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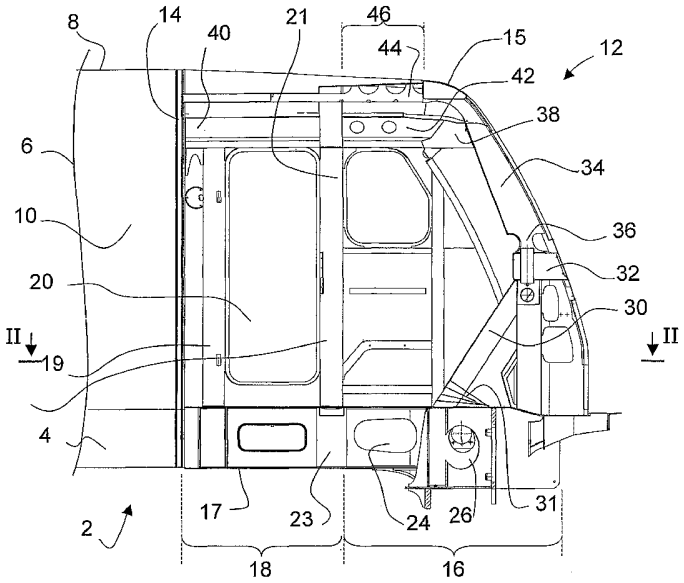
(54) Title: RAILWAY VEHICLE WITH A DEFORMABLE DRIVER'S CAB WITH DEDICATED REPAIR INTERFACE



(57) Abstract: A railway vehicle (2) defining a longitudinal direction and comprising: -a central section (10); - a vehicle cabin (12) that is shorter than the central section, the vehicle cabin (12) comprising a collapsible front section (16) that undergoes controlled collapse in case of collision; and at least one rigid section (18) located between the front section (16) and the central section (10), the front section (16) having a lower resistance to deformation than the rigid section (18); at least one dedicated repair interface (14) for removably fixing the vehicle cabin (12) to the central section (10).

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RAILWAY VEHICLE WITH A DEFORMABLE DRIVER'S CAB WITH DEDICATED REPAIR INTERFACE

The present invention relates to a railway vehicle with a deformable driver's cabin.

The Annex A of the Technical Specification for Interoperability (TSI) published in the Official Journal of the European Communities dated 12.9.2002, page 403 onwards, specifies three different collision scenarios (Scenario 1: Collision between two identical high speed trainsets at a relative speed of 36 km/h; Scenario 2: Collision between a high-speed trainset and a railway vehicle equipped with side buffers at a speed of 36 km/h, wherein the railway vehicle is a four-axle freight wagon UIC 571-2 with an 80 tonne mass; Scenario 3: Collision at a speed of 110 km/h at a level crossing with a 15 tonne lorry represented by a rigid mass presenting a vertical surface for impact). Whereas for scenarios TSI-2 and TSI-3 partial deformation of the front part of the driver's cab is deemed acceptable if a 750mm survival zone remains intact at the back of the driver's cab, no significant spatial deformation of the vehicle structure is supposed to occur in scenario TSI-1. This necessitates improving the energy absorption capability of vehicle structures, i.e. shortening the vehicle structure whilst retaining a specific longitudinal force.

For the absorption of the resulting collision energy, multistage solutions are commonly used, which provide for deformation to progress from front to back.

As a rule, non-structural deformation elements, i.e. elements that do not support parts of the body of the vehicle, such as a collapsible coupling and/or collapsible buffers at the front of the vehicle including energy absorber allowing dynamic plastic deformation are used as a first stage of these solutions, which guarantee, after accidents between similar vehicles (with buffing gear) involving relatively minor collision forces, easy exchangeability, low repair costs and short down-times.

Beyond that, there has so far been no demand for effective maintenance, the main objective being the control of energy absorption and passenger safety.

