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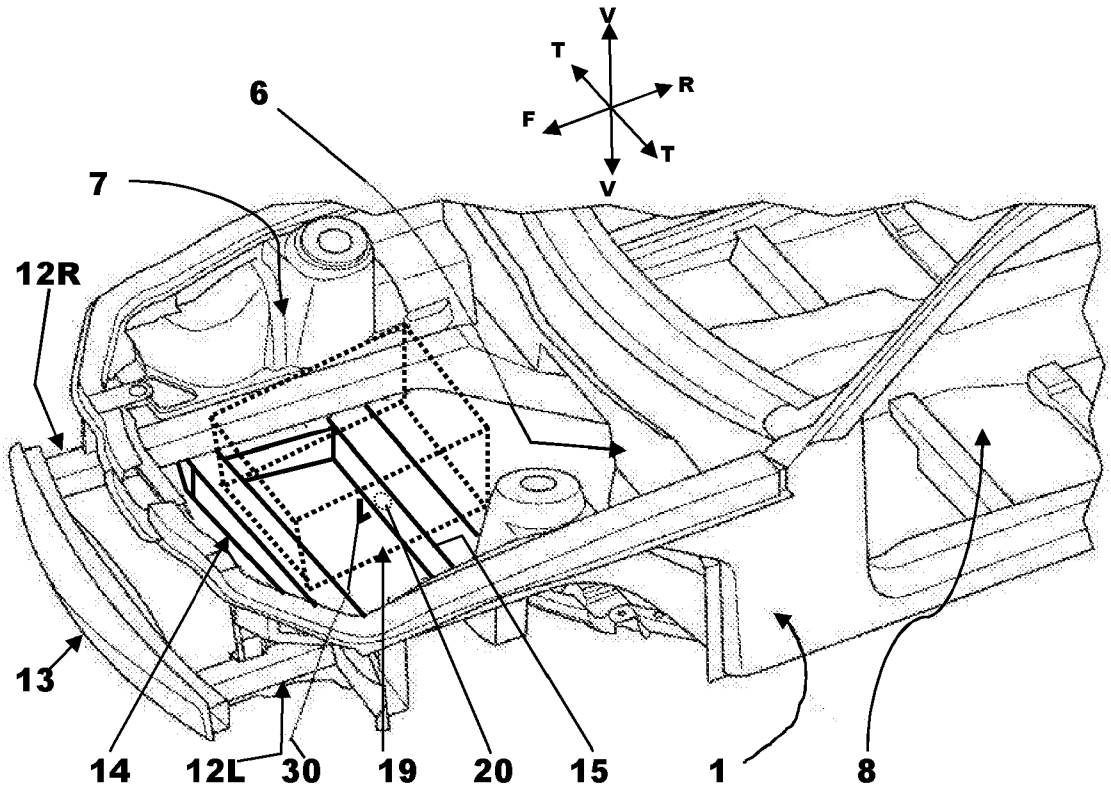


