EUROPEAN PATENT APPLICATION

(54) Front carriage of a train equipped with a front structure that absorbs energy in case of collision

(57) A front carriage (2) of a train (1) is equipped with an automatic coupler (6), which extends longitudinally (3) and is connected to a load-carrying frame (5) of the front carriage (2); the front carriage (2) is also provided with a front structure (24), which is carried by the frame (5) to absorb energy in case of collision and has a substantially vertical and relatively rigid support plate (16); a first absorber (9) constitutes part of the coupler (6) and is plastically deformable to absorb energy in a first stage during a head-on collision, while second absorbers (27,29) are carried by the support plate (16), project from the front of the support plate (16) and are plastically deformable to absorb energy in a second stage during the collision after the first stage has terminated.
Description

[0001] The present invention concerns a front carriage of a train equipped with a front structure that absorbs energy in case of collision.

[0002] As is known, the locomotive or the front carriage of trains, especially so-called high-speed trains, is equipped with front structures that absorb energy by plastically deforming in case of head-on collision to protect the drivers cab.

[0003] There is the need to provide plastically deformable structures that guarantee the safety of the driver in the cab in an optimal manner and that deform progressively. In particular, there is awareness of the need to have plastic deformation only in certain circumscribed zones defining parts of elements that are easily substituted, especially in cases of relatively low impact speeds, and to avoid interference by the elements that have already been deformed or broken in a first stage during the deformation of the front structure in the subsequent stages.

[0004] The object of the present invention is to provide a front carriage of a train equipped with a front structure that absorbs energy in case of collision, which allows the above-stated needs to be met in a simple and economic manner.

[0005] According to the present invention, a front carriage of a train equipped with a front structure that absorbs energy in case of collision is provided, the front carriage comprising:

- an automatic coupler comprising
  a) a head, and
  b) a rod extending in a longitudinal direction of travel of the train and carrying said head on its front end;

- a frame;

- a substantially vertical and relatively rigid support plate, carried by said frame;

characterized by comprising:

- a first absorber which is plastically deformable to absorb energy in a first stage during a head-on collision and which constitutes part of said automatic coupler; and

- second absorbers, which are carried by said support plate, project from the front of said support plate, and are plastically deformable to absorb energy in a second stage during the collision, after said first stage has terminated.

[0006] The invention shall now be described with reference to the enclosed drawings, which illustrate a non-limitative embodiment, where:

- Figure 1 shows, in perspective, a preferred embodiment of the front carriage of a train equipped with a front structure that absorbs energy in case of collision, according to the present invention.

- Figures 2 to 5 show, in perspective from below, a sequence of the deformation of the front structure in Figure 1 during a head-on collision, and

- Figures 6 and 7 are compression resistance graphs of the front structure during the collision.

[0007] In Figure 1, reference numeral 1 indicates a train in its entirety; in the described example, the train 1 is a high-speed one formed by eight carriages, of which only the front carriage 2 is partially shown. The eight carriages are coupled along a longitudinal direction of travel of the train 1: carriage 2 and the end carriage are powered and equipped with a cab 4, four intermediate carriages are drawn and two intermediate carriages are powered and positioned between the drawn ones.

[0008] Regarding passive safety in case of collision, the train 1 is designed to meet the directives imposed by the TSI European regulations of 2002, without evident plastic deformation of the cabs 4.

[0009] The carriage 2 comprises a load-carrying frame 5, or body, defining the cab 4, and is shown without the body or the aerodynamic outer skin that covers the frame 5. The carriage 2 also comprises an automatic coupler 6, which in turn comprises a front head 7, of known type, placed on the outside of the above-mentioned body, and a longitudinal rear rod 8. The rod 8 comprises a rear tubular portion 9 (not visible) housed in a fixed position in the front end of a tube 10.

[0010] With reference to Figures 2 to 5, the tube 10 engages a portion 11 of the body 5, is connected to the body 5 via a breakable device 12 (not described in detail) and can move back into a longitudinal lower compartment 14 of the body 5 after device 12 breaks. In particular, portion 11 defines the front of the compartment 14 and has a cylindrical seat 15, which longitudinally guides the tube 10 during retraction into the compartment 14.

[0011] The front end of the tube 10 is fixed to a substantially vertical portal or support plate 16, by welding for example, and carries a fixed shoulder 17, behind the plate 16, in particular, defined by an external ring that longitudinally faces portion 11 in order to strike against portion 11 and define an end stop for the backward travel of the tube 10.

[0012] Plate 16 is placed in front of a vertical plate 22, frontally defining the bottom part of the cab 4, is spaced apart from plate 22 and has an aperture 23 (Figure 1) through which the rod 8 passes.

