels.

SUMMARY OF THE INVENTION

[0007] The foregoing shortcomings of the prior art are addressed by the present invention. According to one aspect of the invention, there is provided method of assembling a rail vehicle car body of a given overall length, comprising:

- extruding a number of longitudinal aluminium alloy profiles;
- longitudinally welding together the longitudinal profiles to form a doorless tubular module with two open ends, at least some of the longitudinal profiles extending from one of the open ends of the tubular module to the other, the longitudinal distance between the open ends of the tubular module being greater than 75% of the overall length of the car body,
- inserting an interior outfit into the tubular module through at least one of the two open ends,
- manufacturing two end modules, at least one of which is provided with a lateral access door opening,
- mechanically fastening the two end modules to the open ends of the tubular module in a releasable manner, at least one of the end modules being fastened to the tubular module after the interior outfit has been inserted into the tubular module.

[0008] The terms "mechanically fastening" apply to different kinds of mechanical connection in which no substantial heating of the profiles takes place. The mechanical connection is "releasable" within the meaning of the present invention if assembly and removal of the end module can be carried out without substantial deformation of the aluminium alloy profiles.The end modules can preferably be bolted or riveted to the tubular module, welding being formally excluded since it involves substantial heating and does not provide a releasable mechanical connection.

[0009] Thanks to the sequence of assembly steps efficient assembly of the interior outfit can be ensured after completion of the welding operations and prior to the attachment of the end modules, through the large open ends of the tubular module.

[0010] Preferably, the method further comprises painting the tubular module after the longitudinal aluminium profiles have been welded together and before inserting the interior outfit.

[0011] The method may further comprise manufacturing two bolster subassemblies from steel, and bolting the bolster subassemblies to the tubular module.

[0012] The method may further comprise cutting window openings in the tubular module. Where a window opening interrupts a longitudinal welding line between two longitudinal profiles, the edge of the window opening

at the intersection with the welding line should preferably be perpendicular to the latter.

[0013] In the case of an intermediate car, the end modules are provided with a gangway opening.

[0014] According to a further aspect of the invention, there is provided a method of assembling a rail vehicle car body of a given overall length, comprising:

- extruding a number of longitudinal aluminium alloy profiles,
- longitudinally welding together the longitudinal profiles to form a doorless tubular module with two open ends, at least some of the longitudinal profiles extending from one of the open ends of the tubular module to the other, the longitudinal distance between the open ends of the tubular module being greater than 75% of the overall length of the car body,
- manufacturing two end modules, at least one of which is provided with a lateral access door opening, and
- mechanically fastening two each of the two end modules in a releasable manner to a respective one of the two longitudinal ends of the tubular module, at least one of the two end modules being provided with a lateral access door opening.

[0015] With such a structure, the interior outfit of the rail car, which may include the ceiling, flooring, interior panels, cabling, lighting and insulation, can be installed through one of the open ends of the tubular module after the longitudinal profiles have been welded together and painted. Similarly, refurbishment is simplified, since one of the end modules can be removed to give access to the interior of the tubular module.

[0016] The length of the tubular module is more than 75% of the total length of the car body, the remaining 25% being allocated to the two end modules. The aluminium alloy extruded longitudinal profiles preferably form two body side walls, a roof and a floor.

[0017] According to a preferred embodiment, the longitudinal profiles form double skinned walls, which provide mechanical strength to the shell.

[0018] The tubular module may further comprise two steel bolster subassemblies each mechanically attached to the tubular module towards a respective one of the two end modules and providing an interface for a bogie and a coupler. The bolster subassembly is preferably a welded and machined assembly, manufactured from steel and attached to the aluminium tube e.g. using bolts bolted into tapping bars inserted in a diaphragm welded to the car body extruded profiles. The material selection provides the necessary strength and stiffness with a minimised vertical cross section to ensure that the passenger area of the vehicle has as low a walking floor height as possible.

[0019] At least one of the end modules may comprise a steel sub-frame and an upper structure bolted to the steel sub-frame, the upper structure being manufactured from formed internal and external aluminium panels, which are welded together. The module may be provided with a communication gangway opening for accessing an adjacent rail car through a gangway attached to the upper structure. The sub-frame provides the necessary strength to react to coupler lateral damper loads and the overriding reaction forces from the coupler and anti-climbers.

[0020] Advantageously, at least one, and preferably each of the longitudinal ends of the tubular module comprises a strengthening annular diaphragm extending in a plane perpendicular to the longitudinal extruded profiles and welded to the extruded profiles extending from one of the two longitudinal ends of the tubular module to the other. Advantageously, each strengthening annular diaphragm can be provided with holes for receiving bolts for fastening the end modules to the tubular module.

[0021] According to a further aspect of the invention, there is provided a method of refurbishing a rail vehicle car body as disclosed hereinbefore, comprising:

- removing at least one end module from the tubular module, to give free access to at least one open end of the tubular module,
- removing the existing interior outfit from the tubular module through the at least one open end,
- installing a new interior outfit in the tubular module through the at least one open end,
- fastening the removed end module to close the open end.