Fig.1

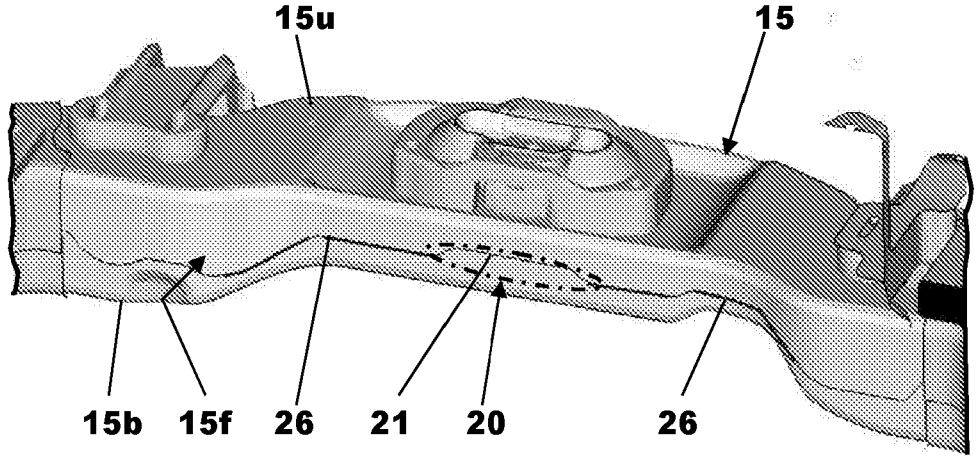


Fig.4

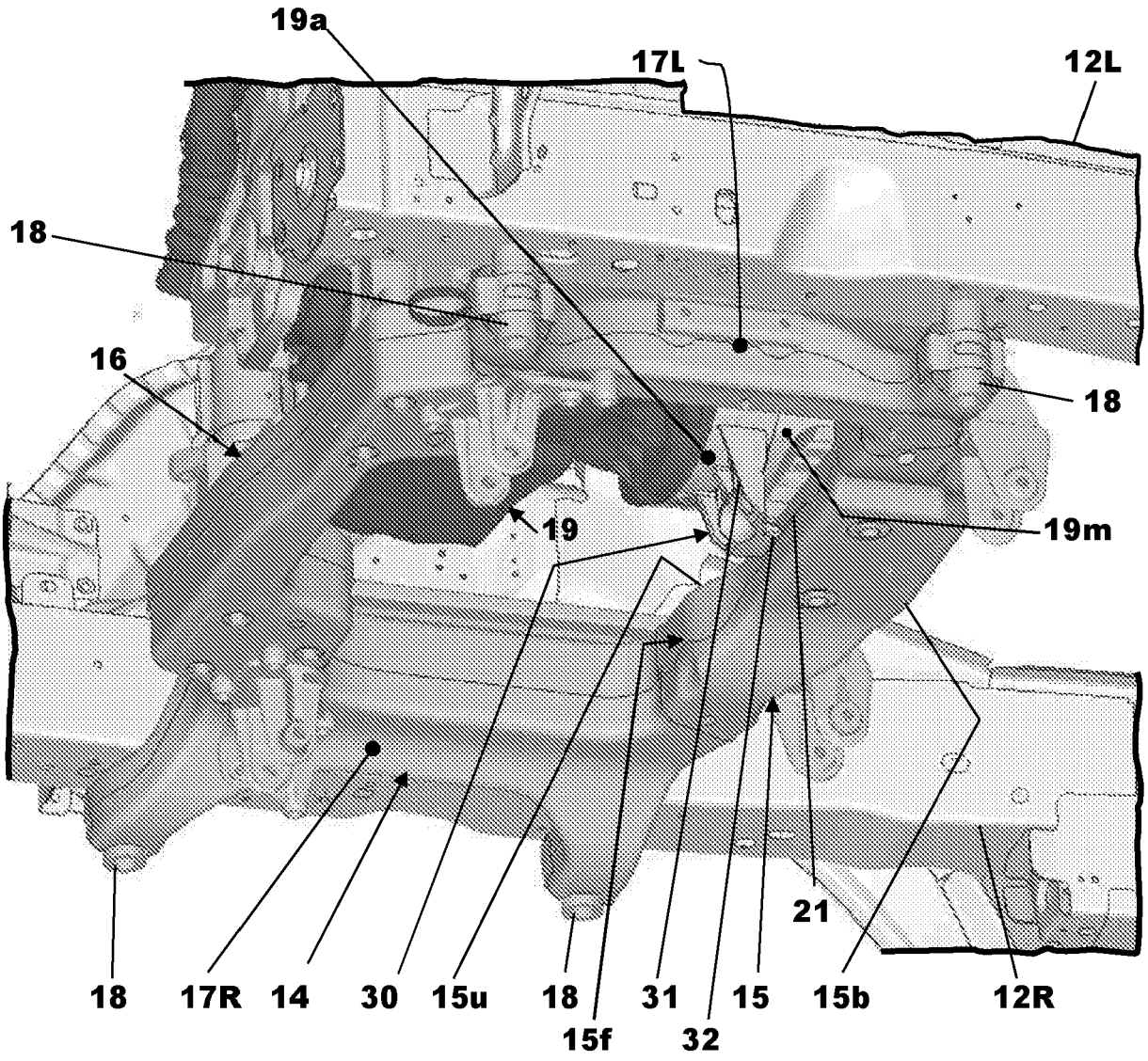

19a
17L
12L
18
16
18
19
19m
21
18
17R
14
30
15u
18
31
15
15b
12R
15f
32

Fig.2

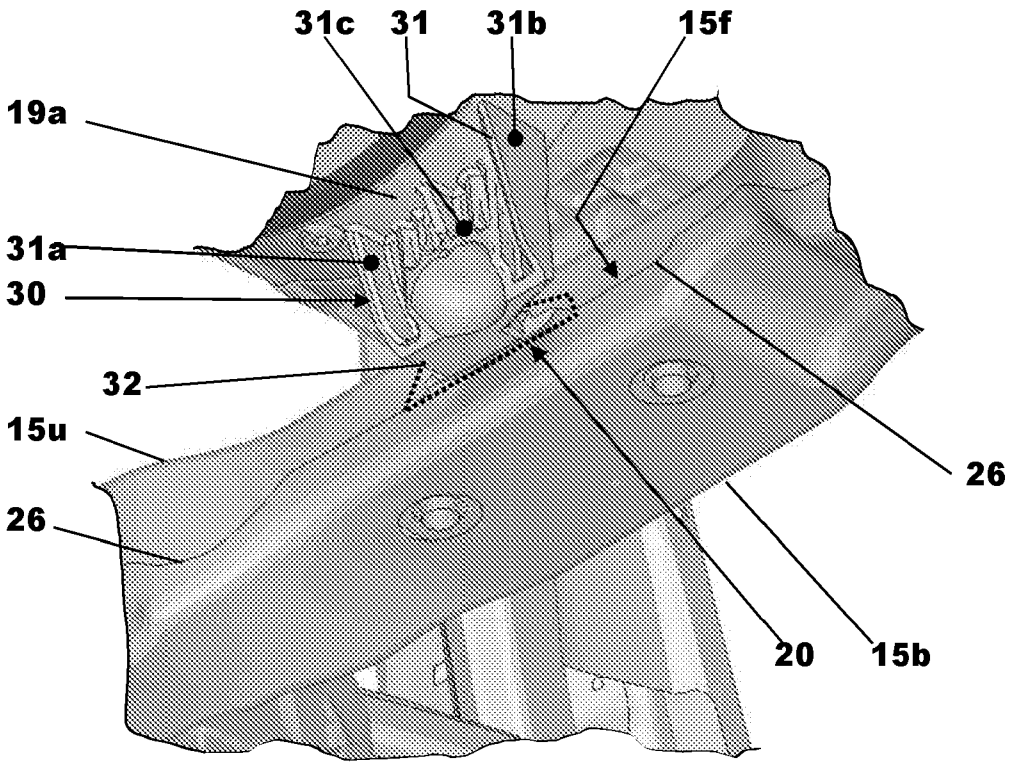


