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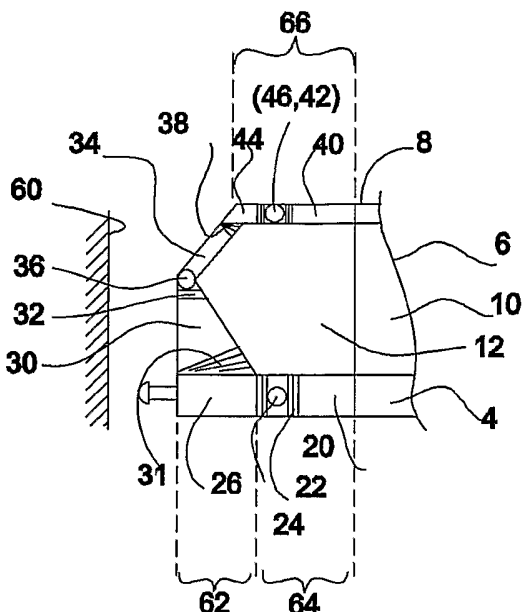
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(54) Title: DEFORMABLE FRAME FOR A VEHICLE CABIN



(57) Abstract: A frame for a vehicle cabin comprising a plurality of frame members defining front, base, roof and side portions of the vehicle cabin, the frame comprising a plurality of yieldable regions distributed in the frame members, whereby the front portion of the frame is allowed to controllably deform substantially in conformity with the forces of an impact on the frame.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

DEFORMABLE FRAME FOR A VEHICLE CABIN

The invention relates to a frame for a vehicle cabin, in particular, a frame for a rail vehicle and a rail vehicle comprising the same. The invention also relates to a method for the manufacture of a vehicle having such a frame.

A frame for a railway locomotive cabin is disclosed in EP0802100B1 in which the frame's structure comprises several energy absorbing elements positioned within the frame's longitudinal members, and within the chassis level of the railway locomotive cabin. The energy absorbing elements deform longitudinally in a crumpling, or a concertina, effect absorbing some of the energy of an impact with an obstacle, while the frame has a high rigidity to protect the occupants of the railway locomotive cabin from high speed collisions with obstacles.

However, said frame for a railway locomotive cabin does not always absorb kinetic energy sufficiently in the case when a railway locomotive collides with an obstacle at high speed. This is particularly the case when the obstacle is for example, heavier or, stiffer than the locomotive, or is irregularly shaped. Once the longitudinal energy absorbing elements are spent, there is no more absorption of the remaining kinetic energy and, if the obstacle cannot absorb the kinetic energy for example, for a heavy and/or stiffer obstacle such as a railway locomotive, or a vehicle's load, then the occurrence of local overload or cracking of the frame structure can occur. This can lead to further catastrophic structural failure of the frame and railway locomotive cabin and poses a risk to the safety of the occupants of the railway locomotive cabin.

In particular, prior art frames having energy absorbing elements or crumple zones, in the longitudinal members are ill adapted to transfer impact loads from one longitudinal member to the others. In general, cross-members may be provided linking the longitudinal frame members. Should a localised impact occur in the region of one longitudinal member, the cross-members will transmit some of the force to the other longitudinal members. However, if the cross-members or their connection with the longitudinal members are too rigid, there is a danger that they

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may shear off and provide no further force transmission. Similarly, if they or their connections are too flexible, there will be insufficient transfer of force.

5 Locomotive vehicle bodies of conventional design are generally relatively stiff, due to the high operating loads and the greater concentration of weight in the underframe level, and tend to collapse in an uncontrolled manner in collisions with other heavy rail vehicles. End driver cabins have a structure on the front between the underframe and the lower edge of the window which is used for impact protection and which must be designed for specific static loads (300 kN according to EN 12663 and even
10 700 kN on some railways). This already guarantees extensive protection for the occupants of the driver's cabin in a collision with an obstacle. However, major deformation and collapse of the impact protection may occur in the case of a particularly heavy, stiff, high obstacle, particularly the bodywork and load of heavy road vehicles, which may cause large intrusion into the cabin by the obstacle and
15 serious or even fatal injury to the occupants of the driver's cabin. Very high loads on the cabin structure occur in collisions with such high obstacles at the approximate height of the obstacle, as the bending load is at its maximum at this point. The problem is aggravated by a knuckle-joint effect, which may generate abrupt tensile stresses at the same crucial point. This entails the risk of cracking in conjunction with
20 a pronounced loss of resistance to deformation and reduced absorption of energy (structural collapse). The obstacle can then penetrate deeply into the cabin. Space for additional reinforcing or impact absorbing structure at obstruction height is restricted (impact protection member, control panel, air intake, windscreen wipers, etc). Solutions are therefore required which provide favourable, i.e. high-energetic and
25 smooth deformation behaviour with no local risk of cracking.

Attempts have been made to overcome the problem of impact at cabin height by providing an integral, very stiff cabin structure, with a solid, continuous front wall below the windscreen, possibly complemented by energy-absorbing elements which
30 can be mounted on said front wall. This increases the resistance of the cabin to deformation and absorbs a higher proportion of collision energy from the obstacle (greater deformation of the obstacle, less deformation of the rail vehicle), thus

protecting the occupants of the cabin better in the design collision scenarios than a vehicle structure of conventional design. This “crashworthiness concept” does not however solve some specific problems of conventional designs and there are even additional disadvantages.

5 1) Should a collision occur between a heavy and, compared to an integral cabin structure, stiffer obstacle and should the energy absorption potential in front of the front wall then be insufficient to absorb the proportional collision energy, collapse in an uncontrolled manner of the locomotive body structure will occur despite this crashworthiness concept.

10 2) In a collision with another rail vehicle, in which the proportional collision energy exceeds the design scenario, the stiff cab structure will inhibit further progressive energy absorption. Uncontrolled collapse of the locomotive body structure will then occur in this case too.

 3) The structural collapse occurring in cases 1) and 2) does not guarantee any
15 protection for the occupants of the rail vehicle in such serious accidents if they take refuge in the machine compartment located behind the cabin.

