(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 930 226 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
11.06.2008 Bulletin 2008/24

(51) Int Cl.:
B61D 15/06 *(2006.01)* ***B61D 17/06*** *(2006.01)*

(21) Application number: **07122184.0**

(22) Date of filing: **03.12.2007**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

(30) Priority: **04.12.2006 IT TO20060863**

(71) Applicant: **ANSALDOBREDA S.p.A.**
80147 Napoli (IT)

(72) Inventor: **Raiti, Stefano**
55049 Viareggio (IT)

(74) Representative: **Jorio, Paolo et al**
Studio Torta S.r.l.
Via Viotti, 9
10121 Torino (IT)

(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.

EP 1 930 226 A1

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 3 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 longitu-

dinally 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 time T during a collision at 74 km/h against an obstacle 25 defined by a wagon that is stationary, but free to roll on the railway track.

[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 D 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 coupler 6, without having to intervene on 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 effective for protecting cabs of high-speed trains.

[0031] Finally, from the foregoing, it is clear that modifications and variants can be made to the described carriage 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 absent 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 obstacle deflector placed below absorbers 27 to laterally deflect relatively low obstacles and defining further plastic 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 carrying said head (7) on its front end;

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

   characterized by comprising:

   - a first absorber (9) which is plastically deformable 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 deformable to absorb energy in a second stage during the collision, after said first stage has terminated.

2. The front carriage according to claim 1, **characterized 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 absorber (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 intermediate phase (d) in which said front structure (24) offers substantially zero resistance to longitudinal compression.

6. The front carriage according to claim 4, **characterized 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 position in said tube (10).

8. The carriage according to claim 6 or 7, **characterized 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 breakage of said second connection means (12).

9. The front carriage according to claim 8, **characterized 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, **characterized 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).