Fig.3

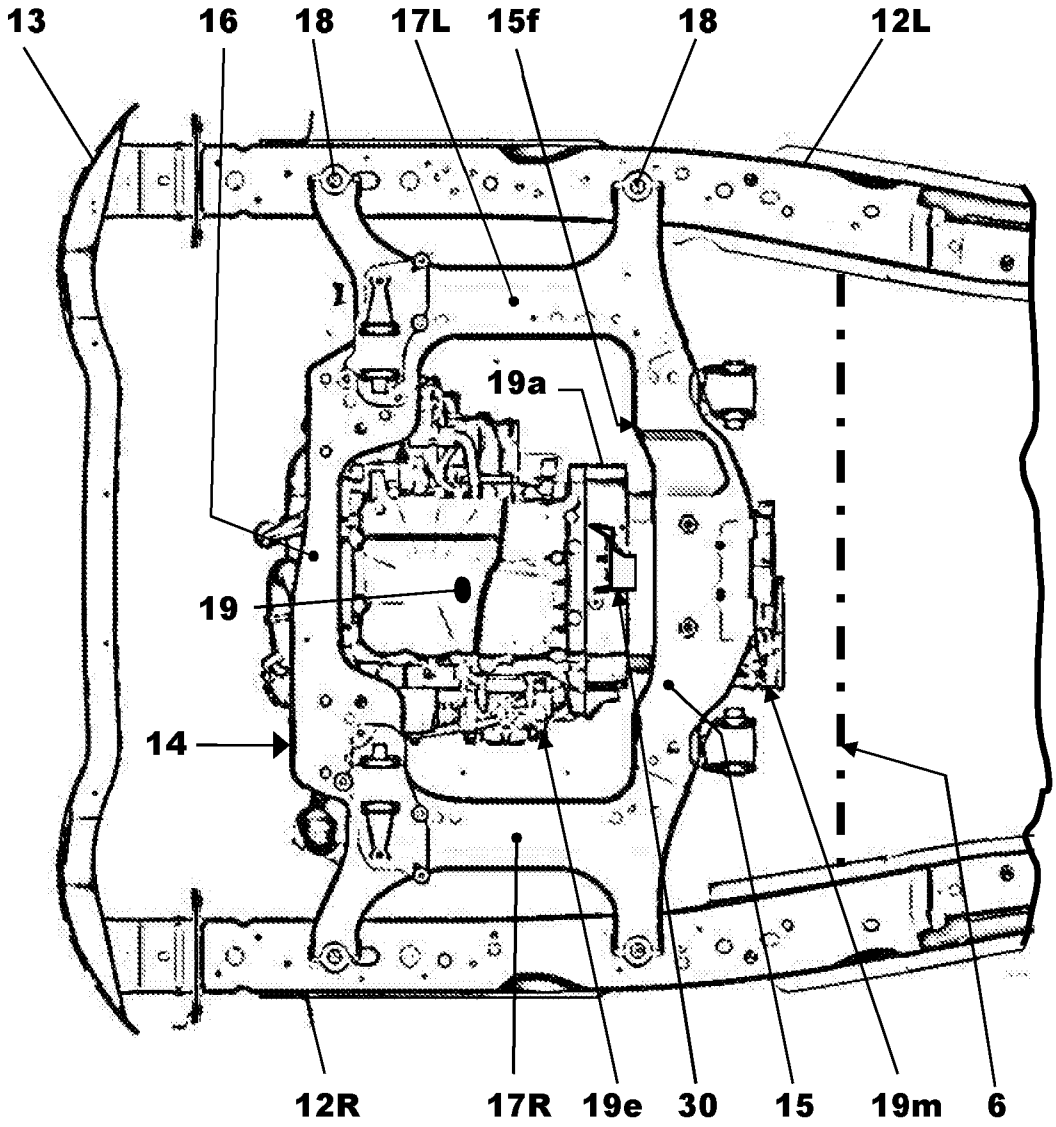


Fig.5

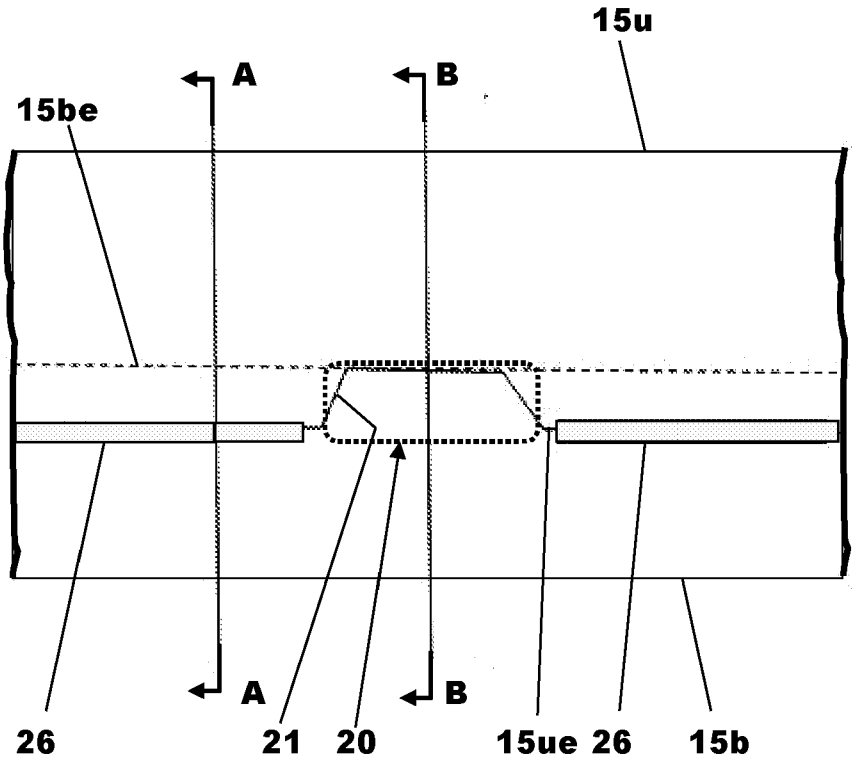


Fig.6

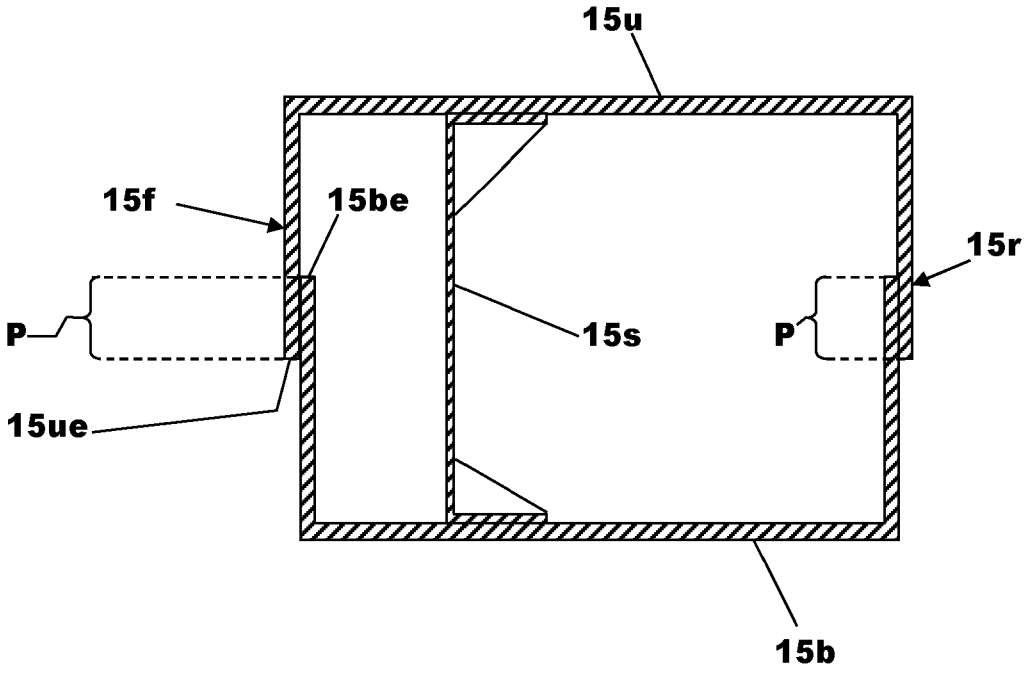
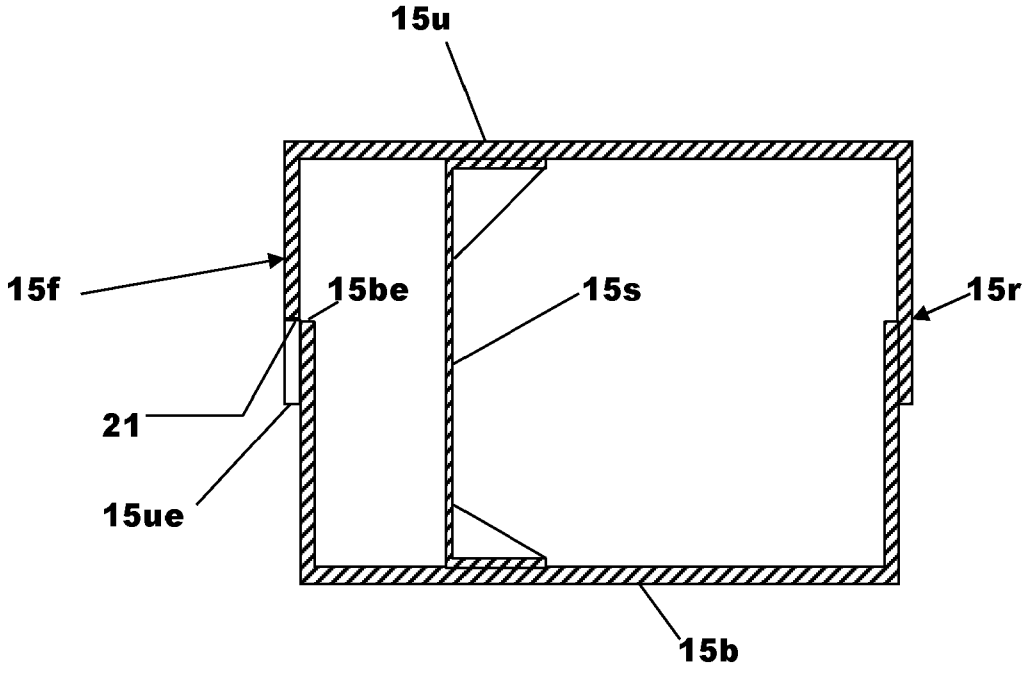