[0022] The car body shell structure can also be adapted to a driving car, in which case one of the end modules is a driver's cab.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] Other advantages and features of the invention will become more clearly apparent from the following description of specific embodiments of the invention given as non-restrictive examples only and represented in the accompanying drawings in which:

- figure 1 is a side view of a car body of rail vehicle in accordance with the invention,
- figure 2 illustrates an exploded view of the car body of figure 1,
- figure 3 illustrates a cross-section of a tubular module of the car body of figure 1,

- figure 4 illustrates a bolster subassembly of the car body of figure 1,
- figure 5 illustrates an end module of the car body of figure 1,
- figure 6 illustrates a subframe of the end module of figure 5,
- figure 7 illustrates the underside of the vehicle of figure 1,
- figure 8 illustrates the interior layout of the car body of figure 1, and
- figure 9 illustrates a detail of a second embodiment of the invention;

DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS

[0024] Referring to figure 1, the car body 10 of passenger rail vehicle 12 consists of two end modules 14 and one tubular module 18 extending from one of the two end modules to the other. As illustrated, the tubular module 18 constitutes the major part of the car body 1. Its length amounts to more than 75%, and preferably more than 85% of the overall length of the car body. For a typical car body length of 25,500 mm, the length of the tubular module is preferably more than 19,125 mm and, in the specific example of figure 1, equal to 22,350 mm.

[0025] As illustrated in figure 2, the tubular module 18 comprises a roof 20, left and right doorless side walls 22 and a floor 26. These panels extend from one of the two end modules to the other and are longitudinally welded together, i.e. in a direction parallel to the longitudinal axis of the tubular module.

[0026] More specifically, and as illustrated in figure 3, each of the roof, floor and side walls is composed of a plurality of extruded profiles cut to the appropriate length, which are welded along their length and machined as far as necessary. In this particular embodiment, the roof 20 includes a roof plank 201 flanked by two cant rails 202, 203. The roof plank 201 and cant rails 202, 203 are longitudinally welded together to form the roof before they are assembled to the side walls 22. Similarly, each side wall 22 includes an upper body side 221, a centre body side 222 and a lower body side 223, which are welded together along their length before the side wall 22 itself is welded to the roof 20 and floor 26. In case a side wall 22 requires window and/or other openings, the cutting out and/or other machining operations are carried out before welding the side wall 22 to the roof 20 and floor 26. The floor 26 includes a planar wall section made of a centre floor plank 261, flanked by two inner floor planks 262 and two outer floor planks 263. The plan wall section itself is flanked by two sole bars 264. These extruded elements are longitudinally welded together and machined before the floor is welded to the side walls 22. One or more jigs (not shown) may be used to temporally maintain the extruded elements in position during welding.

[0027] While some of the extruded profiles may be interrupted to accommodate window openings or roof recesses for electrical equipment, at least some of the extruded profiles, and singularly the cant rails 202, upper body sides 221, lower body sides 223, sole bars 264 and outer floor planks 263 located at the upper and lower edges of the car body shell as well as the centre and inner floor planks 261, 262 extend from one end of the tubular module to the other and are welded to one another along the full length of the tubular module without interruption.

[0028] As can be seen on figure 3, the cant rails 202 are thicker than the roof plank. 201, to provide additional rigidity to the corners of the shell structure cross-section. The floor planks 261, 262, 263, sole bars 264, body sides 221, 222, 223, roof planks 201 and cant rails 202 are all double skinned extrusion profiles to ensure a lightweight self-supporting tube design whilst meeting all necessary strength and stiffness requirements. Additional stiffness is provided at the edges of the car body shell by the sole bar 264 and cant rail 202 extrusion elements, which are larger in section than the other extrusion elements.

[0029] All the extruded elements are pre-drilled so that no machining is required during the final assembly of the car body. C-shaped slots 30, 32 are provided on the bottom of the sole bar and other floor-related extrusion elements for mounting underfloor equipment and inside de car body, protruding from the floor planks, body sides and/or roof planks for the mounting of seats, interior installation and trim, providing a high degree of flexibility in the interior layout.

[0030] One or more structural ring-shaped diaphragms 34 can be welded or otherwise secured at the centre and/or at intermediate positions of the tubular module 18 to increase body shell stiffness and to provide a channel for air ducts between the floor and roof space. Similarly, two annular end diaphragms 38 are welded at the ends of the tubular structure to reinforce the stiffness of the tubular structure and reduce the major modes of vibration of the tubular module. The two annular end diaphragms are also provided with holes in and constitute an attachment interface for each of the end modules.