The damage inflicted on the vehicle and the zones where damage occurs have not been taken into account. In some designs, the deformation zones described are arranged in their entirety in front of a relatively rigid, non-deformable driver's cab. In others, parts of the driver's cab are made deformable and also used for energy absorption. The first solution accepts that, when the frontal deformation elements are spent, there may be immediate and heavy structural damage to the driver's cab and engine room, which cannot normally be repaired in a cost-effective way. The second solution allows higher energy absorption in a limited structural space, but still bears the risk of the deformation force then progressing to the next structural zones, i.e. the driver's cab and/or engine room. This too would normally prevent repairs from being cost-effective.

An example of such a vehicle is found in EP0888946B1. The railway vehicle described therein has a main vehicle body, including a central section for accommodating passengers, and a steel end frame which is bolted onto the front end of the central section. A prefabricated driver's cab having quick-release connections for the controls and circuits by a vehicle interface is fitted within the steel end frame. The frame includes impact-absorbing elements, such as buffers and couplings, installed to the front of the frame and railway vehicle. The steel end frame is enclosed by a removable fairing that is flush-fitting to the central section. However, the steel end frame is rigid and not designed for a controllable collapse in the case of a collision where the impact-absorbing elements are spent or fully collapsed. In particular, if the longitudinal beams of the frame start to bend in response to the front impact, high uncontrolled bending loads will be transmitted to the repair interface. The excess impact energy would not be able to be absorbed by the steel end frame increasing the risk that the impact energy is transferred to the central section. This will increase the likelihood of local overloads and cracking of the driver's cab and/or central section resulting in a catastrophic structural collapse. Further, in such an impact the vehicle interface would most likely be damaged, which would prevent the driver's cab and/or parts of the driver's cab, such as control panels, from being replaced successfully without also replacing the vehicle interface and, most likely, in

worse scenarios having the inability to salvage the remaining damaged portions of the central section.

It would be desirable to have solutions allowing control and limitation of deformation, and structurally providing pre-defined repair interfaces, that also apply to the above incidents. In that case it would be possible, even after heavy collisions, to repair the damaged vehicles at relatively low cost and expenditure of time.

Accordingly, there is a need for a removable deformable vehicle cabin for a railway vehicle, whereby the vehicle cabin absorbs the energy of an impact with an obstacle by the controlled collapse of the vehicle cabin, thus protecting the central section whereby the railway vehicle can be repaired for re-use.

According to the invention there is provided a railway vehicle defining a longitudinal direction and comprising:

- a central section ;
- a vehicle cabin that is shorter than the central section, the vehicle cabin comprising a collapsible front section that undergoes controlled collapse in case of collision; and at least one rigid section located between the front section and the central section, the front section having a lower resistance to deformation than the rigid section ;
- at least one dedicated repair interface for removably fixing the vehicle cabin to the central section.

The dedicated repair interface can be used in the support and replacement of a vehicle cabin that absorbs the impact of a collision by controlled deformation while still retaining the intact central section of the railway vehicle. The dedicated repair interface can also be used to complete the manufacture of a railway vehicle, such as for the placement and alignment of the vehicle cabin and associated parts, and for the

repair, or upgrade of a railway vehicle thus reducing among other costs, but not limited to, maintenance and/or fleet operating costs.

Preferably the dedicated repair interface lies in a vertical plane perpendicular to the longitudinal direction. It is advantageous to position the dedicated repair interface in a plane perpendicular to the longitudinal axis since it ensures a reduced longitudinal stress is placed on the dedicated repair interface. However, the repair interface can also be inclined or graded.

Preferably the repair interface comprises a thick sheet metal plate extending in the plane perpendicular to the longitudinal direction. This sheet metal plate may extend over the whole cross-section of the vehicle body, with or without an opening for allowing access from the vehicle cabin to the central section.