15u
15f
15be
15r
P
15s
P
15ue
15b

Fig.6a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15s
15r
21
15ue
15b

Fig.6b

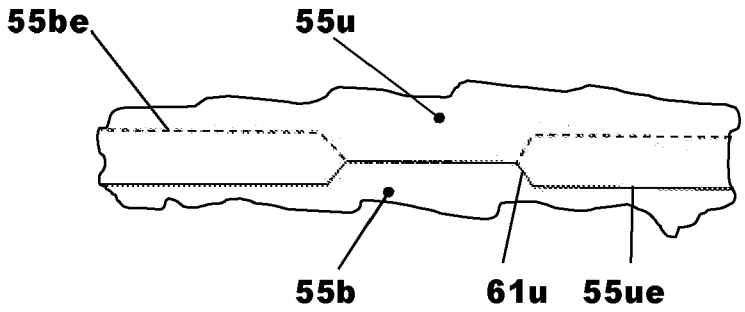

Fig.7a

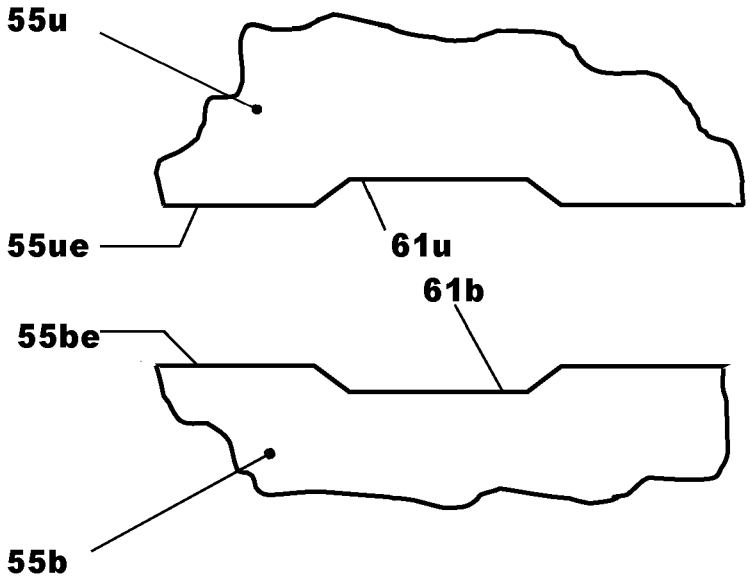

Fig.8

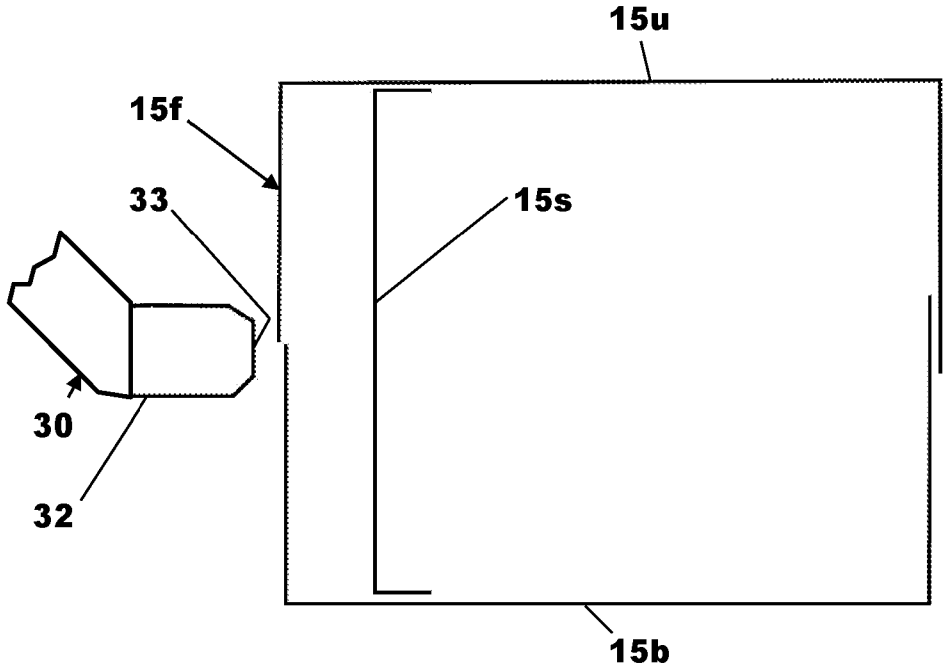

Fig.9a

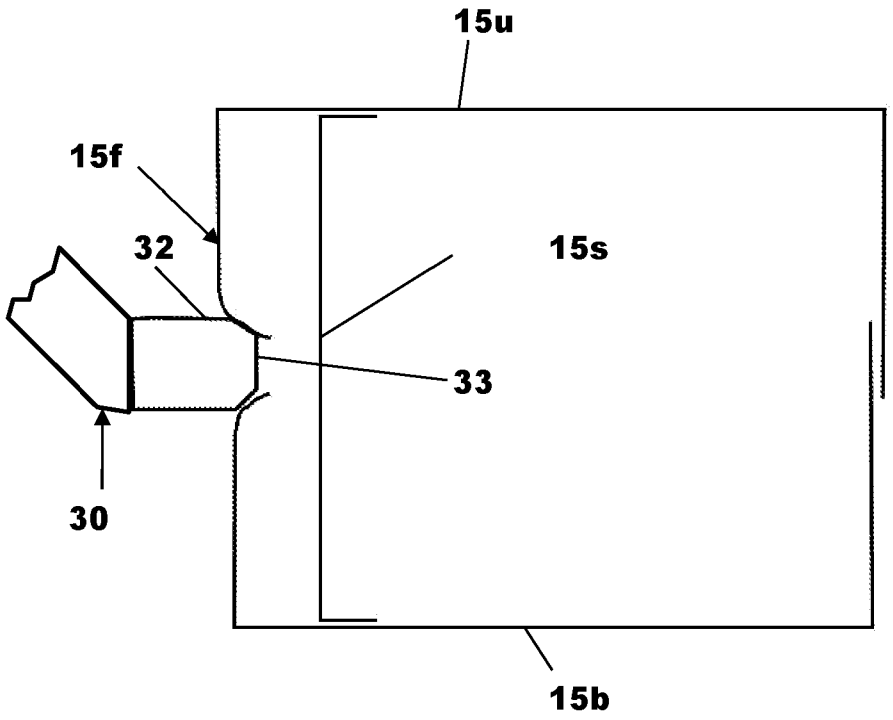

Fig.9b

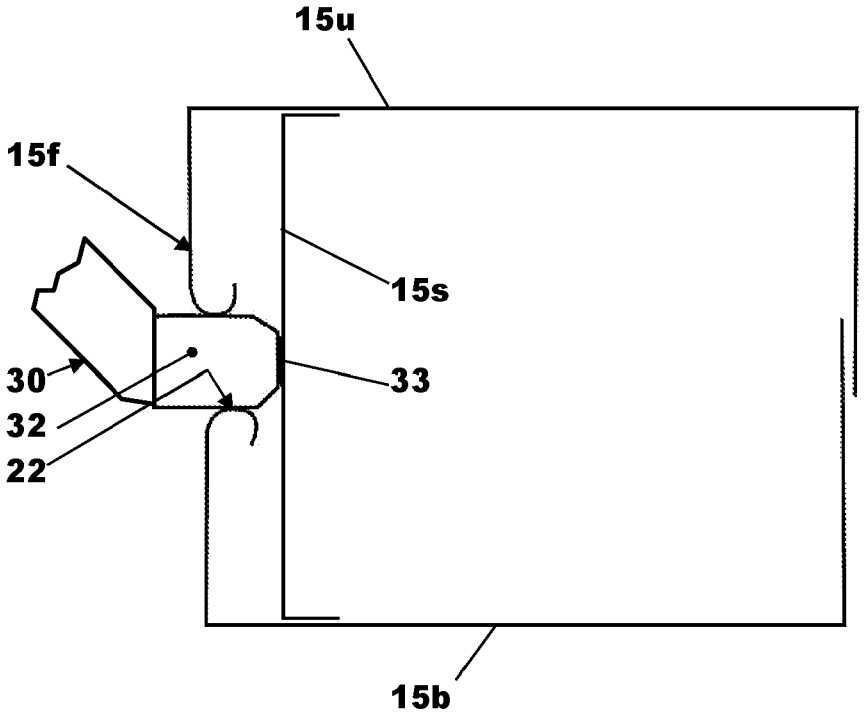

Fig.9c

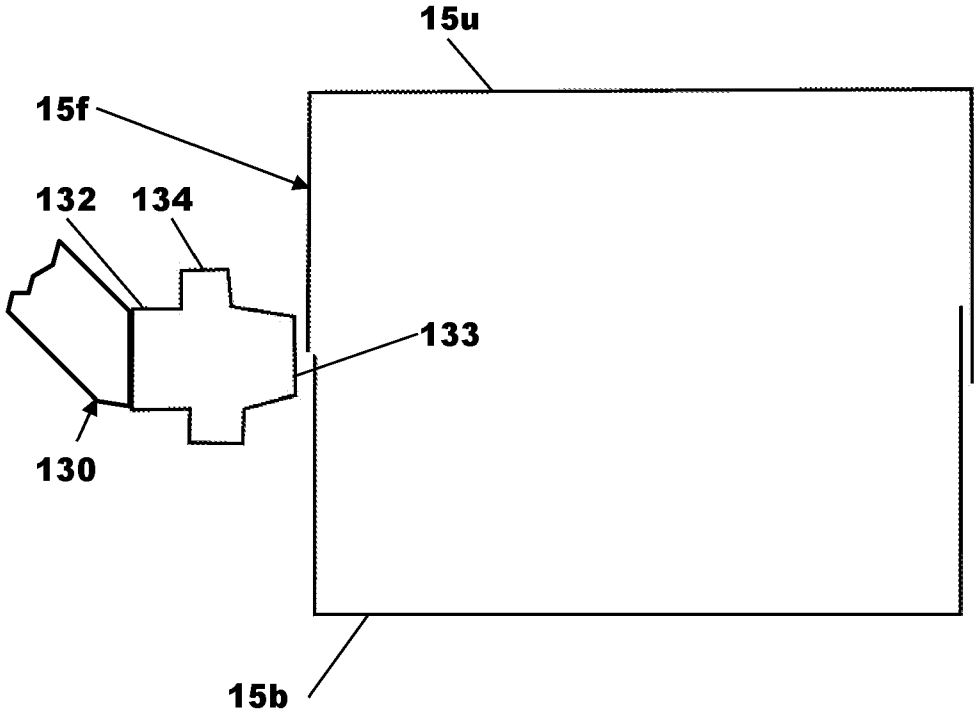

Fig.10a

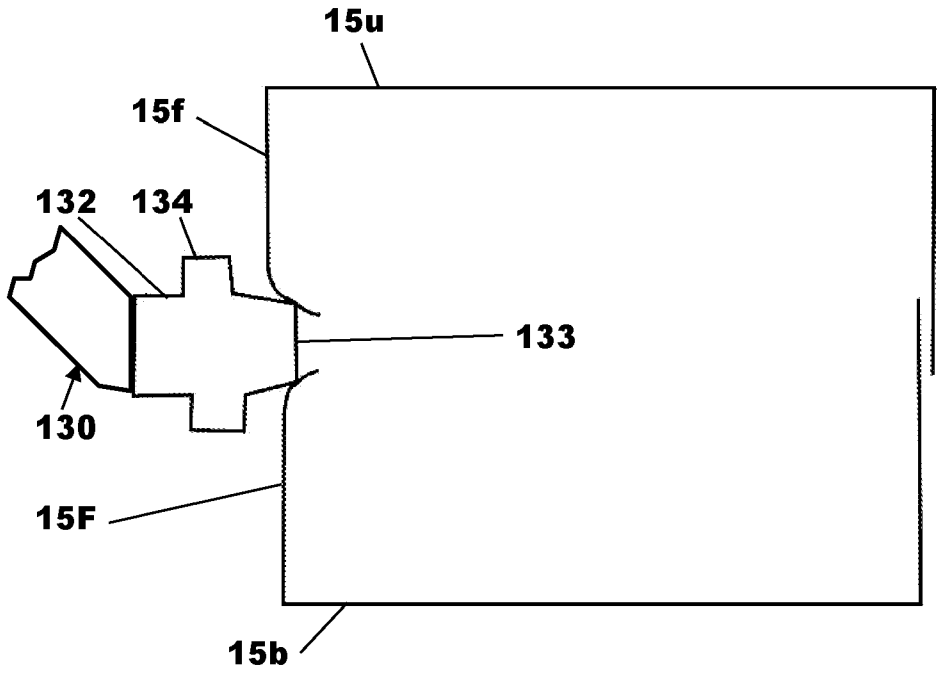

Fig.10b