 4) Due to obstruction of the progress of deformation in cases 1) and 2), the efforts necessary for any repair of the vehicle, which might be possible, increase.

 5) The structure with a rigid integral cabin with added-on frontal energy
20 absorbers leads to greater overall length (overhang) and greater vehicle weight. Both factors represent considerable disadvantages in normal locomotive operations (e.g. maintenance of tracking forces, admissible operating forces in pushing operation, energy absorption, wear, etc).

 6) Properties (geometry, weight, deformability, etc) of the obstacle then have
25 a crucial effect upon the forces acting on the structure, acceleration, and indirectly the necessary structural mass (necessary strength / rigidity of the survival areas).

Thus, in prior art constructions there is no guarantee of protection for the occupants of the railway locomotive cabin even if they take refuge in other parts of the railway locomotive, such as the main body or central section, for example when the central
30 section is a machine compartment comprising the driving means of the railway locomotive. In addition, the possible properties an obstacle has, such as shape, weight, and deformability to name a few, have a crucial effect upon the forces acting

on the frame and railway locomotive cabin in a collision. In the prior art, it is evident that these have not been fully considered due to the rigidity of the frame of the railway locomotive cabin. Finally, the catastrophic structural collapse of the railway locomotive cabin, and hence railway vehicle, increases the efforts and cost
5 necessary for repairing or salvaging the railway locomotive if at all possible. These problems have been particularly evident in the construction of rail vehicles where great emphasis in the past has been placed on the absorption of symmetrical frontal impacts in the buffer region and insufficient attention has been paid to driver protection in the case of impacts with less conventional objects.

10

Accordingly, there is a need for a frame that absorbs as much kinetic energy of a collision as is possible and further redirects the kinetic energy away from the occupants of the vehicle cabin.

15

According to the present invention, there is provided a frame for a vehicle cabin comprising a plurality of frame members defining front, base, roof and side portions of the vehicle cabin, the frame comprising a plurality of yieldable regions distributed in the frame members, whereby the front portion of the frame is allowed to controllably deform substantially in conformity with the forces of an impact on the
20 frame. In a simple arrangement, this may be achieved by providing longitudinal frame members having yieldable regions for absorbing longitudinal deformations and wherein the front portion comprises transverse frame members yieldably joining the longitudinal frame members and being adapted to absorb energy in response to relative longitudinal movement between longitudinal frame members.

25

According to a preferred embodiment, it is advantageous to incorporate yieldable regions into the front portion of the frame's structure since in most circumstances impacts occur in the front portion of the frame, and hence the vehicle cabin. Furthermore, such yieldable regions allow the frame to adapt to the shape, weight,
30 and position of the obstacle in order to absorb as much kinetic energy of a collision as is possible. It has also been found that this frame structure minimises the weight of the vehicle since there is less need to incorporate further energy absorbing

elements. Further, this structure minimises the possibility of derailments as the frame can adapt to a range of impact conditions, including but not limited to, frontal and oblique impacts.

- 5 The structure of the frame may comprise frame members which include but are not limited to, girders, hollow-box girders, beams, struts, energy absorbing struts, structural subassemblies, energy absorbing elements and/or components. The frame members can be made of including but not limited to, steel, mild steels, fibreglass, aluminium, carbon fibre, laminates thereof, or any other such material, subassembly
10 or component that is suitable for the purpose of the frame.

A yieldable region is a portion of a frame member having a lower resistance to deformation compared to the rest of the frame member, such that the yieldable region localises deformation of the frame member on impact. The yieldable regions may be
15 designed to provide what is known as a plastic hinge, that is, the yieldable region has a plasticity wherein it can deform by bending, buckling or folding without cracking such that the yieldable region acts like a hinge, alternatively referred to as a hingeable yieldable region, allowing rotation of the frame member's portions according to an impact. This may be achieved by a change in section of the
20 respective frame member or by a change in its material properties. Examples of changes in section may include a change from box section to flat strip or solid rod and changes in material properties may include changes in material e.g. transition from steel to carbon fibre or changes in property of the material itself e.g. from high to low modulus steel as a result of heat treatment. These changes may be local and
25 abrupt or extended and/or incremental. Yieldable regions specifically for absorbing torsional or bending forces between two members may also be provided by struts or webs between the two members, the struts or webs being designed to collapse in a controlled manner thereby absorbing energy.

- 30 Preferably one or more yieldable regions within the frame members defining the front portion are disposed generally centrally at a point between the base and the roof portion. This is advantageous since the frame members within the front portion can

yield, for example with the yieldable region acting like a plastic hinge on impact with an obstacle, allowing the obstacle initially to penetrate the vehicle cabin with relatively low resistance. The yieldable region is deflected towards the interior of the vehicle cabin and it has been found that the contact surface between the obstacle and the adapting and/or deforming frame (and vehicle cabin) becomes increasingly greater and two dimensional. This allows enhanced energy absorption further reducing local overloads and cracking within the frame. A further advantage is that the risk of derailment on impact is found to be lower if the deformation takes place centrally within the front portion, as opposed to the side, base or roof portions. By adopting the present invention a slim, space-saving protective combination can be designed in the vicinity of the centre cross member, producing good compatibility between the crashworthiness concept and a practical arrangement of functional components such as the impact protection member, air intake, windscreen wipers, control panel, etc.

Preferably one or more frame members within the front portion are connected between one or more members defining the roof and/or base portions. The remaining kinetic energy of the impact can be transferred away from the occupants of the vehicle cabin, for example around the occupants, which may be accomplished by connecting the front portion to the roof portion, or base portion, or both.

Preferably a plurality of yieldable regions are located within one or more frame members defining the roof portion. This is advantageous since the frame members transfer the remaining kinetic energy of a collision through the roof portion which can further absorb the kinetic energy. As much of the remaining kinetic energy as is possible is absorbed within the vehicle cabin, and not transferred to the rest of the vehicle's structure such as the vehicle's central section. Further, the roof portion can absorb impacts from off high obstacles.

Preferably a plurality of yieldable regions are located within one or more frame members defining the base portion. This has been found to provide not only additional energy absorption and redirection of kinetic energy, but also it provides an

anti-climbing function for the vehicle and can prevent twisting of the transverse headstock.