[0031] A steel bolster subassembly 40 is attached underneath the tubular module 18 to an underside of the floor 26 and comprises a bolster 42 providing an interface for the bogie 44, a crossmember 46 projecting towards the adjacent end of the tubular module and a pair of girders 47 extending from the crossmember to the bolster and the coupler. As illustrated in figure 4, the bolster subassembly 40 is a rigid welded and machined assembly, manufactured from steel. This subassembly is attached to the underside of the floor using bolts and tapping bars inserted in the car body extrusion elements. The number of bolts is adapted to the longitudinal shear loads and

vertical loads applied to the subassembly in several scenarios, including collision. The material selection provides the necessary strength and stiffness with a minimised vertical cross-section to ensure that the passenger area of the vehicle has as low a walking floor height as possible.

[0032] Referring to figures 5 to 7, each end module 14 includes an upper structure 140 manufactured from formed internal and external aluminium panels and/or extruded elements, which are welded together to create a stiff, lightweight design. This upper structure 140 includes a roof 140A, side walls 140B provided with passenger door openings 142 and end wall 140C provided with a gangway opening 143, a floor 140D as well as an annular diaphragm 138 extending in a vertical transverse plane to provide rigidity and form an interface with the tubular module. The aluminium upper structure is bolted to a steel sub-frame 144. As illustrated in figure 5, energy absorbing anti-climbers 145 are mounted at floor level at the ends of the sub-frame for absorbing the crash energy associated with the collision scenarios detailed in the High Speed TSI revision. They are specified to work in conjunction with the energy absorbing intermediate coupler system. Since the end module houses the passenger doors, it is not designed to deform during the specified collision scenarios, in order to preserve the doors as a means of emergency exit. Therefore, the sub-frame includes a square-shaped non-deformable open box structure with an inner transverse sill 146, an outer transverse sill 147 connected by a series of longitudinal sills 148, and a series of additional elements 149 which provide an interface for fixing the sub-frame 144 to the upper structure 140. The inner transverse sill 146 of this structure also provides an attachment interface extending in a vertical plane and bolted to the crossmember 46 at the end of the bolster subassembly 40 when the end module is mechanically fastened to the tubular module. The coupler 60 shown in figure 6 has an inner end 62 directly connected to the crossmember 46 of the bolster subassembly or to the transverse sill 146 and a coupling end 64 protruding from the sub-frame through a window 150 formed in the transverse sill 147, which provides lateral and vertical abutments to the coupler. The coupler is provided with a telescopic shock absorbing structure 66 as is well known in the art. The sub-frame 144 provides the necessary strength to react to coupler lateral damper loads and to the overriding reaction forces from the coupler, while the longitudinal loads are directly transmitted to the crossmember 46 of the bolster subassembly 40 or to the transverse sill 146. Thus, loads applied during collision are distributed between the transverse sill 147, the sub-frame 144 and the bolster subassembly 140.

[0033] The interior outfit of the end module 140 can be manufactured after the end module has been bolted to the tubular module. In a preferred embodiment of the invention, however, the end modules are painted, completely equipped with interior outfit and technical equipment like door systems, lighting, control equipment, passenger information modules, etc. and pre-tested before being bolted to the tubular end module

[0034] The interior layout of the car body is shown in figure 8. The interior outfit 50 including ceiling, flooring, interior panels, air ducts, cabling, lighting, seats 52, passenger information and entertainment modules, tables, 54, toilets 56 and insulation is installed in the tubular module 18 from one open end of the module after completion of the welding operations including the welding of the end diaphragms 38 and after the shell of the tubular module has been painted. Finally, the end modules 14 are positioned so that bolts can be inserted through the holes of the inner transverse sill 146 and crossmember 46 and through the holes of the end diaphragms 38 and of the diaphragm 138 of the end modules to mechanically attach the end modules to the tubular modules in a releasable manner. Additionally, an adhesive substance can be used for attaching the upper structure 140 of the end module to the end diaphragm 38. Refurbishment of the car can also be efficiently carried out from the open ends of the tubular modules after removal of one of the end modules.

[0035] While a preferred embodiment of the invention has been described, it is to be understood by those skilled in the art that the invention is naturally not limited to this embodiment. Many variations are possible.

[0036] Additional strengthening extrusions may be provided at the sole bar and cant rail to strengthen the structure to react crash loads associated with the High Speed TSI revision collision scenarios.

[0037] Similarly, an additional U-shaped or ring-shaped diaphragm 238, illustrated in figure 9, can be sandwiched between the end diaphragms 38 of the tubular module 18 and the diaphragm 138 of the respective end module 14 to further reinforce the structure of the car body.

[0038] The car body shell structure can also be adapted to a driving car, in which case one of the end modules is a driver's cab.

Claims

1. A method of assembling a rail vehicle car body of a given overall length, comprising:

   - extruding a number of longitudinal aluminium alloy profiles (201, 202,203,204,221,222,223, 261,262,263);
   - longitudinally welding together the longitudinal profiles to form a doorless tubular module (18) with two open ends, at least some of the longitudinal profiles extending from one of the open ends of the tubular module to the other, the longitudinal distance between the open ends of the tubular module being greater than 75% of the overall length of the car body,
   - inserting an interior outfit into the tubular mod-

ule through at least one of the two open ends,
- manufacturing two end modules (14), at least one of which is provided with a lateral access door opening (142),
- mechanically fastening the two end modules to the open ends of the tubular module in a releasable manner, at least one of the end modules being fastened to the tubular module after the interior outfit has been inserted into the tubular module.