FIG. 1

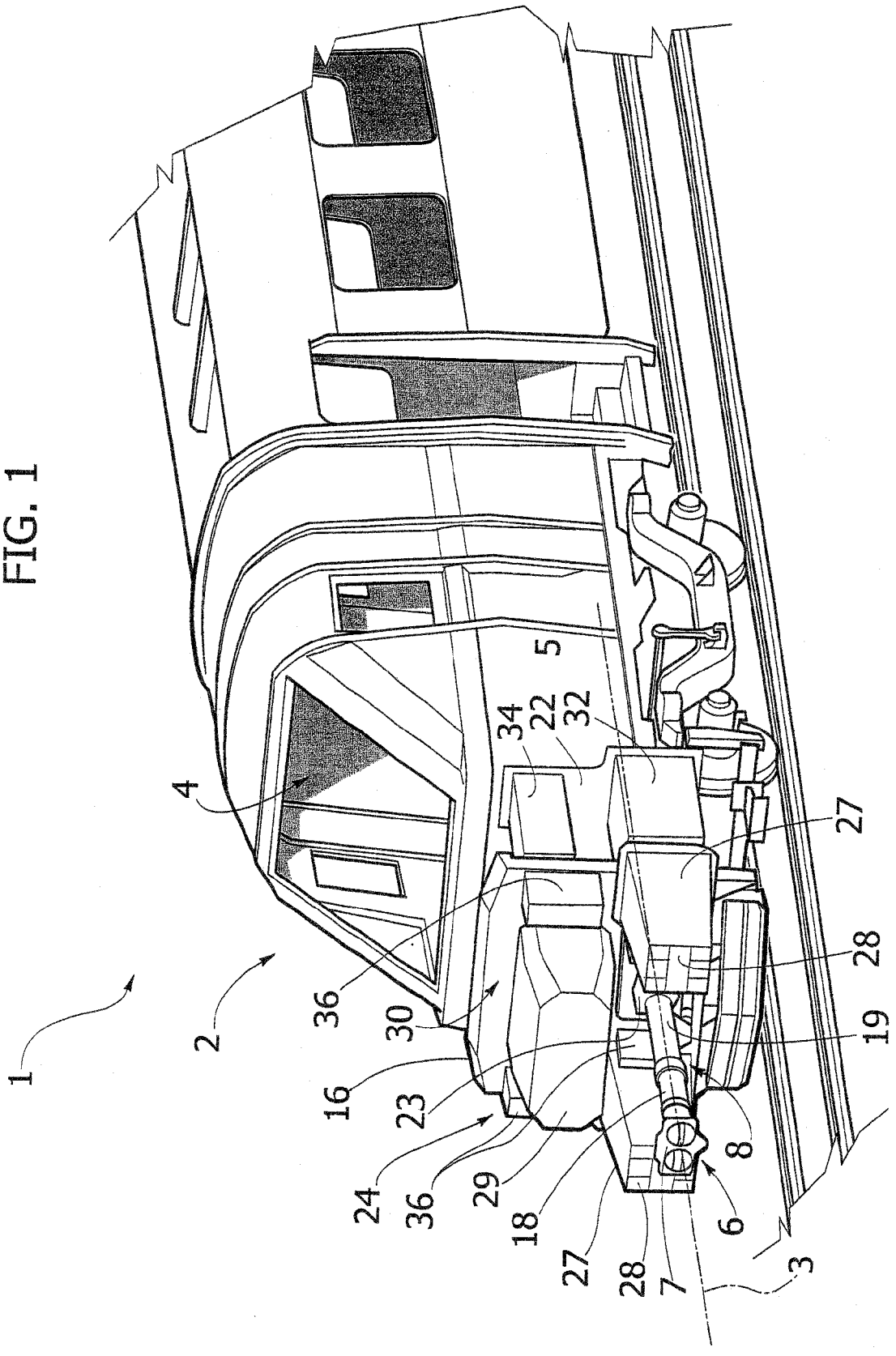


FIG. 2

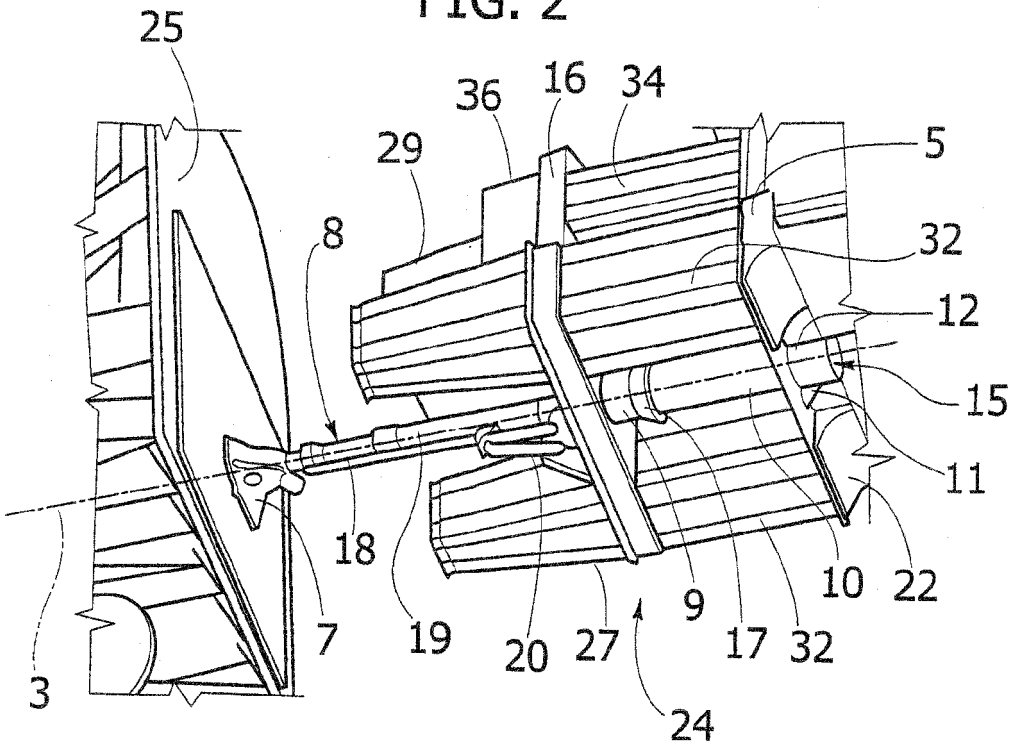

25
36
16
34
29
5
8
32
12
15
11
18