5 Preferably one or more yieldable regions within the frame members are formed by one or more reduced portions of the frame members. The controlled and predictable collapse of the frame may be managed by one or more yieldable regions within the frame members through the reduction of at least one portion of a frame member. The reduced portions, or reduction of at least one portion, of a frame member refers, but is not limited to, removing a section or portion of the frame member, making
10 holes or slits within the frame member, reducing the thickness of the frame member and or any other way of reducing and/or changing the material of a portion the frame member. Preferably the one or more reduced portions are defined by one or more holes in the frame members. The advantage of incorporating holes in the frame member gives the yieldable region numerous purposes, including but not limited to,
15 crumpling in a longitudinal direction along the frame member and/or acting as a plastic hinge, the hinge being localised between holes.

Preferably one or more yieldable regions comprises one or more mechanical hinges. The mechanical hinge can allow rotation, including but not limited to, the direction
20 of impact. This can provide controlled deformation in one or more directions whilst maintaining a high structural stiffness in other directions. In this way, the front portion may initially conform to the shape of the impacting object with little energy absorption and thereafter increased energy absorption may proceed.

25 Preferably however, the one or more yieldable regions comprises one or more crash energy absorption elements. It has been found that other mechanisms for energy absorption, such as crash energy absorption elements, can be applied and easily repaired and replaced. It is also advantageous to provide additional energy absorbing elements, as this reduces the likelihood of further damage to the vehicle's central
30 section that is connected to the vehicle cabin.

Preferably at least one of the frame members is an energy absorbing strut. The energy absorbing strut can provide progressive redirection of the kinetic energy of an impact, additional energy absorption between frame members, and control the amount of deformation that frame members undergo, in various portions of the
5 frame.

Preferably three frame members are arranged in a triangle formed by connecting at least one energy absorbing strut between two frame members. This is advantageous as the impact energy may be transferred away from the occupants of the vehicle
10 cabin. Preferably one of the frame members arranged in the triangle extends a distance from the triangle to a hingeable yieldable region, wherein on impact said frame member deforms at the hingeable yieldable region allowing energy absorption in the energy absorbing strut. This controls the rotational deformation of the deformed frame member, while the remaining impact energy is transferred through
15 the other frame members, and absorbed by the energy absorbing strut.

Preferably the triangle is formed by connecting the energy absorbing strut between one or more frame members within the front portion and one or more frame members within the base portion. It has been found that energy absorption strut positioned in
20 this way can advantageously control the rotational deformation of the frame member within the front portion and transfer the remaining impact kinetic energy towards the frame member within the base portion. The energy absorption strut can provide further energy absorption by compression on impact.

25 Preferably a deformable portion and a non-deformable safety box located behind the deformable portion in the direction of the expected impact. The frame may be further divided into portions, such as a deformable portion, which advantageously absorbs and redirects the kinetic energy of impact, for example a possible variation of the frame may be one having a deformable front, roof and base roof portions.
30 Further, a non-deformable portion, (the safety box), can protect the occupants during a collision, especially if, this non-deformable portion is behind the deformable portion.

Preferably the non-deformable safety box comprises two or more stiff frame members within the side portions connected to one or more frame members within the roof and base portions. This is advantageous in protecting the occupants from side impacts, and can reinforce the non-deformable safety box and avoid compression of the non-deformable safety box in frontal impacts.

Preferably the non-deformable safety box comprises one or more stiff frame members within the roof portion that are connected to one or more frame members within the side portions. This further protects the occupants of the vehicle cabin from high impacts to the roof portion, and strengthens the non-deformable safety box from front impacts.

Preferably the stiff frame members of the non-deformable safety box comprise a doorframe for an escape exit. This is advantageous as the escape exits, which may include, but are not limited to doors or windows allow not only the occupants to escape after an impact, but also to allow rescuers and/or other personnel to aid the occupants if required. As well, the escape exits should be such that they are easily accessible to both occupants and rescuers. Further it is advantageous to have numerous escape exits that may even be within the roof portions and/or base portions in the event of debris blocking any escape exits within the side portions.

Preferably any variation of the frame as described herein for use in a railway vehicle. Any railway vehicle would benefit in both improved safety during a collision and improved cost of maintenance and repair after a collision. The frame can be within the driver's cabin for a railway vehicle, and/or part of the end structural sections of a railway vehicle and/or passenger carriage. The vehicle may be the driving vehicle, for example a train locomotive, since most shock impacts tend to occur to the foremost railway vehicle of a train.

30

The present invention also provides a method for modifying a railway vehicle comprising installing any variation of the frame as described herein. The methods of

installation may range from installing a frame as described herein at the time of manufacture for a vehicle cabin. The vehicle cabin may be connected to at least one end of the central section of the vehicle, the central section including but not limited to, a passenger compartment, a machine room, or a cargo compartment.

5 Alternatively, an existing vehicle may be retrofitted with the aforementioned components, that is components of the frame, to provide, for example, a cost effective solution for current fleet operators so they can benefit from the improved maintenance, repair, and safety of a modified railway vehicle.

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

15 Figure 1a is a longitudinal sectional view of a first embodiment of the present invention.

Figure 1b is a vertical sectional view of the first embodiment of the present invention.

20 Figure 1c is a partial horizontal view of the first embodiment of the present invention.

25 Figure 1d is a perspective view of a yieldable region in a support member of the first embodiment of the present invention;

Figure 2 provides a cross sectional view of a further embodiment of the present invention illustrating a collision with a flat-faced obstacle;

30 Figure 3a is a cross sectional view of a further embodiment of the present invention illustrating the initial stages of a collision with a high contoured obstacle;

Figure 3b is a cross sectional view of a further embodiment of the present invention illustrating an advanced stage of a collision with a high contoured obstacle;

Referring to figures 1a, 1b, 1c, and 1d, there is shown a railway vehicle, generally indicated as 2. Figure 1a, 1b, and 1c shows various views of the railway vehicle 2, with a central section 10 connected to a vehicle cabin 12. Figure 1d illustrates a perspective view of a yieldable region 36 that is in the front of the vehicle cabin 12 as seen in figure 1a.