2. The method of claim 1, further comprising:

- painting the tubular module after the longitudinal profiles have been welded together and before inserting the interior outfit.

3. The method of claim 1 or claim 2, further comprising:

- manufacturing two bolster subassemblies from steel,
- bolting the bolster subassemblies to the tubular module.

4. The method of any one of claims 1 to 3, further comprising:

- positioning a strengthening annular diaphragm at each of the longitudinal ends of the tubular module in a plane perpendicular to the longitudinal extruded profiles, and
- welding each strengthening annular diaphragm to the extruded profiles extending from one of the two longitudinal ends of the tubular module.

5. The method of claim 4, comprising bolting the two end modules to the strengthening annular diaphragm of the tubular module in a releasable manner.

6. The method of any one of claims 1 to 5, further comprising:

- cutting window openings in the tubular module.

7. The method of any one of claims 1 to 6, further comprising:

- providing a gangway opening in each of the end modules.

8. A rail vehicle car body (10) of a given overall length, comprising:

- a doorless tubular module (18) having two longitudinal ends and comprising aluminium alloy extruded longitudinal profiles longitudinally welded together (201, 202, 203, 204, 221, 222, 223, 261, 262, 263) at least some of the longitudinal profiles extending from one of the two longitudinal ends of the tubular module to the other, the tubular module further comprising an interior outfit, the longitudinal distance between the ends of the tubular module being greater than 75% of the overall length of the car body, and
- two end modules (14) each mechanically fastened in a releasable manner to a respective one of the two longitudinal ends of the tubular module, at least one of the two end modules being provided with a lateral access door opening (142).

9. The rail vehicle car body of claim 8, wherein the longitudinal extruded profiles form double skinned walls.

10. The rail vehicle car body of claim 8 or claim 9, wherein the tubular module further comprises two steel bolster subassemblies (40) each mechanically attached to the tubular module towards a respective one of the two end modules and providing an interface for a bogie and a coupler.

11. The rail vehicle car body of any one claims 8 to 10, wherein at least one of the end modules comprises a steel sub-frame (144) and an upper structure (140) bolted to the steel sub-frame, the upper structure being manufactured from formed internal and external aluminium panels, which are welded together.

12. The rail vehicle car body of any one of claims 8 to 11, wherein each of the longitudinal ends of the tubular module comprises a strengthening annular diaphragm (38) extending in a plane perpendicular to the longitudinal extruded profiles and welded to the extruded profiles extending from one of the two longitudinal ends of the tubular module to the other.

13. The rail vehicle of car body of claim 12, wherein each strengthening annular diaphragm is provided with holes for receiving bolts for fastening the end modules to the tubular module.

14. A method of refurbishing a rail vehicle car body as claimed in any one of claims 8 to 13, comprising:

- removing at least one end module (14) from the tubular module (18), to give free access to at least one open end of the tubular module,
- removing the existing interior outfit from the tubular module through the at least one open end,
- installing a new interior outfit in the tubular module through the at least one open end,

- fastening the removed end module to close the open end.