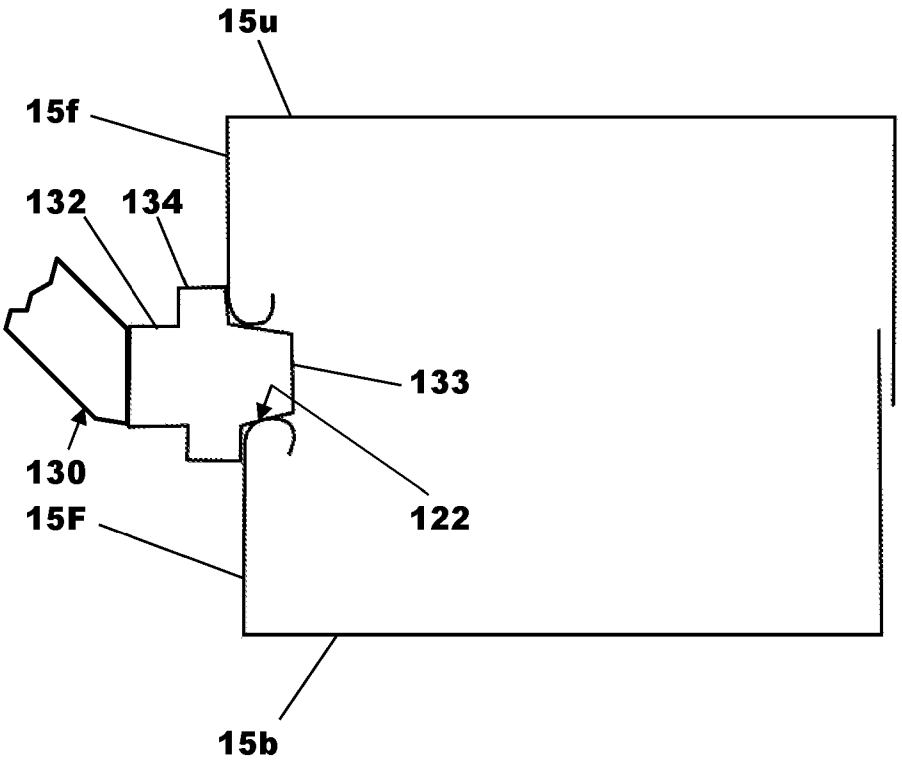

Fig.10c

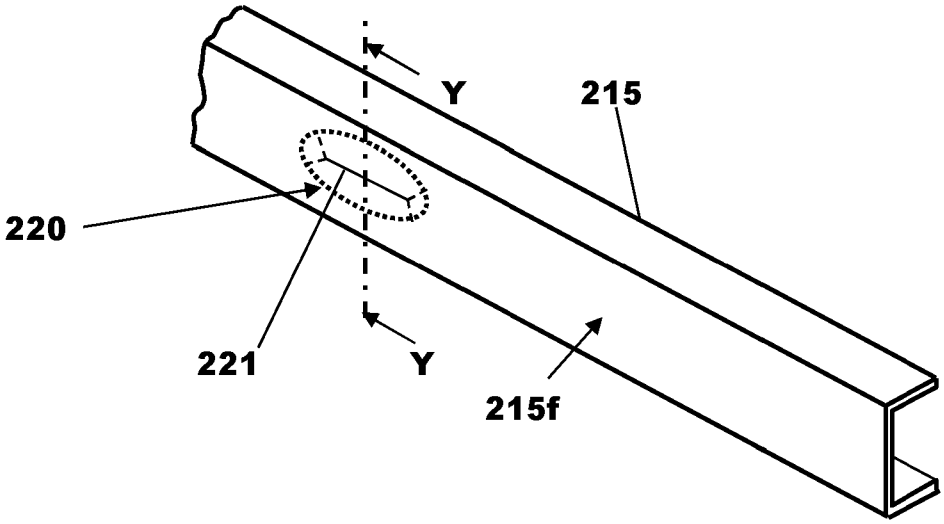

Fig.11a

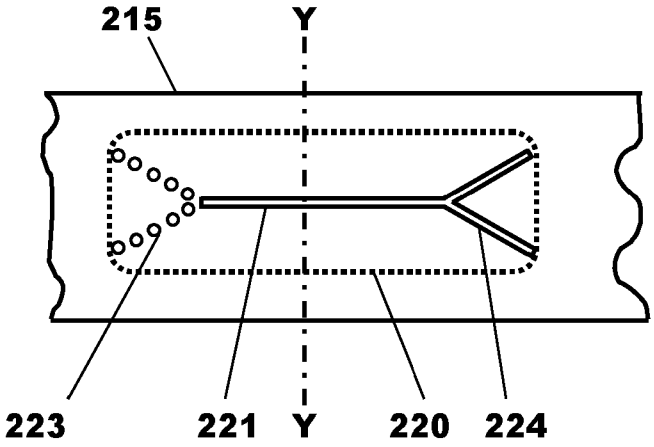

Fig.11b

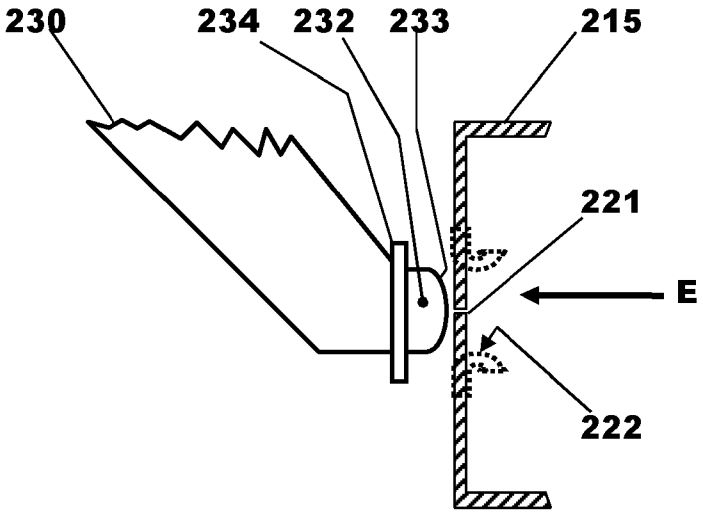

Fig.11c

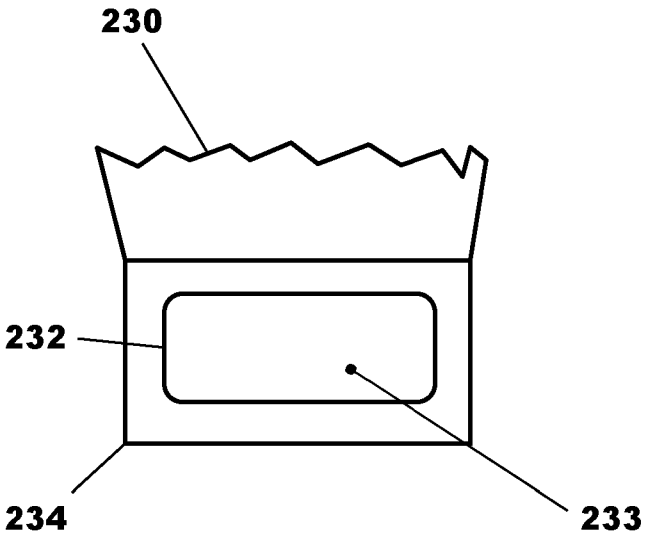

Fig.12

A Road Vehicle Having a Powertrain Catcher Apparatus

This invention relates to road vehicles and, in particular, to a powertrain catcher apparatus to restrain movement of the powertrain in the event of a frontal impact.