[0013] The rod 8 comprises a front portion 18 and an intermediate tubular portion 19, which are positioned in front of plate 16, are coaxial with portion 9 and are coupled together via a hydraulic cartridge (not shown), defining a reversible type of relative longitudinal sliding. Portion 19 is connected to plate 16 via a breakable device 20 (not described in detail) and can move back longitudi-
ordinarily to plastically deform portion 9 when device 20 breaks in the case of head-on collision against an obstacle 25. In other words, portion 9 absorbs energy in a first stage of deformation or absorption during the collision (curve segment (a) in Figure 7).

[0014] With reference to Figure 1, in case of collision, a front structure 24 is provided to absorb energy in a second and in a third stage following the first one. Structure 24 is symmetrical with respect to an ideal vertical plane on which direction 3 lies and comprises two absorbers 27 defined by truncated-cone boxed elements placed on opposite sides of portion 19 and equipped with respective vertical frontal anti-climber plates 28, and a central absorber 29 defined by a honeycomb structure placed above portion 19. The absorbers 27 and 29 are mounted in fixed positions, projecting from a front face 30 of plate 16 and are plastically deformable to absorb energy in the second stage (curve segment (b) in Figure 7) during the collision.

[0015] Structure 24 also comprises two lower absorbers 32 and two upper absorbers 34, which are placed behind plate 16, connect plates 16 and 22 together, are plastically deformable to absorb energy in the third stage (curve segment (c) in Figure 7) during the collision and are horizontally aligned with absorbers 27 and absorber 29 respectively. In particular, absorbers 32 and 27 are mutually coaxial along axes parallel to direction 3.

[0016] Finally, structure 24 comprises two pairs of stops 36, which are relatively rigid, carried by face 30 in fixed, projecting positions and, with respect to the entrance of aperture 23 in face 30, have a longitudinal bulk greater or equal to the length of the head 7.

[0017] Figure 6 shows a theoretical curve, set by design, and related to the longitudinal compression resistance Y that the carriage 2 exerts as a function of the longitudinal travel X effected by the obstacle 25 towards the body 5, starting from the moment in which the obstacle 25 is struck by the head 7. Instead, Figure 7 shows an experimental curve of the resistance Y as a function of travel X in the third stage (curve segment (c) in Figure 7) during the collision and is defined by the above-mentioned hydraulic cartridge, device 20 breaks so as to allow portion 19 to move back to plastically deform portion 9, which offers resistance Y equal to a value A (preferably constant and equal to approximately 1.4 * 10^6 N) and for a maximum travel B (preferably equal to approximately 0.40 m).

[0018] The absorbers 9, 27, 29, 32 and 34 are able to absorb an overall maximum quantity of energy of approximately 6 MJ and progressively collapse in stages, i.e. they start to plastically deform at different moments as the travel X increases.

[0019] The element that is first subjected to impact is the coupler 6 (Figure 2): when the longitudinal compression exerted by the obstacle 25 on the head 7 exceeds a preset threshold (after partial relative sliding between portions 18 and 19, which is in function of the speed of impact and is defined by the above-mentioned hydraulic cartridge), device 20 breaks so as to allow portion 19 to move back to plastically deform portion 9, which offers resistance Y equal to a value A (preferably constant and equal to approximately 1.4 * 10^6 N) and for a maximum travel B (preferably equal to approximately 0.40 m).

[0020] In order not to obstruct or interfere with the deformation of absorbers 27 and 29, after travel B, the coupler 6 moves back longitudinally, essentially without any resistance. In particular, the rod 8 moves back freely, guided by tube 10, while tube 10 remains fixed with respect to plates 16 and 22.

[0021] The second stage starts when the obstacle 25 comes into contact with plates 28 (Figure 3), in particular, after the obstacle 25 has covered an "unchecked" distance C (approximately 0.7 m), i.e. travel in which the rod 8 has offered substantially zero longitudinal resistance (curve segment (d) in Figure 7) once the deformation of portion 9 has terminated.

[0022] During the second stage, absorbers 27 and 29 offer resistance Y equal to a value A for a maximum travel E (preferably equal to approximately 0.8 m). Value D is greater than value A and, in particular, grows as travel E increases (for example, from approximately 2.8 * 10^6 N up to approximately 3 * 10^6 N).

[0023] The second stage terminates when the obstacle 25 hits the stops 36 (Figure 4): in this phase, it has been experimentally found that the resistance Y has a peak (curve segment (e) in Figure 7).

[0024] Starting from this phase, the head 7 remains seated between the obstacle 25 and plate 16, without affecting the progress of the deformation that has been planned for the third stage.

[0025] Following impact of the obstacle 25 against the stops 36, tube 10 is pushed longitudinally by plate 10, causing device 12 to break. Afterwards, tube 10 is free to slide longitudinally in compartment 14 beneath the cab 4, while being guided by portion 11.