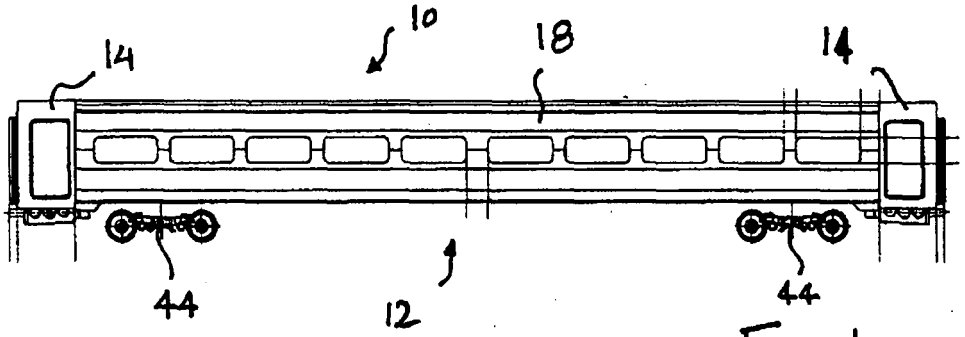

Fig.1

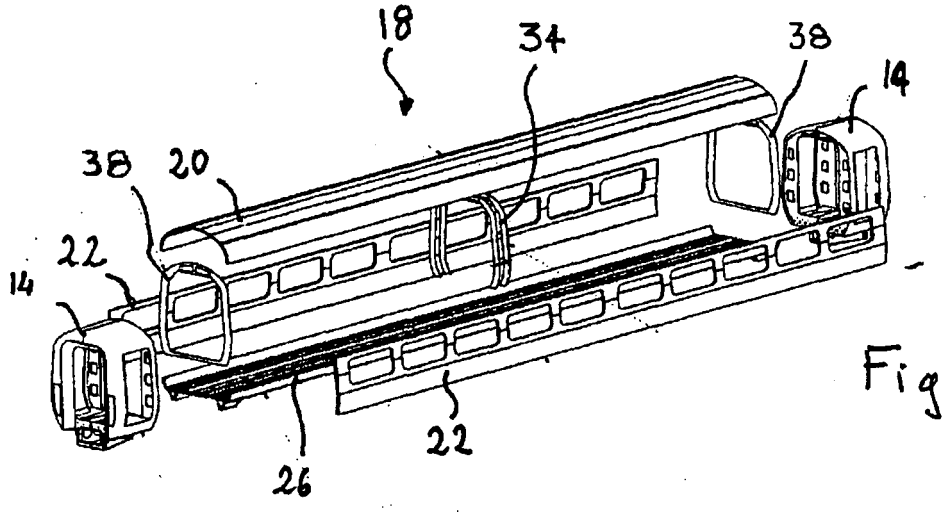

Fig.2

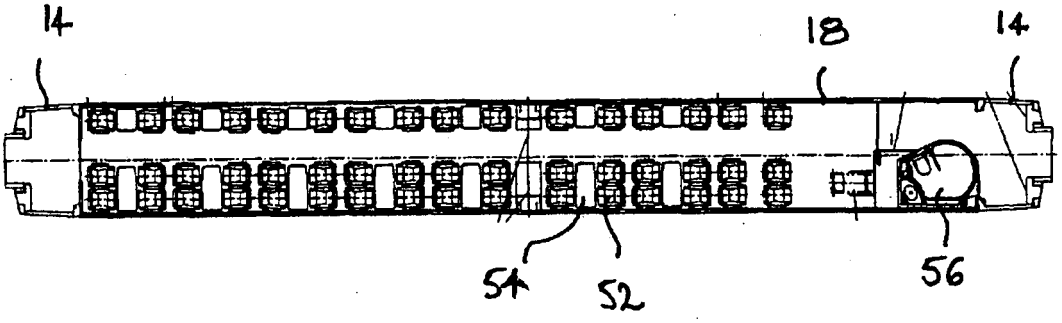

Fig.8

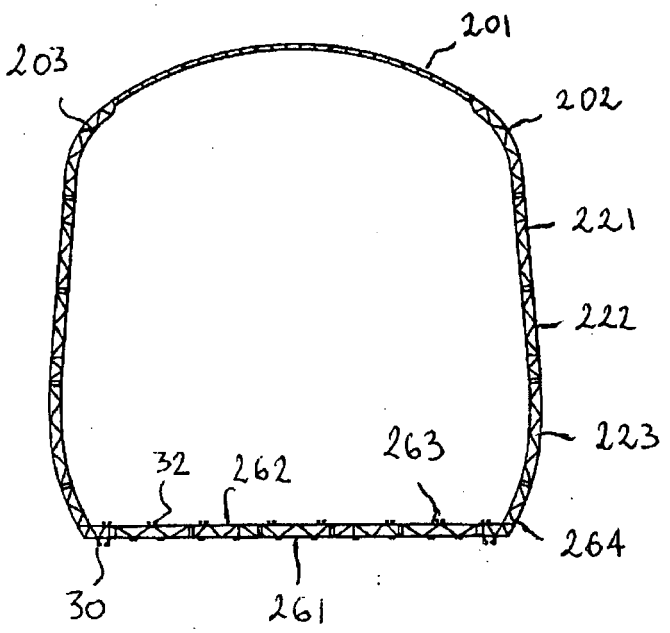