10 The railway vehicle 2 of figures 1a, b, and c has a chassis or vehicle base 4 supported on one or more bogies (not shown). The vehicle base 4 supports a central section 10, defining a longitudinal direction, including main walls 6 extending towards the roof 8, (only one wall is shown in the longitudinal cross section of figure 1a). Connected to at least one end of the central section 10 in the longitudinal direction is a vehicle
15 cabin 12.

A yieldable region is defined as a region of the frame members (26, 32, 30, 34, 20, 40, 44), having a lower resistance to deformation than the rest of the respective frame member (26, 32, 30, 34, 20, 40, 44), such that the yieldable region localises
20 deformation of the frame members (26, 32, 30, 34, 20, 40, 44) on impact to provide controlled collapse of the vehicle cabin 12.

The vehicle cabin 12 comprises a frame that is divided into portions, namely, the front portion 62, the base portion 64, the roof portion 66 and side portions 68 as seen
25 in figures 1a, 1b, and 1c. The base portion 64 includes at least one base frame member 20 that connects from the vehicle base 4, at the point where the vehicle cabin 12 joins the central section 10, and extends longitudinally to the front portion 62. At least one base yieldable region 22 is positioned within the base frame member 20, the base yieldable region 22 being defined by having an oblong shaped
30 section 24 removed from the base frame member 20.

Connected adjacent and in front of the base yieldable region 22 is the front portion 62, which connects to the base yieldable region 22 by a headstock frame member 26. Further sub-assemblies (not shown) that can be supported by the headstock frame member 26 may include but are not limited to, buffers (not shown), couplings (not shown), cowcatchers (not shown), bull-bars (not shown), anti-climbing devices (not shown). The headstock frame member 26 extends in the lateral dimension between the two side portions 68.

On top and adjacent to the headstock frame member 26 is connected at least one lower frame member 30 which inclines 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 roof and the base portions 64 and 66. Connected to the lower frame member 30 is a middle frame member 32. The middle frame member 32 extends in the lateral dimension between the two side portions 68. At the base of the lower frame member 30 is located at least one lower yieldable region 31. The lower yieldable region 31 may include but is not limited to, an energy absorbing strut.

Further, adjoining the top of the lower frame member 30 is an upper frame member 34. In fact, the lower and upper frame member 30 and 34 may be made out of one piece of a frame member that extends from the base to the roof portion. Substantially near the adjoining region of the upper frame member 34 and the lower frame member 30 is a central yieldable region 36, a perspective of which can also be seen in figure 1d. In this instance, the central yieldable region 36 is above the connection between the middle frame member 32 and the lower frame member 30. As can be seen in figures 1a and d, the central yieldable region 36 is made of two essentially opposing non-intersecting semi-circular portions removed from either/or both the lower and upper frame members 30 and 34. This gives a plastic hinge, or a hingeable yieldable region, allowing a controlled rotation of the lower and upper frame members 30 and 34 in a collision. The upper frame member 34 can be composed of a material with a high stiffness.

At least one upper yieldable region 38 is located either adjacent the top of the upper frame member 38, or within the top of the upper frame member 38. Adjacently connected to the upper frame member 34 and/or the upper yieldable region 38 is the roof portion 66. The connection of the front portion 62 to the roof portion 66 is made by at least one first roof frame member 40. A first roof yieldable region 42 is positioned near the end of the first roof frame member 40 that is adjacent to the upper frame member 34 or the upper yieldable region 38.

As well, at least one second roof frame member 44 is disposed adjacent and above the first roof frame member 40. The second roof frame member 44 also connecting to either/or both the upper frame member 34 or the upper yieldable region 38. A second roof yieldable region 46 is substantially positioned near the end (towards the front portion 62) of the second roof frame member 44 and is adjacent to the first roof yieldable region 42.

The first roof yieldable region 42 includes at least two holes, longitudinally spaced along the first roof frame member 40. This acts as a plastic hinge, the hinge positioned between the two holes, as well as, longitudinal energy absorption in the form of a crumpling or buckling. The second roof yieldable region 46, having semi-circular corrugations within the top and lower edges and/or surfaces of the second roof frame member 44, wherein the second roof yieldable region 46 performs energy absorption through compression.

Connected to, or adjoining the roof frame members 40 and/or 42 at a suitable distance from the front portion 62 and preferably at the rear of the vehicle cabin 12 is a non-deformable safety box 50. The non-deformable safety box 50 is made up of essentially parallel stiff frame members 52 within both side portions 68. These stiff frame members 52 connect with the base frame member 20 of the base portion 64 and the first roof frame member 40 of the roof portion 66. Located between the essentially parallel stiff frame members 52 in at least one side portion 68, (most likely both side portions 68) is a doorframe for at least one escape exit 54. The escape exit 54 can be made of but is not limited to, the entrance doors or windows, or

can be purpose built for an escape exit 54 being made of a similar stiff material as the stiff frame members 52.

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 portion 62 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 yieldable regions, respectively 31, 36, and 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 yieldable regions, respectively 22, 42, and 46 will absorb the kinetic energy of the impact generally by crumpling or buckling in the longitudinal direction of the corresponding frame member.

In a collision with a high contoured obstacle that impacts at a height that is centrally between the roof and base portions 66 and 64 the yieldable regions co-operate to adapt to the contours of the obstacle and absorb the kinetic energy of the impact. The base and roof frame members 20, 40 and 44 typically undergo a rotational and/or bending deformation, such that the members rotate inwards towards the interior of the vehicle cabin 12 about the yieldable regions 22, 42 and 46. Simultaneously, as the obstacle impacts centrally, most likely, against the upper frame member 34 the central deformable region 36 deflects and undergoes a rotational and/or bending deformation, acting like a plastic hinge, about the central yieldable region 36. The obstacle pushes the central yieldable region 36 further into the vehicle cabin 12. However, the upper frame member 34, due to its stiffness, prevents the obstacle from 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 upper, lower, first roof, second roof, and base yieldable regions 38, 31, 42, 46 and 22 undergo further rotational deformation absorbing the energy of impact as much as possible. The remaining impact energy is also transferred via the lower and upper yieldable regions 31 and 38 towards the base and roof longitudinal support members 20, 40 and 44 by the further compression of the lower and upper

yieldable regions 31 and 38. Finally, this energy is dissipated within the base and roof yieldable regions 22, 42 and 46 by a longitudinal compression of these frame members. The kinetic energy of the impact is effectively transferred away from the occupants of the vehicle cabin 12. The front portion 62 will adapt to the shape of the obstacle and absorb as much kinetic energy as possible by the deformation of the central yieldable region 36 and the other yieldable regions.