10
22
9
7
19
20
27
17
32
3
24

FIG. 3

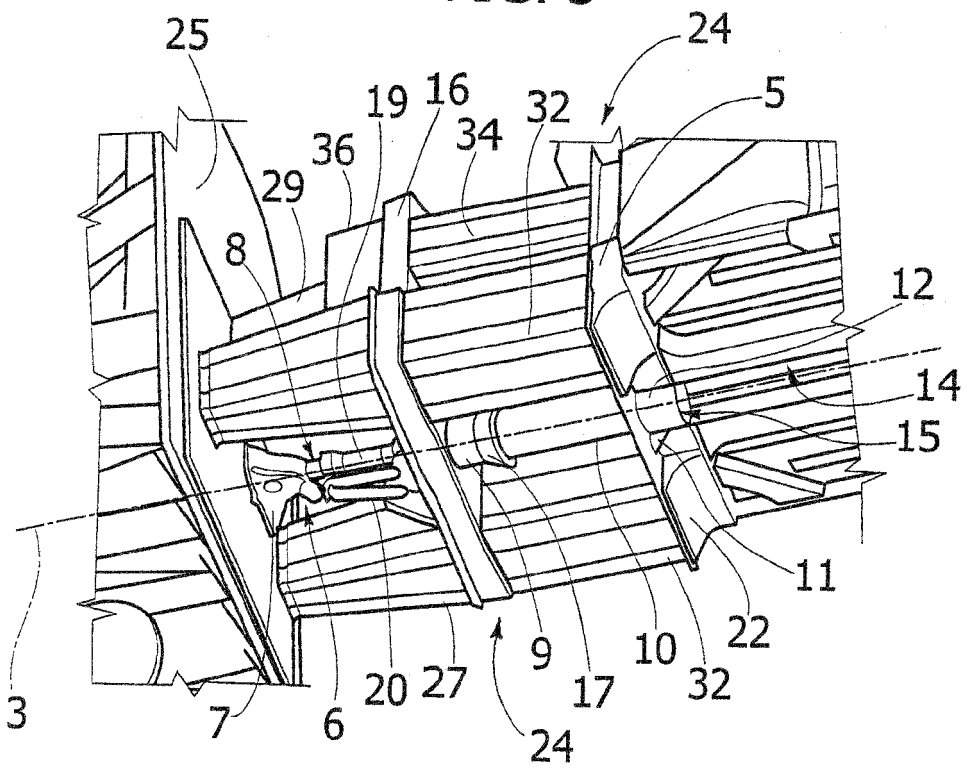

25
24
19
16
32
5
36
34
29
8
12
14
15
11
22
9
10
32