Preferably the rigid section comprises a reinforced ring structure extending in a plane perpendicular to the longitudinal direction. The reinforced ring is preferably located at a distance in front of the interface plane and rigidly connected via rigid longitudinal frame members to rear rigid frame members extending in a further vertical transverse plane located between the ring and the dedicated repair interface. Preferably, the rear rigid frame members are rigidly affixed to the dedicated repair interface.

Preferably, the rigid section is such as not to deform in the event of a front collision between of the railway vehicle with a four-axle freight wagon UIC 571-2 with an 80 tonne mass equipped with side buffers at a speed of 36 km/h, and/or in the event of a collision of the railway vehicle at a speed of 110 km/h at a level crossing with a 15 tonne lorry represented by a rigid mass presenting a vertical surface for impact.

Preferably the vehicle cabin further comprises a driver's instrument panel located in the front section for driving the railway vehicle, and/or a survival space located in the rigid section or directly behind the dedicated repair interface. It is further

advantageous for the vehicle cabin to have a survival space enhancing the safety for the occupants in an impact to the front section. Such a survival space would be made of stiff rigid material to protect the occupants from the obstacle, vehicle parts, and/or debris of a collision.

According to another aspect of the invention, there is provided a method for modifying a railway vehicle comprising installing the vehicle cabin and dedicated repair interface of any of the variations described herein.

The advantage of installing the replaceable vehicle cabin and the dedicated repair interface in a railway vehicle is that railway vehicles and their main bodies, or central sections, therein would benefit from both the controlled deformability of the vehicle cabin and the ability to replace deformed portions of the vehicle cabin while re-using or salvaging the remaining central section of the railway vehicle. There are numerous methods for installing at least one dedicated interface and vehicle cabin to a railway vehicle. For example, at the time of manufacture variations of the dedicated repair interface and vehicle cabin, as described herein, may be installed in railway vehicle. Alternatively, an existing railway vehicle may be retrofitted with the aforementioned components providing a cost effective solution for current fleet operators.

Other advantages and features of the invention will become more apparent from the following description of a specific embodiment of the invention given as non-restrictive example only having reference to the accompanying drawings, in which :-

- Figure 1a provides a longitudinal sectional view of a railway vehicle of the present invention; and

- Figure 1b is a partial vertical longitudinal section along line II-II of figure 1a.

Referring to figure 1a and 1b, these figures show a railway vehicle indicated as 2. The railway vehicle comprises a vehicle cabin 12 that is attached to a central section 10 by means of a dedicated repair interface 14.

The railway vehicle 2 of figures 1a and 1b includes a chassis or vehicle base 4 supported on one or more bogies (not shown). The vehicle base 4 supports a body structure including main walls 6 extending upwards towards the roof 8, (only one wall is shown in the longitudinal section of figure 1a), wherein the walls 6, the roof 8 and the vehicle base 4 are referred to as the central section 10 defining a longitudinal direction. Included in the central section 10 is at least one central interface 13, which is connected, in a plane substantially perpendicular to the longitudinal direction, to the outer perimeter of at least one end of the framework of the body structure and vehicle base 4. The central interface 13 provides a mounting platform for mounting and supporting the dedicated repair interface 14, as well as, providing an interface for electrical and mechanical connections that can be connected for the control of the railway vehicle 2.

The dedicated repair interface 14 comprises a thick sheet metal plate that extends throughout the vertical cross-section of the vehicle and is provided with a central opening to allow passage between the vehicle cabin and the central section of the vehicle.The dedicated repair interface 14 can include conduits for electrical and mechanical connections for the required equipment that can be used to operate the railway vehicle 2. The sheet metal plate welded to the frame structure of the central section. It provides high dimensional stability and accuracy so that, at the manufacturing stage, it can act as an integrated production device, and as a dimensional reference during repairs. The sheet metal plate is connected to the frame of the vehicle cabin via permanent (e.g. a welded) or detachable (e.g. a riveted or screwed) connections.