During the impact the occupants of the vehicle cabin 12 can be pushed back, by the deforming front portion 62, into the non-deformable safety box 60. Alternatively, the occupants can be pushed towards the non-deformable safety box 60 by the drivers console which can be located within the front portion 62 of the vehicle cabin 12, or they can take refuge within the non-deformable safety box 60.

After a collision with an obstacle the deformed vehicle cabin 12 should have absorbed most of the kinetic energy of the impact leaving the central section 10 intact. The vehicle cabin 12 can simply either be repaired or replaced while re-using the central section 10. This gives an improved saving on maintenance and operating costs of the railway vehicle.

Referring now to figure 2, provided is a cross sectional view of an alternative embodiment of the present invention, and the railway vehicle 2 that can be similarly described as in the embodiment of figure 1a, 1b, 1c, and/or 1d.

Figure 2 illustrates the operation of the yieldable regions, namely the base, lower, central, upper, roof and second roof yieldable regions, respectively 22, 31, 36, 38, 46 and 42 in a medium frontal collision with a flat-faced obstacle 60. As can be seen, the lower, central, upper yieldable regions, respectively 31, 36 and 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 yieldable regions, respectively 22, 46 and 42 will absorb the kinetic energy of the impact in the longitudinal direction by longitudinally compressing the base, first roof, and second roof frame members 20, 40 and 42.

Referring now to figures 3a and 3b, provided is a cross sectional view of another embodiment of the present invention illustrating a collision with a high contoured obstacle, wherein the railway vehicle 2 is similarly described as in the embodiment of figure 1a, 1b, 1c and/or 1d.

5

Figure 3a illustrates a collision to the vehicle cabin 12 at the initial stage of impact, and figure 3b illustrates an advanced stage of the collision to the vehicle cabin 12. The cooperation of the yieldable regions, namely the base, lower, central, upper, roof and second roof yieldable regions, respectively 22, 31, 36, 38, 46 and 42 to a high
10 obstacle 62 is shown.

Initially, in figure 3a, the roof and base frame members 40, 44 and 20 perform a rotational deformation as the obstacle impinges above the central yieldable region 36. Further in figure 3b, the obstacle impacts against the upper frame member 34,
15 wherein the central yieldable region 36, (also known as a hingeable yieldable region), deflects and undergoes a rotational deformation, acts as a plastic hinge, in relation to the lower and upper frame members 30 and 34. The obstacle pushes the central yieldable region 36 further into the vehicle cabin 12. However, the upper frame members 34 are made of a stiff material and prevents the obstacle from
20 actually penetrating 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 upper, lower, roof, second roof, and base yieldable regions (38,
25 31, 46, 42 and 22 respectively) undergo a rotational deformation absorbing the energy of impact as much as possible. Further, the impact energy is transmitted via the lower and upper yieldable regions 31 and 38 towards the base and roof frame members 20, 40 and 44 by a further compression of the lower and upper weak members 31 and 38. Finally, this energy is dissipated within the base and roof
30 yieldable regions 22, 46 and 42 respectively, further compressing these respective yieldable regions as much as possible and absorbing as much kinetic energy as is possible. The kinetic energy of the impact is effectively redirected away from the

occupants of the vehicle cabin 12. The front portion also adapts to the shape of the obstacle and absorbs as much kinetic energy as possible through the deformation of the central yieldable region 36.

5 It will be appreciated that the present invention in general and by way of specific aspects and embodiments provides a means whereby the vehicle cabin of a vehicle can absorb as much kinetic energy of a collision as is possible in a controllable and predictable fashion, by using multiple yieldable regions strategically placed substantially within the front, roof, base, and side portions and further redirecting the
10 kinetic energy away from the occupants of the vehicle cabin. In this respect, the present invention represents a significant advantage over established and conventional forms of energy absorption for a vehicle cabin of a vehicle, which by their very nature do not improve the safety, repair and re-use of the vehicle's structure.

15 Although in the present specification, reference has been made to rail vehicles, it is also considered that the teachings of the present invention may equally be applied to other vehicles. As such, references to a "vehicle" or "vehicles" are not to be taken to be limited to a particular type of transport, but are to be interpreted as embracing all
20 types of vehicles, including but not limited to rail vehicles, trains, passenger carriages, cargo carriages, locomotives, guided vehicles and transports, buses, aircraft, vans, campervans, caravans, trucks, lorries, trailers, and the like. The terms "vehicle" and "vehicles" are used herein to refer to this generic group of items, unless otherwise specified.

25 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.

30

CLAIMS

1. A frame for a vehicle cabin comprising a plurality of frame members defining front, base, roof and side portions of the vehicle cabin, the frame comprising
5 a plurality of yieldable regions distributed in the frame members, whereby the front portion of the frame is allowed to controllably deform substantially in conformity with the forces of an impact on the frame.
2. The frame according to claim 1, wherein one or more yieldable regions
10 within the frame members defining the front portion are disposed generally centrally at a point between the base and the roof portion.
3. The frame according to any preceding claim, wherein one or more frame
15 members within the front portion are connected between one or more members defining the roof and/or base portions.
4. The frame according to any preceding claim, wherein a plurality of yieldable
20 regions are located within one or more frame members defining the roof portion.
5. The frame according to any preceding claim, wherein a plurality of yieldable
regions are located within one or more frame members defining the base
portion.
- 25 6. The frame according to any preceding claim, wherein the one or more yieldable regions within the frame members are formed by one or more reduced portions of the frame members.
7. The frame of claim 6, wherein the one or more reduced portions are defined
30 by one or more holes in the frame members.