It is well known to mount a powertrain for a vehicle at the front end of a vehicle in a compartment often referred to as an engine compartment.

In the event that the vehicle is involved in a high speed frontal collision it is often the case that the powertrain can break loose from its mountings and travel in an unrestrained manner which is undesirable as it can interfere with the operation of other equipment designed to reduce the effect of such a collision such as deformable front end members.

It is a further problem that such an unrestrained powertrain can move rearwardly and impact against a bulkhead separating the engine compartment from a passenger compartment. This is undesirable because it can result in intrusion of the bulkhead into the passenger compartment.

One problem associated with the provision of a strong and robust powertrain catcher apparatus is that there is significant motion of the powertrain on its mountings during normal use and so a fixed rigid restraining apparatus is not suitable for use.

It is an object of this invention to provide a vehicle having a powertrain catcher apparatus that in the event of a frontal impact can effectively restrain movement of the powertrain while permitting motion of the powertrain on its mountings during normal use.

According to a first aspect of the invention there is provided a road vehicle having a powertrain, a bulkhead dividing a front compartment of the vehicle in which the powertrain is mounted from a passenger compartment of the vehicle and a powertrain catcher apparatus comprising a powertrain catcher and a transverse structural member forming part of the vehicle positioned rearwardly with respect to the powertrain catcher wherein the powertrain catcher is disposed between the powertrain and the transverse structural member and comprises a rigid arm portion extending away from a structural part of the powertrain and a punch member portion extending rearwardly away from the arm portion towards the transverse structural member, the punch portion having an impact surface that, during normal use, is spaced away from a weakened region of transverse structural member and that, in the event of rearward displacement of the powertrain, impacts against the weakened region of the transverse structural member thereby causing the punch portion to push through the weakened region of the transverse structural member to form an aperture with which the punch portion is tightly engaged.

The transverse structural member may be located on the vehicle between the powertrain catcher and the bulkhead dividing the front compartment from the passenger compartment.

The vehicle may have left and right hand side rails extending forwardly from the bulkhead and the transverse structural member may be fastened at one end to the left side rail and is fastened at an opposite end to the right side rail.

The transverse structural member may be a rear cross member of a sub-frame used to support the powertrain in the front compartment.

The sub-frame may also have a left hand side member, a right hand side member and a front cross member and the rear cross member may be fastened to the left and right side rails via the left hand and right side members respectively.

The powertrain catcher may be formed as an integral part of the structural part of the powertrain.

Alternatively, the powertrain catcher may be a separate component that is fastened to the structural part of the powertrain.

The powertrain catcher apparatus may further comprise a travel stop to limit rearward movement of the powertrain after engagement of the punch member with the aperture.

The travel stop may be formed as part of the powertrain catcher. Alternatively, the travel stop may be formed as part of the transverse structural member.

The transverse structural member may be a box section beam formed of upper and lower members having overlapping edge portions that are secured together to form the box section beam. In which case, at least one edge of the upper and lower members forming in combination a front face of the box section beam may be recessed to form a cutaway forming the weakened region.

There may be only one thickness of material forming the front face of the box section beam in the weakened region.

In order to further weaken the transverse structural member in the weakened region, the upper and lower members forming the front face of the box section beam may not secured together in the weakened region of the transverse structural member.

The invention will now be described by way of example with reference to the accompanying drawing of which:-

Fig.1 is a pictorial representation of a front end of a road vehicle showing a powertrain mounted in a front compartment of the vehicle;

Fig.2 is a pictorial underside view of a part of a front end of the vehicle showing a first embodiment of a powertrain apparatus according to the invention;

Fig.3 is an enlarged pictorial view from below of the powertrain catcher apparatus shown in Fig.2;

Fig.4 is a pictorial view from above of a transverse structural member forming part of the powertrain catcher apparatus shown in Figs.2 and 3;

Fig.5 is an underside view of the front end of the vehicle showing the location of the powertrain catcher apparatus of Figs.2 to 4;

Fig.6 is a schematic side view of a central part of a transverse structural member such as the transverse structural member shown in Figs.2 to 4 showing its construction as a box section beam and a first arrangement for producing a weakened region;

Fig.6a is a scrap cross-section on the line A-A on Fig.6;

Fig.6b is a scrap cross-section on the line B-B on Fig.6;

Fig.7 is a side view of an alternative constructional arrangement of a weakened region in a

transverse structural member such as the box section beam shown in Fig.6;

Fig.8 is a side view showing upper and lower members of the box section beam of Fig.7 prior to assembly to form the box section beam showing two cutaway portions used to produce upon assembly the weakened region;

Fig.9a is a scrap cross-sectional view through a box section beam as shown in Fig.6b showing a first embodiment of a powertrain catcher during normal use of a vehicle of which it forms a part;

Fig.9b is a view similar to that of Fig.9a but showing the powertrain catcher forming an opening in a front face of the box section beam due to rearward movement of a powertrain to which the powertrain catcher is connected;

Fig.9c is a view similar to that of Figs.9a and 9b but showing the powertrain catcher engaged in an aperture that it has formed and in contact with a travel stop formed as part of the box section beam used to inhibit further rearward motion of the powertrain;

Fig.10a is a scrap cross-sectional view through a box section beam as shown in Fig.6b showing a second embodiment of a powertrain catcher during normal use of a vehicle of which it forms a part;

Fig.10b is a view similar to that of Fig.10a but showing the powertrain catcher forming an opening in a front face of the box section beam due to rearward movement of a powertrain to which the powertrain catcher is connected;

Fig.10c is a view similar to that of Figs.10a and 10b but showing a travel stop formed as part of the powertrain

catcher engaging the box section beam to inhibit further rearward motion of the powertrain;

Fig.11a is a pictorial view of a transverse structural member formed as a single part having an alternative arrangement for producing a weakened region;

Fig.11b is an enlarged view of the weakened region shown in Fig.11a showing three alternative weakening arrangements;

Fig.11c is a cross-section view on the line Y-Y on Figs. 11a and 11b showing a powertrain catcher approaching the transverse structural member; and

Fig.12 is a view in the direction of the arrow E on Fig.11b showing on an enlarged scale an end portion of the powertrain catcher.

With reference to Fig.1 there is shown a front end of a road vehicle 1 provided for reference purposes. The vehicle 1 has a pair of side rails 12L, 12R extending forwardly from a bulkhead 6 to support at a front end of the vehicle 1 a bumper beam 13.

A powertrain 19 is shown in dotted outline supported by a sub-frame 14 in a front compartment 7 of the vehicle 1. The sub-frame 14 is fastened to the two side rails 12L, 12R so as to provide a strong support for the powertrain 19.

The powertrain 19 is connected to the sub-frame 14 by a number of flexible mounts (not shown) so as to reduce the transmission of vibration from the powertrain 19 to other parts of the vehicle 1 such as a passenger compartment 8.

The passenger compartment 8 is separated from the front compartment 7 by a bulkhead 6 as is well known in the art.

A powertrain catcher 30 is shown schematically depending from the powertrain 19 so as to be spaced away from a transverse structural member 15 of the sub-frame 14. The transverse structural member 15 includes a weakened region 20 with which the powertrain catcher 30 engages in the event that the powertrain 19 is moved rearwardly in the event of a collision.