20
27
17
3
7
6
24

FIG. 4

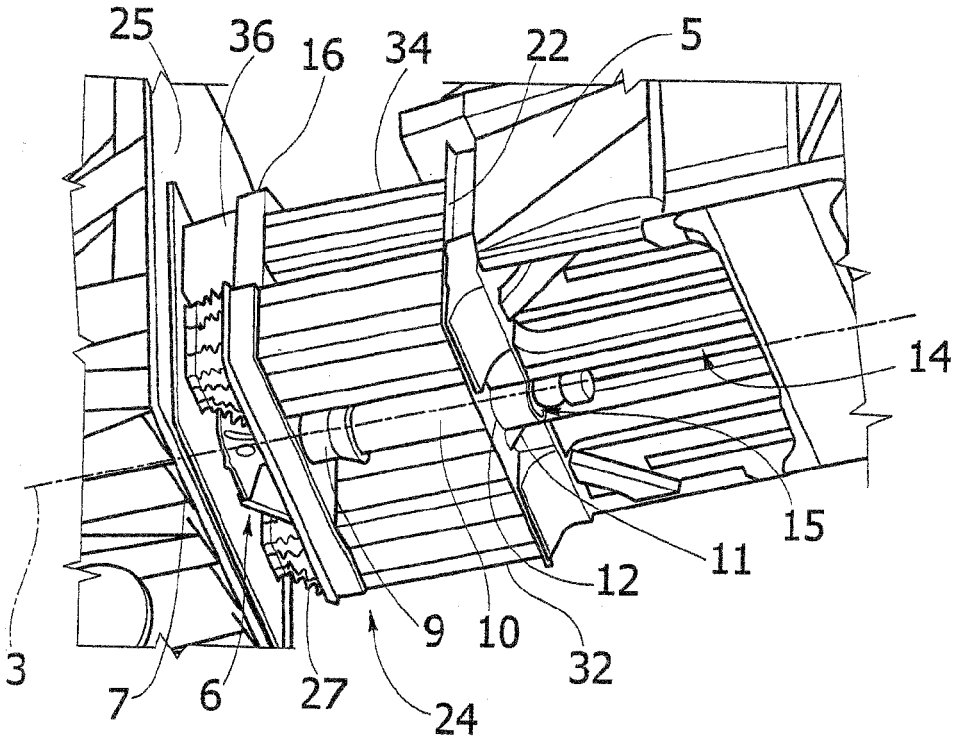

25
36
16
34
22
5
14
15
11
12
9
10
32
3
7
6
27
24

FIG. 5