8. The frame according to any preceding claim, wherein one or more yieldable regions comprises one or more mechanical hinges.
9. The frame according to any preceding claim, wherein one or more yieldable regions comprises one or more crash energy absorption elements.
10. The frame according to any preceding claim, wherein at least one of the frame members is an energy absorbing strut.
11. The frame according to claim 10, wherein three frame members are arranged in a triangle formed by connecting at least one energy absorbing strut between two frame members.
12. The frame according to claim 11, wherein one of the frame members arranged in the triangle extends a distance from the triangle to a hingeable yieldable region, wherein on impact said frame member deforms at the hingeable yieldable region allowing energy absorption in the strut.
13. The frame according to any of claims 11 to 12, wherein the triangle is formed by connecting the energy absorbing strut between one or more frame members within the front portion and one or more frame members within the base portion.
14. The frame according to any preceding claim, comprising a deformable portion and a non-deformable safety box located behind the deformable portion in the direction of the expected impact.
15. The frame according to claim 14, wherein the non-deformable safety box comprises two or more stiff frame members within the side portions connected to one or more frame members within the roof and base portions.

16. The frame according to any of claims 14 or 15, wherein the non-deformable safety box comprises one or more stiff frame members within the roof portion that are connected to one or more frame members within the side portions.
- 5 17. The frame according to any of claims 15 or 16, wherein the stiff frame members of the non-deformable safety box comprise a doorframe for an escape exit.
18. The frame according to any preceding claim for use in a railway vehicle.
- 10 19. The frame substantially as hereinbefore described having reference to figure 1a, figure 1b, figure 1c figure 1d, figure 2, figure 3a or figure 3b.
20. A railway vehicle comprising the frame of any of claims 1 to 19.
- 15 21. A method for modifying a railway vehicle comprising installing the frame of any of claims 1 to 19.