Fig. 3

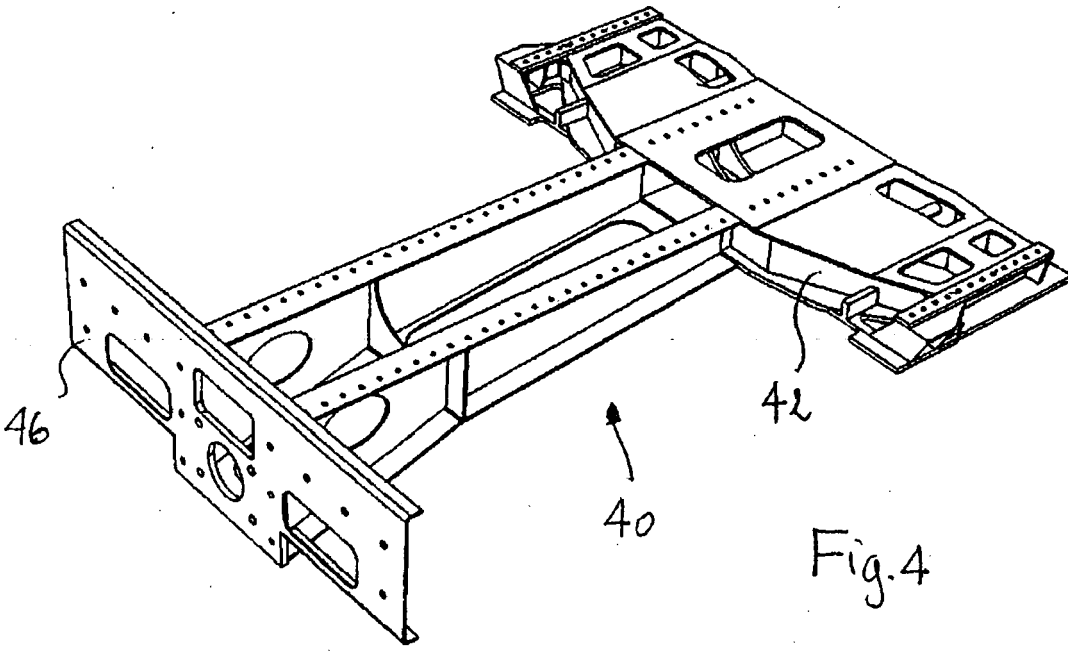

Fig. 4

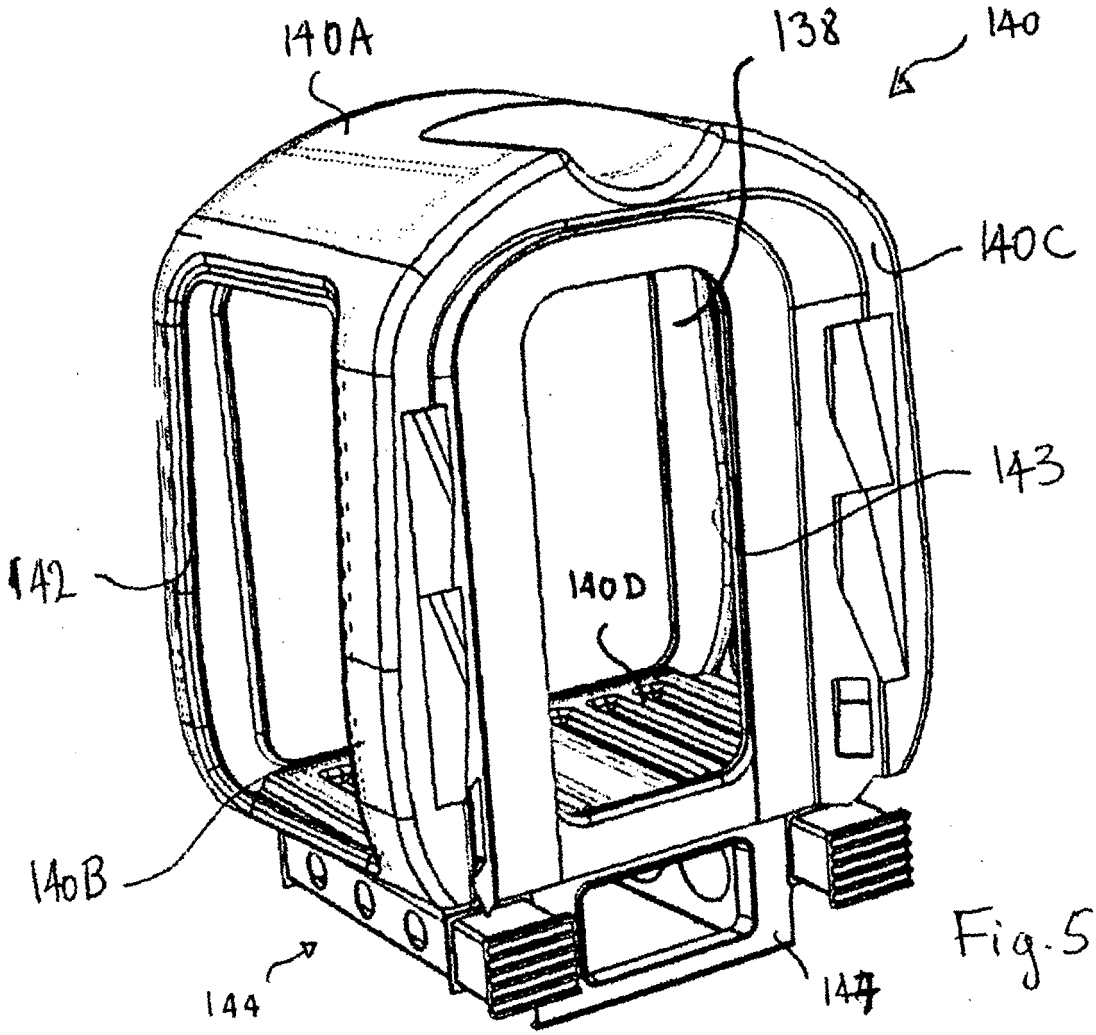
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Fig.5