The vehicle cabin 12 includes a rigid section 18 and a front section 16. The vehicle cabin 12 is supported by a cabin base 15 (some of which may not be shown) and a cabin roof 17 is supported by the rigid section 18 and front section 16.

The rigid section 18 is positioned between the repair interface 14 and the front section 16 and comprises a bracing ring that extends perpendicular to the longitudinal axis. The cross-sectional bracing ring has to be resistant to bending and torsion, and is advantageously formed of structural tubing. On each lateral side of the vehicle, this ring also forms the front doorpost of a lateral exit 20 that can be used both for entering the cabin and as escape exit. The rear doorposts 21 are formed by a reinforced frame member welded or otherwise rigidly connected to the repair interface 14. The rear doorposts are rigidly connected to the ring via a rigid part of a longitudinal girder 23 of the vehicle base and an upper frame member 40. This connection is also reinforced by a central girder (not shown) extending in the longitudinal centre plane of the vehicle. A survival space is located within the rigid section 18, so that in the event of an emergency, the driver can flee from the front section 16 where the instrument panel and the driver's seat are located and shelter in the survival space.

The front section 16 comprises at least one deformable region that has a lower resistance to deformation compared to the rigid section 18. The front section 16 comprises load-bearing frame members 23, 26, 30, 32, 34 and 44. These frame members can be made of, among other materials but not limited to, steel, mild steels, fibreglass, aluminium, carbon fibre, laminates thereof, or any other such material, subassembly or component that is suitable for the purpose of the front section 16. To minimise the bending torque transmitted to the ring 19 and to the interface, the load-bearing frame members 23, 26, 30, 32, 34, and 44 have a predetermined limitation of their bending strength.

The girder 23 extends longitudinally towards the front of the front section 16and includes at least one oblong section 24 removed, which defines a base deformable region 24. The base deformable region 24 provides energy absorption through longitudinal crumpling and/or buckling.

Connected to the front end of the shock absorbing girder 23, and adjacent to the base deformable region 24, is a headstock frame member 26. The headstock frame member 26, extends a distance between the sides of the vehicle cabin 12, and supports the front portion of the front section 16. Further supported on the headstock frame member 26 can be sub-assemblies including, but not limited to, buffers, couplings, cowcatchers, bull-bars, anti-climbing devices or further non structural energy absorbing elements that do not support parts of the body of the vehicle and allow energy absorption via dynamic plastic deformation.

On top of, and/or adjacent, to the headstock frame member 26 is connected at least one lower frame member 30 which inclines at an angle towards the front of the vehicle cabin 12, wherein the top of the lower frame member 30 is centrally disposed at a distance between the cabin base 15 and cabin roof 17 of the vehicle cabin 12. The lower frame member 30 can redirect impact energy that can impinge on the top of the lower frame member 30, towards the shock absorbing girder 23 and into the base deformable region via the headstock frame member 26.

A lower deformable region 31 is positioned at the base of the lower frame member 30. The lower deformable region 31 can provide energy absorption by compressions or crumpling and/or act as a hinge for bending or buckling due to a collision with an obstacle. The lower deformable region 31 promotes deformation of the lower frame member 30 in a direction towards the interior of the vehicle cabin 12.

Connected adjacent to the top of the lower frame member 30 is a central frame member 32, which extends in the transverse dimension between the sides of the vehicle cabin 12. Further, adjoining the top of the lower frame member 30 is at least one upper frame member 34. Substantially near the adjoining region of the upper frame member 34 and the lower frame member 30 is a central deformable region 36. In this instance, the central deformable region 36 is positioned above the connection of the central frame member 32 and the lower frame member 30.

The positioning of the central frame member 32 and the lower frame member 30 aids the deformation and deflection of the central deformable region 36, in the event of a collision, towards the interior of the vehicle cabin 12. As can be seen in figure 1a, the

central deformable region 36 is made of two essentially opposing non-intersecting semi-circular removed sections, this gives the property of rotational deformation to the lower and upper frame members 30 and 34. The upper frame member 34 may be composed of a material with a high stiffness, this prevents an obstacle from fully penetrating the vehicle cabin 12 in a collision.