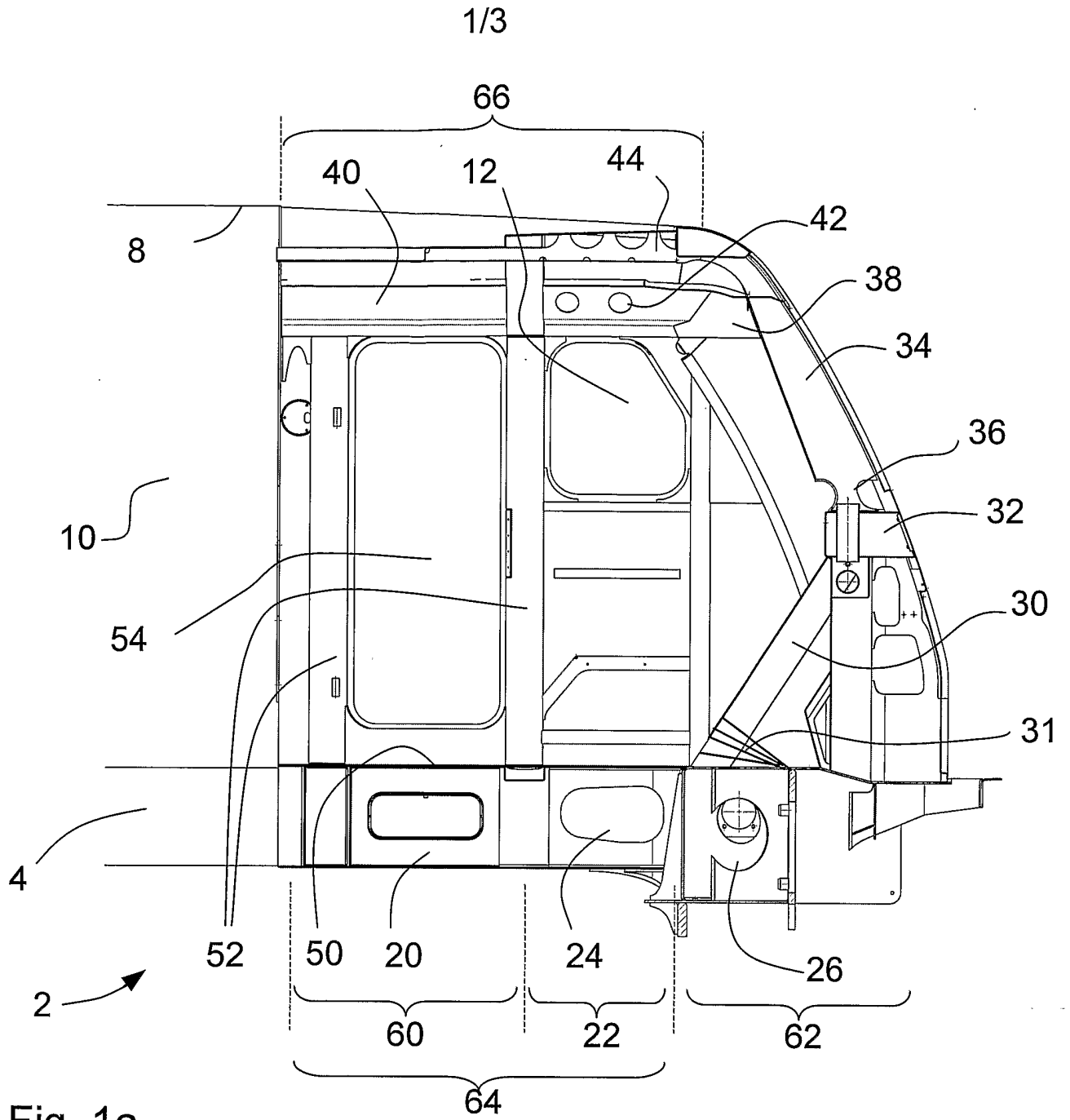


Fig. 1a

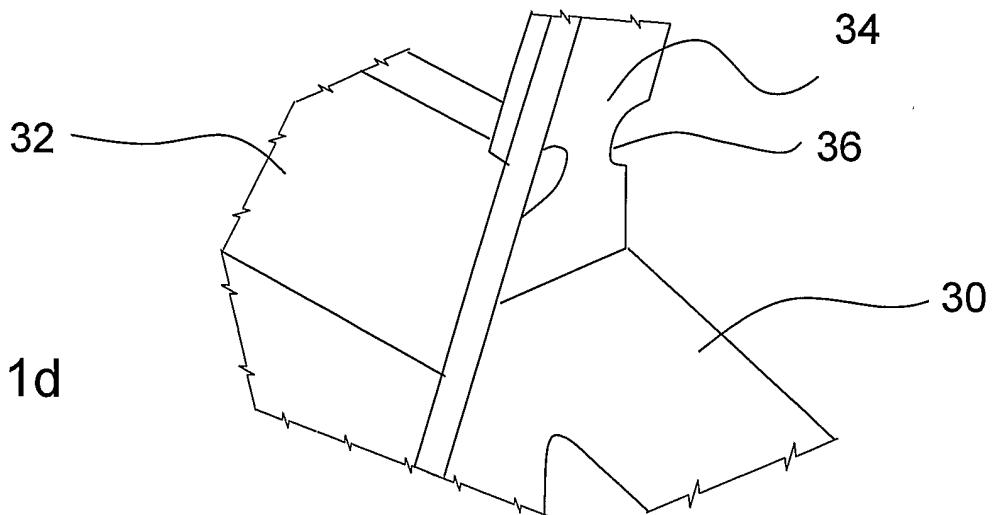


Fig. 1d

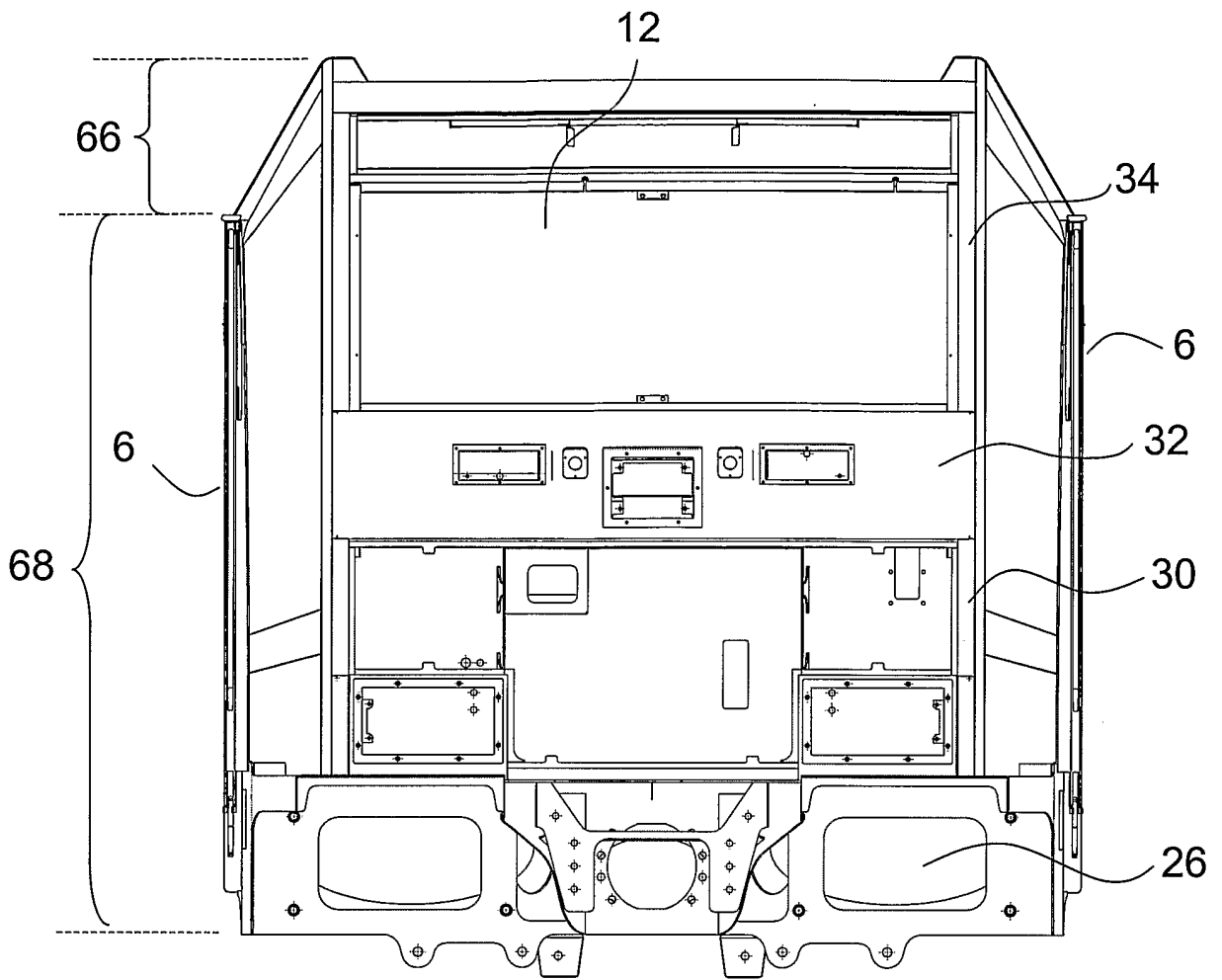


Fig. 1b

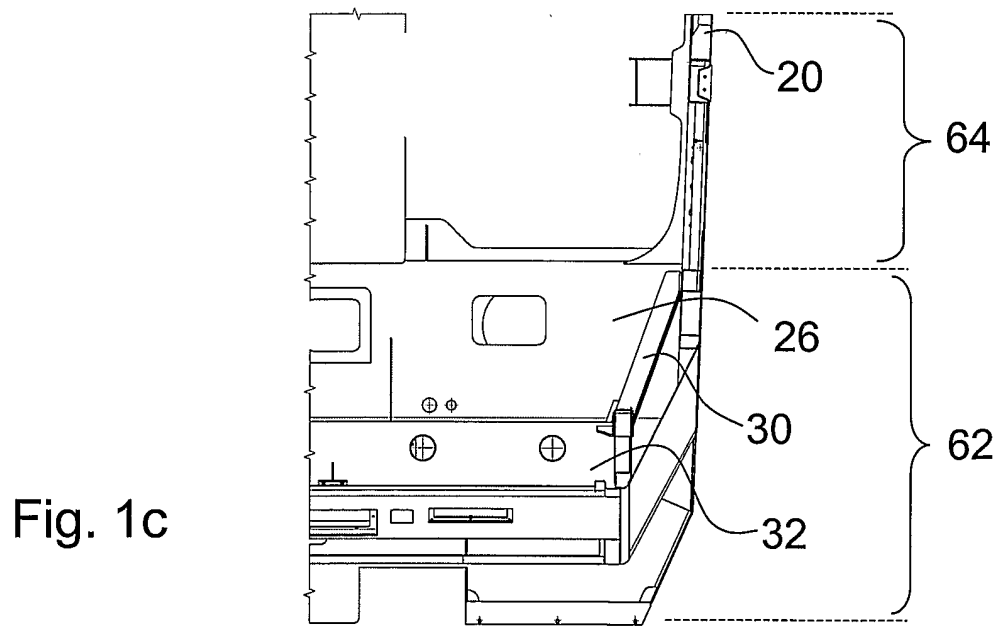
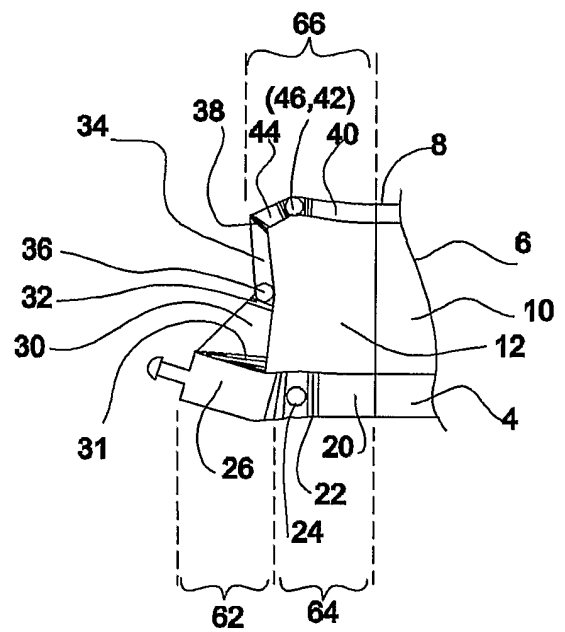
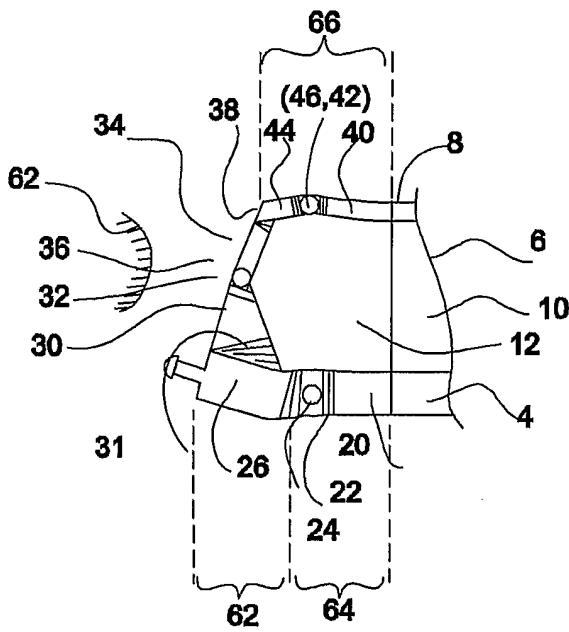
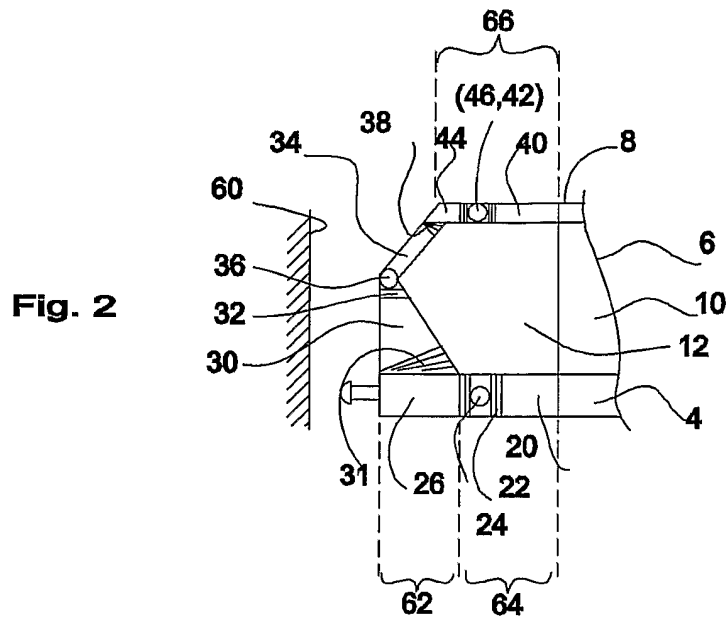


Fig. 1c



INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2005/002092

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B61D15/06 B62D21/15

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 B62D B61G

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

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A	EP 0 655 565 A (GEC ALSTHOM TRANSPORT SA) 31 May 1995 (1995-05-31) abstract; figures	1, 20, 21
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A	DE 101 55 257 A1 (ALSTOM LHB GMBH) 22 May 2003 (2003-05-22) abstract; figures	1, 20, 21
A	FR 2 715 904 A (SARDOU MAX) 11 August 1995 (1995-08-11) page 2, lines 14-22; figures	1, 20
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

° Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
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- *Z* document member of the same patent family

Date of the actual completion of the international search

15 July 2005

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2005/002092

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
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