Fig.1 provides reference directions with the double arrow T-T indicating a transverse axis of the vehicle 1, the double arrow V-V indicating a vertical axis of the vehicle 1 and the double arrow F-R indicating a longitudinal axis of the vehicle 1 with "F" indicating the front and "R" indicating the rear. These references are used throughout to indicate the orientation of objects and so an object said to be 'extending transversely' or said to be "transverse" will be arranged to extend substantially in the direction of the transverse axis T-T.

It will be appreciated that the term "passenger compartment" means any compartment in which one or more occupants can be accommodated.

With particular reference to Figs.2 to 9c there is shown in more detail a first embodiment of a powertrain catcher apparatus for inhibiting movement of the powertrain 19 forming part of the road vehicle 1 in the event of a severe frontal collision.

The powertrain catcher apparatus forms part of a road vehicle such as the road vehicle 1 shown in Fig.1.

As before the vehicle includes a bulkhead 6 (shown as a dotted line in Fig.5) dividing the front compartment 7 of the vehicle 1 in which the powertrain 19 is mounted from the passenger compartment 8 of the vehicle 1.

In accordance with this invention, the powertrain catcher apparatus comprises the powertrain catcher 30 and the transverse structural member 15 positioned rearwardly with respect to the powertrain catcher 30.

The powertrain catcher 30 is disposed between the powertrain 19 and the transverse structural member 15 and, in the case of this embodiment, comprises a rigid arm portion 31 extending away from a structural part 19a of the powertrain 19 and a punch member portion 32 extending in a rearward direction of the vehicle 1 away from the arm portion 31 towards the transverse structural member 15.

The powertrain catcher 30 is formed as an integral part of the structural part 19a of the powertrain 19. The structural part in the case of this example is a cast metal adaptor ring 19a joining an engine 19e to an electric machine 19m.

It will however be appreciated that in other embodiments the structural part can be any structurally strong part of a powertrain such as, for example a cylinder block of an engine, a transmission casing or a housing of an electric machine.

The powertrain catcher 30 is formed as an integral part of the structural part 19a of the powertrain 19 by being cast as one with the adaptor ring 19a. It will however be appreciated that in other embodiments the powertrain catcher can be a separate component that is fastened to the structural part of the powertrain by for example threaded fasteners.

As shown in Fig.3, the rigid arm portion 31 is comprised of two flanges 31a, 31b and a central web 31c and is substantially L-shaped with the rigid arm portion 31

extending downwardly from the adaptor ring 19a and the punch portion 32 extending rearwardly from a lower end of the rigid arm portion 31.

The punch portion 32 has an impact surface 33 (not visible in Figs. 2 to 5) at a free end thereof that, during normal use, is spaced away from the weakened region 20 of the transverse structural member 15.

In the case of this example, the transverse structural member is in the form of a rear cross member 15 of the sub-frame 14 used to support the powertrain 19 in the front compartment 7.

The sub-frame 14 has in addition to the rear cross member 15, a left hand side member 17L, a right hand side member 17R and a front cross member 16. The rear cross member 15 is fastened to the left and right side rails 12L and 12R via the left hand and right side members 17L and 17R respectively by means of threaded fasteners 18.

The rear cross member 15 forming the transverse structural member is in the case of this example formed by a box section beam formed of C-shaped upper and lower members 15u and 15b that are secured together by a continuous welding process which produces welded joints 26. In other examples the upper and lower members 15u and 15b can be secured together by some other method such as, for example, spot welding or riveting.

The upper and lower members 15u and 15b have free edges 15ue and 15be and overlap one another along a front face 15f and a rear face 15r of the rear cross member beam 15 to form an overlap regions “P” (see Fig.6a) extending along the front and rear faces 15f and 15r of the rear cross member 15. In the case of this example the upper member 15u

overlies the lower member 15b to form the overlap regions "P".

The edge 15ue of the upper member 15u forming part of the front face 15f of the rear cross member 15 has a recess 21 in the edge 15ue of the upper member 15u. The recess 21 forms the weakened region 20 of the box section beam 15 by producing an cutaway area on the front face 15f of the rear cross member 15 in which there is only one thickness of material forming the front face 15f of the rear cross member 15. In the case of this example, the one thickness of material is the material forming the overlapping portion of the lower member 15b of the rear cross member 15. However, it will be appreciated that if, as an alternative, a cutaway area is formed in the lower member 15b then the one thickness of material forming the front face 15f of the rear cross member 15 would be the upper member 15u.

The provision of a single material thickness enables the punch portion 32 of the powertrain catcher 30 to more easily punch through the rear cross member 15 as will be described in more detail hereinafter. To further weaken the rear cross member 15 the upper and lower members 15u and 15b forming the front face 15f are not secured together in the region of the weakened region 20. Any securing means such as seam welding or spot welding extends up to or is located close to the weakened region 20 in order to prevent undesirable distortion outside of the weakened region 20 which could reduce the stabilising effect of the engagement of the punch portion 32 with the aperture 20.

The rear cross member 15 is located between the powertrain catcher 30 and the bulkhead 6 dividing the front compartment 7 from the passenger compartment 8 so that in the case of rearward movement of the powertrain 19 the powertrain catcher 30 will contact the rear cross member 15. More specifically, the impact surface 33 of the punch

portion 32 will, in the event of rearward displacement of the powertrain 19, impact against the weakened region 20 on a front face 15f of the rear cross member 15 causing the punch portion 32 to punch through the weakened region 20 of the rear cross member 15 to form an aperture 22 (see Fig.9c) in the rear cross member 15. The punch portion 32 thereafter remains tightly engaged with the aperture 22 thereby restraining both vertical movement of the powertrain 19 and transverse movement of the powertrain 19.

It will be appreciated that the punch portion 32 has a complementary shape to the aperture 22 formed by it.

As shown in Figs.6a, 6b and Figs.9a to 9c the rear cross member 15 includes a travel stop 15s to limit rearward movement of the powertrain 19 after engagement of the punch member 32 with the aperture 22. The travel stop in the case of this example is formed by a C-shaped member 15s fastened inside the rear cross member 15 however it will be appreciated that the travel stop could be formed in some other manner by for example, shaping one of the upper and lower member 15u and 15b to form the travel stop.

As described hereinafter with reference to Figs.9a to 9c, the travel stop 15s is engaged by impact surface 33 of the punch portion 32 of the powertrain catcher 30 to restrain further movement of the powertrain 19 in a rearward direction by transferring force from the powertrain 19 through the powertrain catcher 30 to the travel stop 15s and the rear cross member 15 which will is deflected in a controlled manner thereby absorbing energy. This deformation of the rear cross member 15 will reduce rearward movement of the powertrain 19 compared to an unrestrained condition so that contact of the powertrain 19 with the bulkhead 6 is either significantly reduced or prevented depending upon the magnitude of the force transferred from

the powertrain 19 and the distance of the un-deformed rear cross member 15 from the bulkhead 6.

In Figs.7 and 8 there is shown an alternative arrangement for producing a weakened region that use two rather than one cutaway area to produce the weakened region in the rear cross member 15.

In Fig.8 upper and lower members 55u and 55b forming the rear cross member 15 are shown in the region of a weakened region 60 prior to assembly.

In the case of this example, an edge 55ue of the upper member 55u forming part of a front face of the rear cross member 15 is cutaway to form a recess 61u in the edge 55ue of the upper member 55u and an edge 55be of the lower member 55b forming the other part of a front face of the rear cross member 15 is cutaway to form a recess 61b in the edge 55be of the lower member 55b.

When the upper and lower members 55u and 55b are assembled together the two cutaways formed by the recesses 61u,61b define the weakened region 60 of the rear cross member 15 by producing an area on the front face of the rear cross member 15 in which there is only one thickness of material forming the front face.

With particular reference to Figs.9a to 9c there is shown diagrammatically how the powertrain catcher apparatus operates.

In Fig.9a the punch portion 32 of the powertrain catcher 30 is shown in a normal use position prior to a frontal collision of the vehicle 1. In this normal position the impact surface 33 of the punch portion 32 is spaced away from the front face 15f of the rear cross member 15. The powertrain 19 is therefore free to move on its mountings and

there is no contact between the powertrain 19 or the powertrain catcher 30 and the rear cross member 15.