At least one upper deformable region 38 is located either adjacent to the top of the upper frame member 38, or within the top of the upper frame member 38. Adjacently connected to either the upper frame member 34, or the upper weak region 38 is at least one first roof frame member 40. At least one first roof deformable region 42 is located near the end of the first roof frame member 40 that is adjacent to the upper frame member 34 or the upper deformable region 38. The first roof frame member 40 extends towards the rear of the vehicle cabin 12 above the rigid section 18 ending at the dedicated vehicle interface 14. Adjacent and above the first roof frame member 40 is a second roof frame member 44 with at least one second roof deformable region 46 disposed within it. The second roof deformable region 46 is adjacent to the first roof deformable region 42.

The first roof deformable region 40 includes at least two longitudinally spaced holes, which act, as a hinge, to provide energy absorption by rotation through an axis of rotation located between the two holes. Further the holes can act as a longitudinal energy absorption mechanism, in the form of a crumpling or buckling effect. The second roof deformable region 46 comprises semi-circular corrugations within the top and lower edges of the second roof frame member 44. The second roof deformable region 46 performs energy absorption by longitudinal crumpling or buckling to further minimise the transmission of impact energy to the rear of the vehicle cabin 12.

In the event of an impact by an obstacle to the front of the vehicle cabin 12 of the railway vehicle 2 given in figure 1a the front section 16 will controllably collapse to absorb the kinetic energy of the impact. In a medium frontal collision with a flat faced obstacle the lower, central, upper deformable regions, respectively 31, 36, 38 do not fully deform since the obstacle is flat-faced and does not penetrate into the vehicle cabin 12. The base, roof and second roof deformable regions, respectively 24, 42, and 46 will absorb the kinetic energy of the impact generally in the longitudinal direction by crumpling or buckling in the longitudinal direction.

In a collision with a contoured obstacle that impacts at a height that is centrally between the cabin base 15 and cabin roof 17 the deformable regions 31, 36, 38 24, 42, and 46 co-operate to adapt to the contours of the obstacle and absorb the kinetic energy of the impact. The base and roof frame members 23, 40, and 44 typically undergo a rotational and/or bending deformation, such that the members rotate inwards to the vehicle cabin 12 about the deformable regions 24, 42 and 46. Simultaneously, as the obstacle impacts centrally, most likely, against the upper frame member 34 the central deformable region 36 then deflects and undergoes a rotational and/or bending deformation about the central deformable region 36. The obstacle pushes the central deformable region 36 further into the vehicle cabin 12. However, the upper frame members 34 prevent the obstacle from actually penetrating and/or puncturing the vehicle cabin 12. This is where the full surface area of the vehicle cabin 12 begins to dramatically absorb the kinetic energy of the impact, eventually stopping the forward momentum of the obstacle.

Simultaneously, the lower, upper, first and second roof, and base deformable regions, 31, 38, 42, 46 and 24 respectively, undergo further rotational deformation absorbing the energy of impact as much as possible. The remaining impact energy is also transferred by compressing the lower and upper deformable regions 31 and 38 towards the base and roof frame members 23 and 40, 44. This remaining impact energy is absorbed within the base and roof deformable regions 24, 42 and 46 by a

longitudinal compression of these deformable regions. The kinetic energy of the impact is effectively transferred away from the occupants of the vehicle cabin 12.

The front section 16 will adapt to the shape of the obstacle and absorb as much kinetic energy as possible by the deformation of the central deformable region 36 and the other deformable regions 31, 38, 42, 46 and 24.

During the impact the occupants of the vehicle cabin 12 are pushed back, by the deforming front section 16, into the survival space located in the rigid section 18. Alternatively, the occupants can be pushed towards the survival space by the drivers console which can be within the front section 16 of the vehicle cabin 12, or they can take refuge within the survival section.