[0026] The thrust of the obstacle 25 on the stops 36 and, consequently, on plate 16 causes deformation of absorbers 32 and 34, which offer resistance Y equal to a value G, greater than value D, for a maximum travel of H (preferably equal to approximately 0.8 m). For example, G is constant and approximately equal to 3.5 * 10^6 N.

[0027] If plastic deformation of absorbers 27, 29, 32 and 34 terminates before the end of travel H, the impact speed is relatively low during the last moments and resistance Y tends to decrease as a function of travel X in a manner not shown. Furthermore, once plastic deformation of absorbers 32 and 34 has terminated (point L in Figure 7), it has been found experimentally that the wagon 25 is pushed away with several "rebounds" on structure 24 (revealed by curve segment (f) in Figure 7).

[0028] From the foregoing, it is clear how the deformation of portion 9 and absorbers 27 and 29 does not take place in parallel, but in sequence, for which in collisions at relatively low speeds, only portion 9 deforms; it is therefore possible to repair the train 1 by just substituting the absorbers carried by plate 16.

[0029] Furthermore, as mentioned above, the coupler 6 does not interfere with the energy absorption that takes place in the second and third stages, thanks to the fact that after travel B, the coupler 6 moves back freely, or
essentially without offering resistance, and thanks to the
space assured by the stops 36 in front of the face 30.

[0030] In addition, absorbers 32 and 34, in synergy
with absorbers 27 and 29, allow a high overall level of
energy to be absorbed, whereby the structure 24 is ef-
fective for protecting cabs of high-speed trains.

[0031] Finally, from the foregoing, it is clear that mod-
ifications and variants can be made to the described car-
riage 2 without leaving the scope of protection of the
present invention, as defined in the enclosed claims.

[0032] In particular, the structure 24 could be devoid
of absorbers 32 and 34, for example, in trains that are
not high-speed ones; in this case, tube 10 could be ab-
sent and/or substituted by another guide element for the
rod 8.

[0033] Furthermore, the first and second stages could
be consecutive, without curve segment (d), namely with
C = 0, and/or resistance Y could have different trends
from those indicated by way of example in each stage
as a function of travel X.

[0034] Lastly, the structure 24 could comprise an ob-
stacle deflector placed below absorbers 27 to laterally
deflect relatively low obstacles and defining further plas-
tic deformation.

Claims

1. A front carriage (2) of a train (1) equipped with a front
structure that absorbs energy in case of collision, the
front carriage comprising:

   - an automatic coupler (6) comprising
     a) a head (7), and
     b) a rod (8) extending along a longitudinal
direction (3) of travel of the train (1) and car-
rying said head (7) on its front end;

   - a frame (5);

   - a substantially vertical and relatively rigid sup-
port plate (16), carried by said frame (5);

characterized by comprising:

   - a first absorber (9) which is plastically deform-
able to absorb energy in a first stage during a
head-on collision and which constitutes part of
said automatic coupler (7);

   - second absorbers (27,29), which are carried
by said support plate (16), project from the front
of said support plate (16), and are plastically de-
formable to absorb energy in a second stage
during the collision, after said first stage has ter-
minalized.

2. The front carriage according to claim 1, character-
ized in that said first absorber (9) constitutes part
of said rod (8) and is fixed with respect to said support
plate (16).

3. The front carriage according to claim 1 or 2,
characterized in that said rod (8) comprises a front
portion (18,19), which is coaxial with said first ab-
sorber (9), is coupled to said support plate (16) via
first breakable connection means (20), and can
move back longitudinally after breakage of said first
connection means (20) to plastically deform said first
absorber (9).

4. The carriage according to claim 3, characterized in
that said front portion (18,19) continues to freely
move back longitudinally through said first absorber
(9) after the plastic deformation of said first absorber
(9).

5. The front carriage according to any of the previous
claims, characterized in that said first and second
stages are separated from each other by an inter-
mediate phase (d) in which said front structure (24)
offers substantially zero resistance to longitudinal
compression.

6. The front carriage according to claim 4, character-
ized by comprising a tube (10) that is fixed to said
support plate (16) and placed behind said support
plate (16), and guides the moving back of said front
portion (18,19) behind said first absorber (9).

7. The carriage according to claim 6, characterized in
that said first absorber (9) is housed in a fixed posi-
tion in said tube (10).

8. The carriage according to claim 6 or 7, character-
ized in that said tube (10) is connected to said frame
(5) via second breakable connection means (12) and
can move back at least partially into a compartment
(14) beneath a cab (4) of said frame (5) after break-
age of said second connection means (12).

9. The front carriage according to claim 8, character-
ized in that the breakage of said second connection
means (12) takes place at the end of said second
stage.

10. The front carriage according to claim 8 or 9,
characterized in that said frame (5) comprises a
support portion (11) engaged by said tube (10) and
defining a guide seat (15) for the longitudinal moving
back of said tube (10) into said compartment (14).