In Fig.9b the powertrain 19 has been moved rearwardly by a frontal collision and the punch portion 32 has impacted against the front face 15f of the rear cross member 15 causing the impact face 33 to punch through the weakened region 20 of the rear cross member 15. This has caused material near the edges of the upper and lower member 15u and 15b respectively to be plastically deformed producing an opening in the front face 15f of the rear cross member 15.

In Fig.9c the rearward movement of the powertrain 19 has continued causing the impact face 33 of the punch portion 32 to impact against the travel stop 15s. In this fully engaged position of the punch portion 32 an aperture 22 has been formed by the punch portion 32 corresponding to the dimensions of the punch portion 32. The punch portion 32 thereafter remains tightly engaged with the aperture 22 that it has produced to prevent vertical or transverse movement of the powertrain 19. In addition, the contact of the impact face 33 of the punch member 32 with the travel stop 15s produces a force path from the powertrain 19 to the rear cross member 15 and any further rearward movement of the powertrain 19 will be resisted by the rear cross member 15 which, if the force applied thereto is high enough, will deform in a predefined manner to absorb energy while reducing rearward movement of the powertrain 19.

With particular reference to Figs.10a to 10c there is shown diagrammatically how an alternative embodiment of a powertrain catcher apparatus operates. The only significant difference between this alternative embodiment and that previously described with respect to Figs.9a to 9c is that in the case of this embodiment a travel stop 134 is formed as part of a powertrain catcher 130 rather than being a part of the rear cross member 15.

In Fig.10a a punch portion 132 of a powertrain catcher 130 is shown in a normal use position prior to a vehicular collision. In this normal position an impact surface 133 on the end of the punch portion 132 is spaced away from the front face 15f of the rear cross member 15. The powertrain 19 is therefore free to move on its mountings and there is no contact between the powertrain 19 or the powertrain catcher and the rear cross member 15.

In Fig.10b the powertrain 19 has been moved rearwardly and the punch portion 132 has impacted against the front face 15f of the rear cross member 15 causing the impact face 133 to be pushed through a weakened region of the rear cross member 15. This has caused material near the edges of the upper and lower member 15u and 15b respectively to be plastically deformed and a opening is formed in the front face 15f of the rear cross member 15.

In Fig.10c the rearward movement of the powertrain 19 has continued causing the impact face 133 of the punch portion 132 to fully enter the rear cross member 15 and the travel stop 134 to impact against the front face 15f of the rear cross member 15. In this fully engaged position an aperture 122 has been formed by the punch portion 132 corresponding to the dimensions of the punch portion 132. The punch portion 132 will then remain tightly engaged with the aperture 122 that it has produced so as to prevent vertical or transverse movement of the connected powertrain 19. This is because the powertrain 19 is likely to be still moving in a rearward direction thereby preventing disengagement of the punch portion 132.

The contact of the travel stop 134 on the powertrain catcher 130 with the front face 15f produces a force path from the powertrain 19 to the rear cross member 15 and any further rearward movement of the powertrain 19 is resisted

by the rear cross member 15 which, if the force applied thereto is high enough, will deform in a predefined manner to absorb energy and reduce rearward movement of the powertrain 19.

It will be appreciated that the deformation of the material forming the rear cross member 15 due to rolling and folding as the punch portion 32, 132 pushes through the weakened region will work harden the material so deformed and produce a reinforcing lip around the aperture 22, 122 so formed enabling the powertrain catcher 30, 130 to perform its desired functionality.

With particular reference to Figs.11a to 12 there is shown an alternative powertrain catcher apparatus in which the fabricated box section beam previously referred to is replaced by a single transverse structural member 215. The transverse structural member 215 can form part of a sub-frame as previously discussed or can be an independent component that is attached directly to the two side rails 12L, 12R.

In the case of this embodiment there is a weakened region 220 of the transverse structural member 215 but it is formed in a different manner to that previously described.

Fig.11b shows on an enlarged scale the weakened region 220 which comprises primarily of a weakening slit 221 extending along the transverse structural member 215. To further weaken the transverse structural member 215 end weakening portions 223, 224 are also provided to assist a powertrain catcher 230 to punch through the transverse structural member 215. The weakening end portions 223, 224 are shown using different weakening strategies with the left hand end portion 223 using a number of spaced apart apertures arranged in a “V” shaped formation and the right hand end portion 224 using a pair of continuous slits or

grooves arranged in a “V” shaped formation. These are merely examples and many other combinations are possible for producing the weakening end portions 223, 224.

As before when a punch portion 232 of a powertrain catcher 230 impacts the weakened region 220 of the transverse structural member 215, the material of the transverse structural member 215 is deformed and the punch portion punches through the weakened region 220 to form an aperture 222 (shown in dotted outline on Fig.11c) with which the punch portion 232 remains tightly engaged to restrain subsequent vertical and transverse movement of the powertrain 19.

Therefore in summary, a powertrain is prevented from moving excessively rearwardly by incorporating an arresting 'powertrain catcher' that punches an aperture in a weakened region of a structural member.

The powertrain catcher remains tightly engaged with the aperture that it has produced thereby restraining further movement of the powertrain.

The interaction between the powertrain catcher and the transverse structural member also has the effect of holding back the powertrain from a bulkhead such as a ‘dash panel’ thereby reducing possible intrusion into an occupant compartment of the vehicle.

It will be appreciated by those skilled in the art that although the invention has been described by way of example with reference to one or more embodiments it is not limited to the disclosed embodiments and that alternative embodiments could be constructed without departing from the scope of the invention as defined by the appended claims.

Claims

1. A road vehicle having a powertrain, a bulkhead dividing a front compartment of the vehicle in which the powertrain is mounted from a passenger compartment of the vehicle and a powertrain catcher apparatus comprising a powertrain catcher and a transverse structural member forming part of the vehicle positioned rearwardly with respect to the powertrain catcher wherein the powertrain catcher is disposed between the powertrain and the transverse structural member and comprises a rigid arm portion extending away from a structural part of the powertrain and a punch member portion extending rearwardly away from the arm portion towards the transverse structural member, the punch portion having an impact surface that, during normal use, is spaced away from a weakened region of transverse structural member and that, in the event of rearward displacement of the powertrain, impacts against the weakened region of the transverse structural member thereby causing the punch portion to push through the weakened region of the transverse structural member to form an aperture with which the punch portion is tightly engaged.

2. A vehicle as claimed in claim 1 wherein the transverse structural member is located on the vehicle between the powertrain catcher and the bulkhead dividing the front compartment from the passenger compartment.

3. A vehicle as claimed in claim 1 or in claim 2 wherein the vehicle has left and right hand side rails extending forwardly from the bulkhead and the transverse structural member is fastened at one end to the left side rail and is fastened at an opposite end to the right side rail.

4. A vehicle as claimed in claim 3 wherein the transverse structural member is a rear cross member of a

sub-frame used to support the powertrain in the front compartment.

5. A vehicle as claimed in claim 4 wherein the sub-frame also has a left hand side member, a right hand side member and a front cross member and the rear cross member is fastened to the left and right side rails via the left hand and right side members respectively.

6. A vehicle as claimed in any of claims 1 to 5 wherein the powertrain catcher is formed as an integral part of the structural part of the powertrain.

7. A vehicle as claimed in any of claims 1 to 5 wherein the powertrain catcher is a separate component that is fastened to the structural part of the powertrain.

8. A vehicle as claimed in any of claims 1 to 7 wherein the powertrain catcher apparatus further comprises a travel stop to limit rearward movement of the powertrain after engagement of the punch member with the aperture.

9. A vehicle as claimed in claim 8 wherein the travel stop is formed as part of the powertrain catcher.

10. A vehicle as claimed in claim 8 wherein the travel stop is formed as part of the transverse structural member.

11. A vehicle as claimed in any of claims 1 to 10 wherein the transverse structural member is a box section beam formed of upper and lower members having overlapping edge portions that are secured together to form the box section beam.

12. A vehicle as claimed in claim 11 wherein at least one edge of the upper and lower members forming in

combination a front face of the box section beam is recessed to form a cutaway forming the weakened region.

13. A vehicle as claimed in claim 12 wherein there is only one thickness of material forming the front face of the box section beam in the weakened region.

14. A vehicle as claimed in claim 12 or in claim 13 wherein, in order to further weaken the transverse structural member in the weakened region, the upper and lower members forming the front face of the box section beam are not secured together in the weakened region of the transverse structural member.