Further, during the impact the rigid section 18 protects the dedicated repair interface 14 from the obstacle and/or portions of the vehicle cabin 12 that can damage the dedicated repair interface 14 and prevents transmission of bending torque to the dedicated repair interface 14.

After a collision with an obstacle provided the central interface and central section 10 are intact, the deformed vehicle cabin 12 can be replaced. This is performed by disconnecting the deformed vehicle cabin 12 from the sheet metal plate of the dedicated repair interface14. The replacement vehicle cabin 12 will be welded or otherwise affixed to the plate so that the central section 10 of the railway vehicle 2 can be re-used, giving a improved savings on maintenance and operating costs.

Furthermore, in smaller impacts instead of replacing the whole vehicle cabin 12, the vehicle cabin 12 could have one or more further dedicated repair interfaces, and/or one or more further collapsible regions, that can be used to only replace those damaged portions of the vehicle cabin 12. For example, a dedicated repair interface, and/or a central interface for mating the dedicated repair interface, may be placed between the rigid section 18 and the front section 16 of the vehicle cabin 12. This

will ensure that only the front section 16 is replaced for collisions that do not damage the section of the vehicle cabin 12 that includes the rigid section 18.

This concept can be followed to even smaller portions of the vehicle cabin 12 being replaceable after deformation.

For example, the front section 16 may have further dedicated repair interfaces, and/or mating central interfaces, attached to portions of the front section

16 that may be damaged so that only that portion is repaired and/or replaced in a collision.

While the present invention has been shown and described with reference to particular illustrative embodiments it will be understood by those skilled in the art that various changes in form and detail may be made without departing from the scope of the invention as defined in the appended claims.

In the present specification, references to a "railway vehicle" or "railway vehicles" is not to be taken to be limited to a particular type of rail transport, but are to be interpreted as embracing all types of railway vehicles, including but not limited to rail vehicles, trains, passenger carriages, cargo carriages, locomotives, trams, guided vehicles and transports, and the like. The terms "railway vehicle" and "railway vehicles" are used herein to refer to this generic group of items, unless otherwise specified.

CLAIMS

1 - A railway vehicle (2) defining a longitudinal direction and comprising:

- a central section (10);
- a vehicle cabin (12) that is shorter than the central section, the vehicle cabin (12) comprising a collapsible front section (16) that undergoes controlled collapse in case of collision; and at least one rigid section (18) located between the front section (16) and the central section (10), the front section (16) having a lower resistance to deformation than the rigid section (18);
- at least one dedicated repair interface (14) for removably fixing the vehicle cabin (12) to the central section (10).

2 - The railway vehicle (2) of claim 1, wherein the dedicated repair interface (14) lies in a geometrical interface plane perpendicular to the longitudinal direction.

3 - The railway vehicle (2) of claim 2, wherein the repair interface comprises a thick sheet metal plate extending in the interface plane perpendicular to the longitudinal direction.

4 - The railway vehicle (2) of any preceding claim, wherein the rigid section (18) comprises a reinforced ring structure extending in a vertical plane perpendicular to the longitudinal direction.

5 - The railway vehicle (2) of claim 4, wherein the ring is rigidly connected via rigid longitudinal frame members to rear rigid frame members extending in a further vertical transverse plane located between the ring and the dedicated repair interface (14).

6 - The railway vehicle (2) of claim 5, wherein the rear rigid frame members are rigidly affixed to the dedicated repair interface (14).

7 - The railway vehicle (2) of any preceding claim, wherein the rigid section (18) is such as not to deform in the event of a front collision between of the railway vehicle with a four-axle freight wagon UIC 571-2 with an 80 tonne mass equipped with side buffers at a speed of 36 km/h.