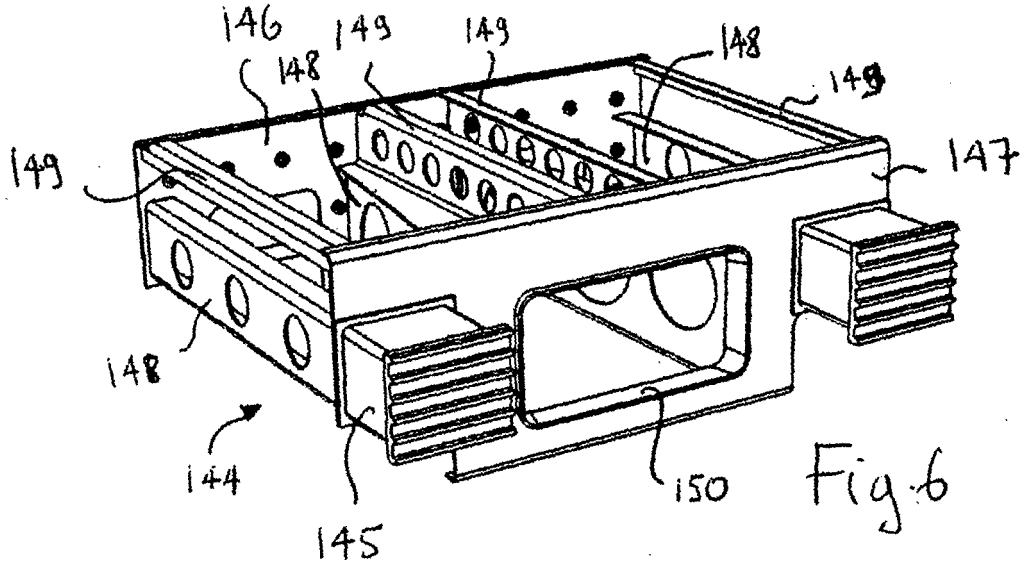
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Fig.6