11. The front carriage according to claim 10, character-
ized in that said tube (10) carries, in a fixed position,
a shoulder (17) able to strike against said support
portion (11) to define an end stop for said longitudinal
moving back.
12. The front carriage according to any of the previous claims, characterized in that said support plate (16) carries on its front, in a fixed position, a plurality of projecting, relatively rigid stops (36), defining the end of said second stage, the longitudinal bulk of said stops (36) with respect to said support plate (16) being at least equal to the length of said head (7).

13. The front carriage according to any of the previous claims, characterized in that said support plate (16) is longitudinally spaced apart from said frame (5), and by comprising third absorbers (32,34) placed behind said support plate (16), defining a connection between said support plate (16) and said frame (5), which are plastically deformable to absorb energy in a third stage of longitudinal compression during the collision, after said second stage has terminated.

14. The front carriage according to claim 13, characterized in that said third absorbers (32,34) are horizontally aligned with said second absorbers (27,29).
### DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document with indication, where appropriate, of relevant passages</th>
<th>Relevant to claim</th>
<th>CLASSIFICATION OF THE APPLICATION (IPC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>EP 0 802 100 A (ALSTOM DDF [FR]) 22 October 1997 (1997-10-22) * column 2, line 25 - column 4, line 28; figures 1-8 *</td>
<td>1-3,6,7, 9-12</td>
<td>INV. B61D15/06</td>
</tr>
<tr>
<td>Y</td>
<td>-----</td>
<td>8</td>
<td>B61D17/06</td>
</tr>
<tr>
<td>Y</td>
<td>-----</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>FR 2 698 840 A (DIETRICH &amp; CIE DE [FR]) 10 June 1994 (1994-06-10) * page 2, line 22 - page 5, line 26; figures 1-6 *</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>-----</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>EP 0 888 946 A (ALSTOM DDF [FR]) 7 January 1999 (1999-01-07) * column 4, line 13 - column 5, line 1; figures 1-4 *</td>
<td>1,3,4</td>
<td>B61D</td>
</tr>
<tr>
<td>Y</td>
<td>-----</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>EP 0 655 565 A (GEC ALSTHOM TRANSPORT SA [FR]) 31 May 1995 (1995-05-31) * page 3, line 47 - page 8, line 45; figures 8,11,14A-17B *</td>
<td>1,13,14</td>
<td></td>
</tr>
</tbody>
</table>

The present search report has been drawn up for all claims.

Place of search: Munich
Date of completion of search: 19 March 2008
Examiner: Wojski, Guadalupe

**CATEGORY OF CITED DOCUMENTS**
- **X**: particularly relevant if taken alone
- **Y**: particularly relevant if combined with another document of the same category
- **A**: technological background
- **O**: non-written disclosure
- **P**: intermediate document
- **T**: theory or principle underlying the invention
- **E**: earlier patent document, but published on, or after the filing date
- **D**: document cited in the application
- **L**: document cited for other reasons
- **S**: member of the same patent family, corresponding document
This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EPO file on. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-03-2008

<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DE 69706597 D1</td>
<td>18-10-2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69706597 T2</td>
<td>11-07-2002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DK 802100 T3</td>
<td>17-12-2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES 2161423 T3</td>
<td>01-12-2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR 2747633 A1</td>
<td>24-10-1997</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PT 802100 T</td>
<td>30-01-2002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CZ 9901300 A3</td>
<td>17-11-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 19817861 A</td>
<td>28-10-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 59912477 D1</td>
<td>06-10-2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PL 332362 A1</td>
<td>25-10-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SK 52699 A3</td>
<td>18-01-2000</td>
</tr>
<tr>
<td>FR 2698840 A</td>
<td>10-06-1994</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69818357 D1</td>
<td>30-10-2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69818357 T2</td>
<td>24-06-2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DK 888946 T3</td>
<td>09-02-2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES 2209091 T3</td>
<td>16-06-2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR 2765543 A1</td>
<td>08-01-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HK 1019723 A1</td>
<td>16-04-2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PT 888946 T</td>
<td>27-02-2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69421043 D1</td>
<td>11-11-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69421043 T2</td>
<td>31-05-2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR 2712950 A1</td>
<td>02-06-1995</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 3734282 B2</td>
<td>11-01-2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 7186951 A</td>
<td>25-07-1995</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5579699 A</td>
<td>03-12-1996</td>
</tr>
<tr>
<td>FR 2879549 A</td>
<td>23-06-2006</td>
<td>CN 101111421 A</td>
<td>23-01-2008</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 1827943 A2</td>
<td>05-09-2007</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2006070103 A2</td>
<td>06-07-2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KR 20070087189 A</td>
<td>27-08-2007</td>
</tr>
</tbody>
</table>

For more details about this annex: see Official Journal of the European Patent Office, No. 12/82