8 - The railway vehicle (2) of any preceding claim, wherein the rigid section (18) is such as not to deform in the event of a collision of the railway vehicle at a speed of 110 km/h at a level crossing with a 15 tonne lorry represented by a rigid mass presenting a vertical surface for impact.

9 - The railway vehicle (2) of any preceding claim, wherein the vehicle cabin (12) further comprises a driver's instrument panel located in the front section (16) for driving the railway vehicle (2).

10 - The railway vehicle (2) of any preceding claim, wherein the vehicle cabin (12) further comprises a survival space located in the rigid section (18).

11 - The railway vehicle (2) substantially as hereinbefore described having reference to Figure 1, Figure 2, Figure 3, or Figure 4.

12 - A method for manufacturing or modifying a railway vehicle (2) comprising installing the vehicle cabin (12) and dedicated repair interface (14) of any of claims 1 to 11.

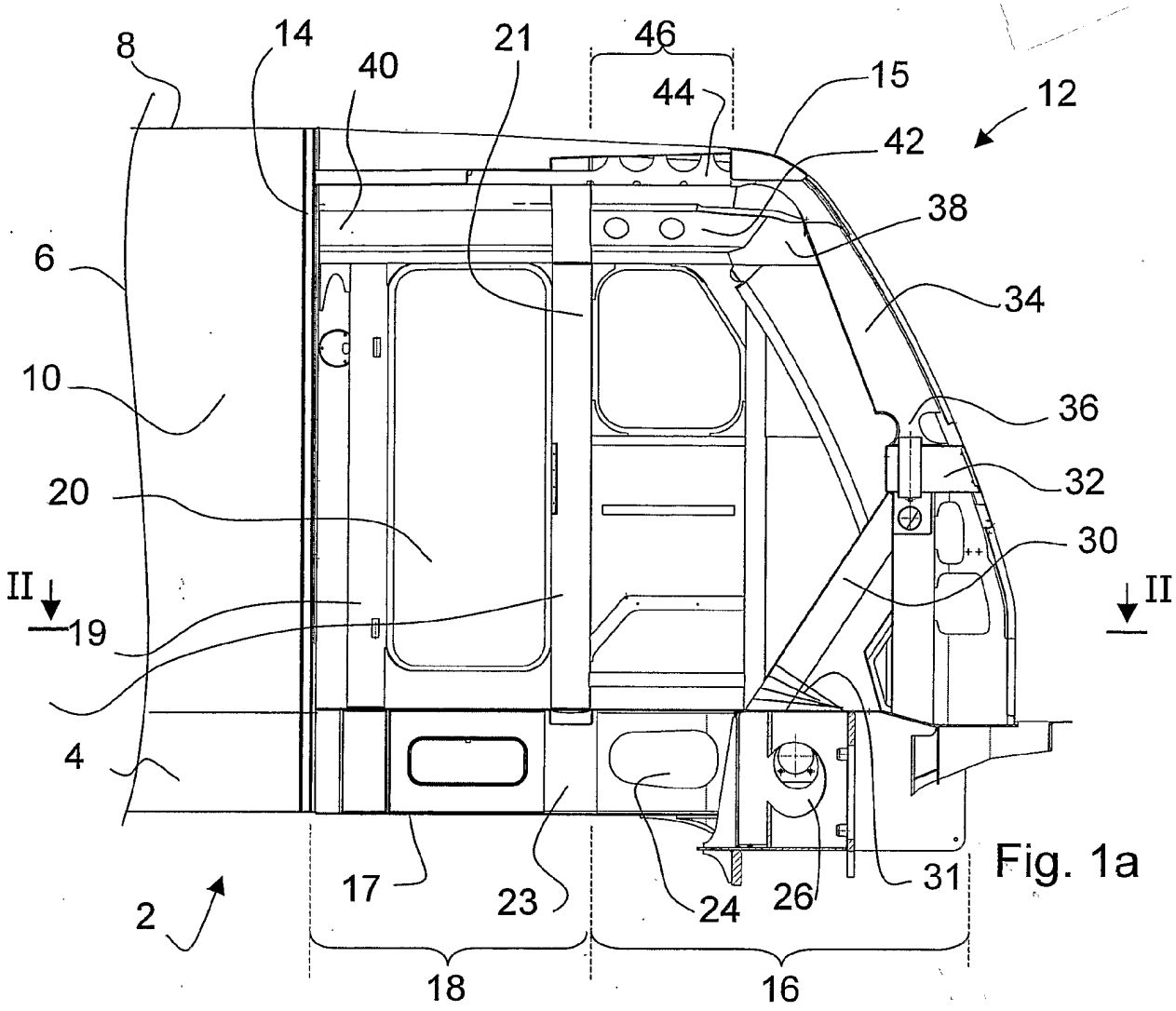
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Fig. 1a