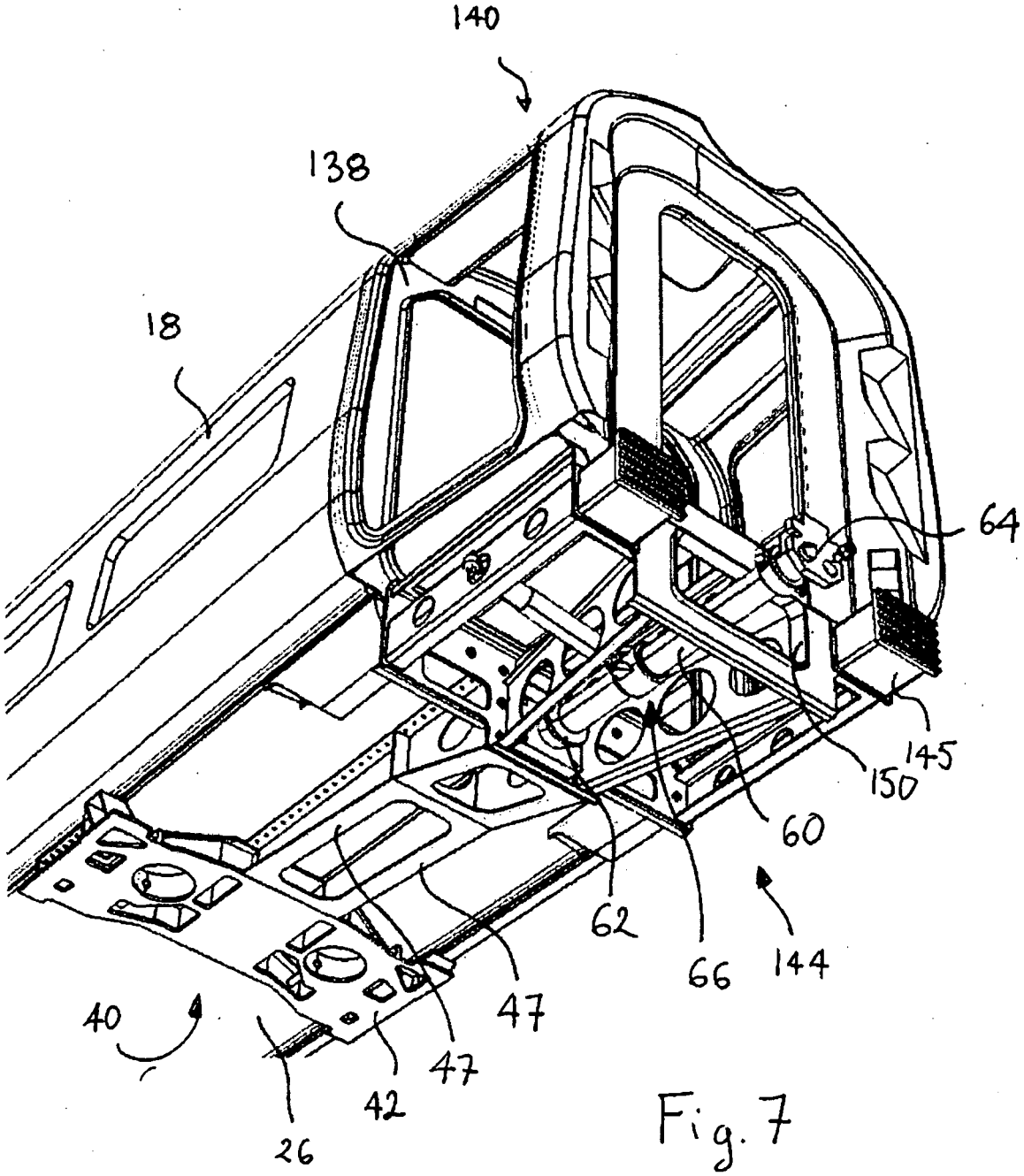

Fig. 7

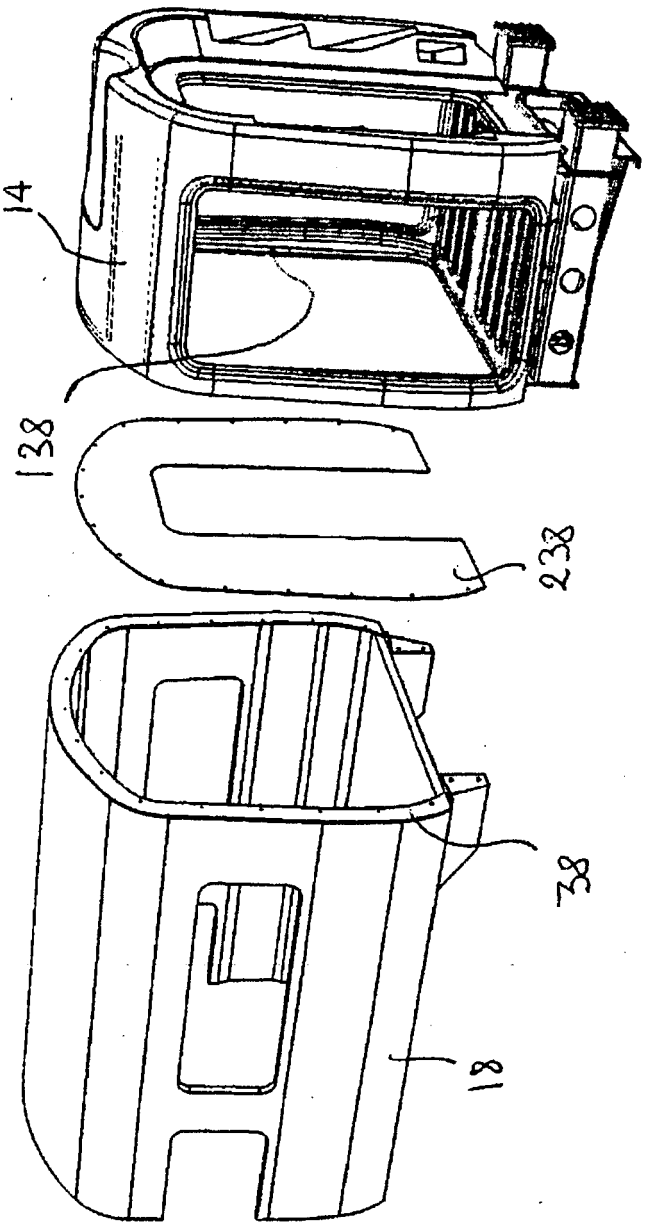

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 08 01 0337

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	EP 0 836 976 A (ABB DAIMLER BENZ TRANSP [DE]) 22 April 1998 (1998-04-22) * column 3, line 9 - column 7, line 51 * * figures 1-14 *	1-14	INV. B61D17/04
Y	EP 1 043 206 A (BISIACH & CARRU [IT]) 11 October 2000 (2000-10-11) * paragraph [0019] - paragraph [0032] * * claims 1-8 *	1-14	
A	EP 0 785 121 A (HITACHI LTD [JP]) 23 July 1997 (1997-07-23) * abstract *	1-14	
A	EP 0 624 501 A (INVENTIO AG [CH]) 17 November 1994 (1994-11-17) * column 2, line 35 - column 6, line 2 * * figures 1-7 *	1-14	
A	DE 10 2006 043925 A1 (VOITH TURBO LOKOMOTIVTECHNIK G [DE]) 27 March 2008 (2008-03-27) * abstract; figures 1-3 *	1-14	TECHNICAL FIELDS SEARCHED (IPC) B61D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 November 2008	Awad, Philippe

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 01 0337

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Patent documents cited in the description

- EP 1043206 A **[0002] [0003]**