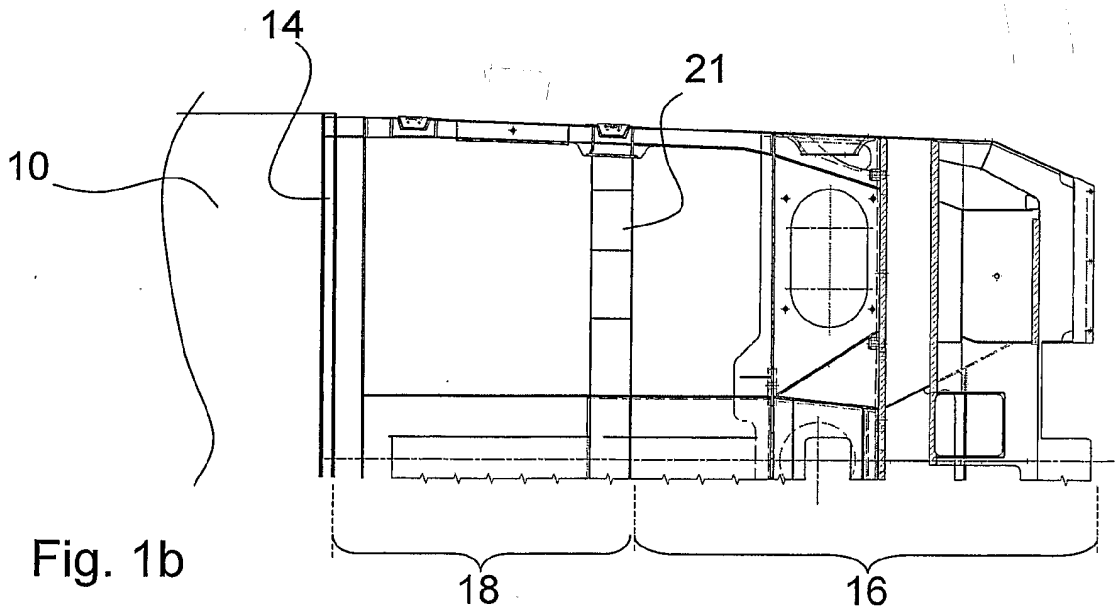
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Fig. 1b

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B61D15/06 B61D17/06 B61C17/04

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B61D B61C B61F B62D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 579 699 A (DANNAWI ET AL) 3 December 1996 (1996-12-03) column 3, line 53 - line 64 column 5, line 28 - column 6, line 24 column 9, line 1 - column 10, line 14; figures 4,8,14-17	1,12
A		4-11
Y	US 6 431 083 B1 (CARSTENSEN HARTMUT ET AL) 13 August 2002 (2002-08-13) column 2, line 62 - column 3, line 14 column 3, line 39 - line 45 column 5, line 37 - column 7, line 9; figures 1,3	1,12
A		2,3,9

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
18 May 2005	31/05/2005

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 295 772 A (HITACHI, LTD) 26 March 2003 (2003-03-26) paragraph '0013! - paragraph '0017!; figures 1,2	1,12
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