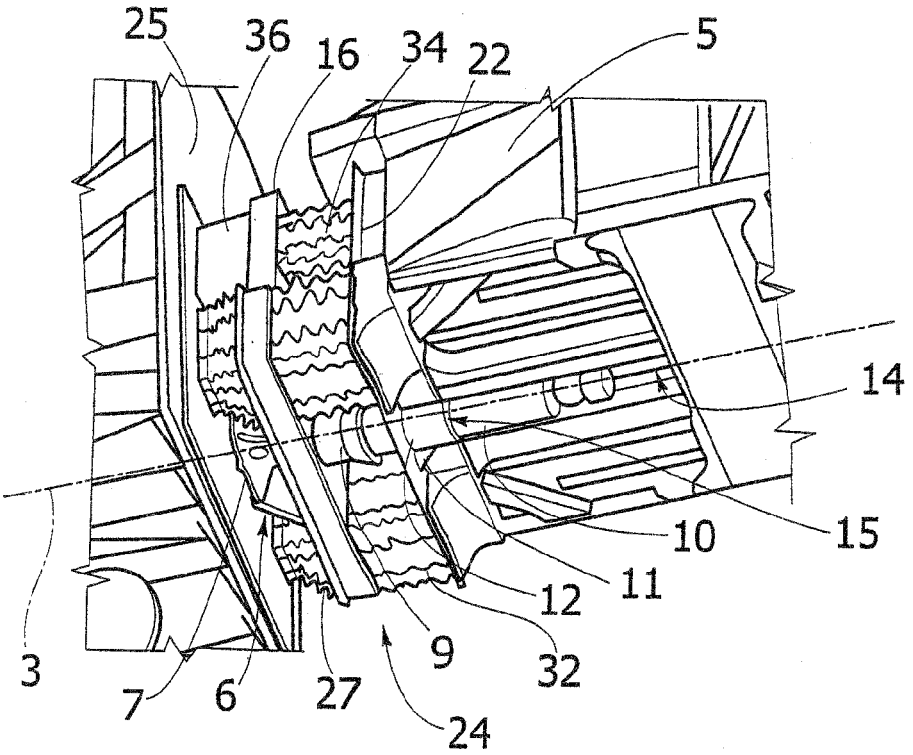

25
36
16
34
22
5
14
15
10
11
12
9
32
3
7
6
27
24

FIG. 6

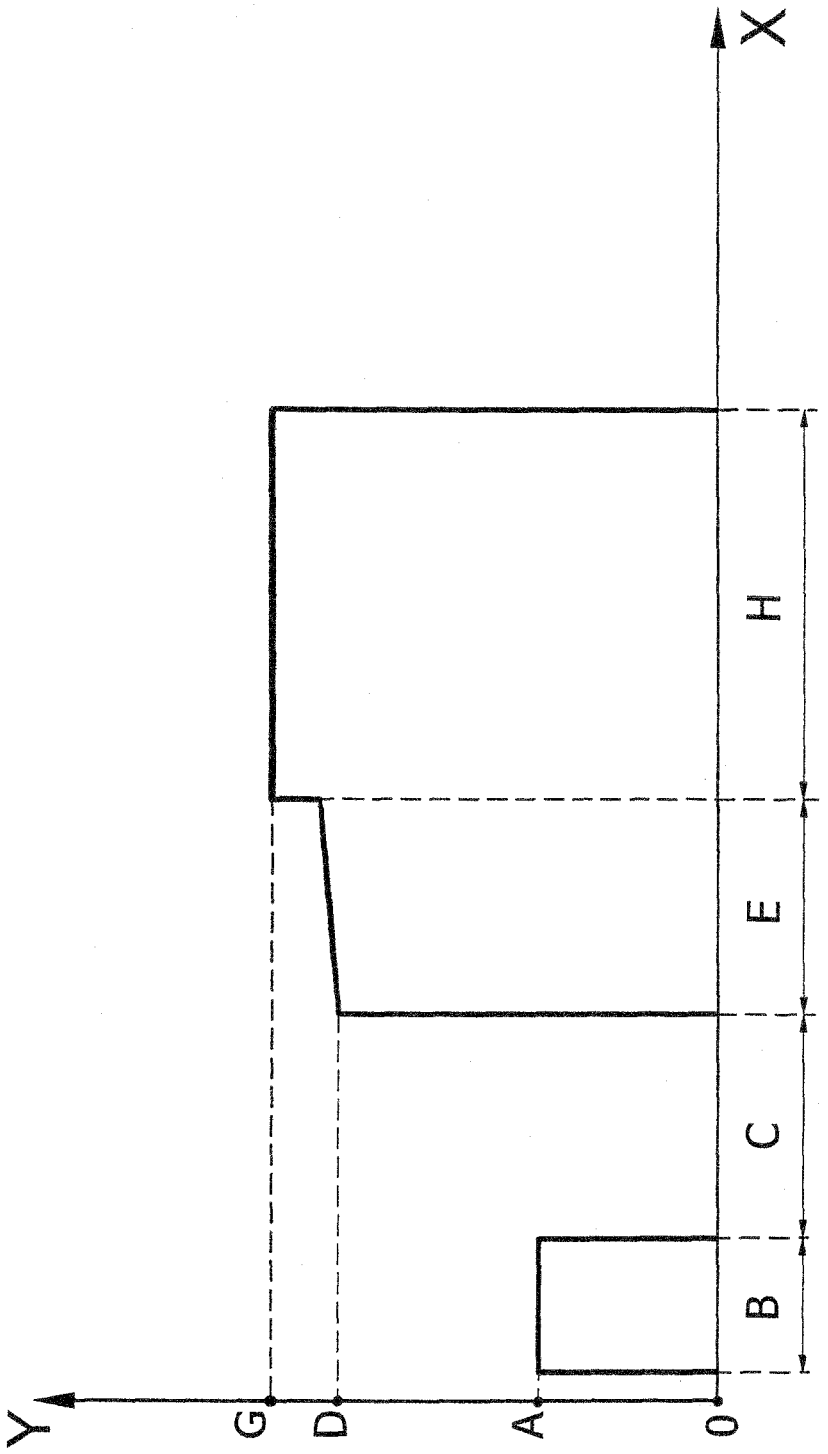
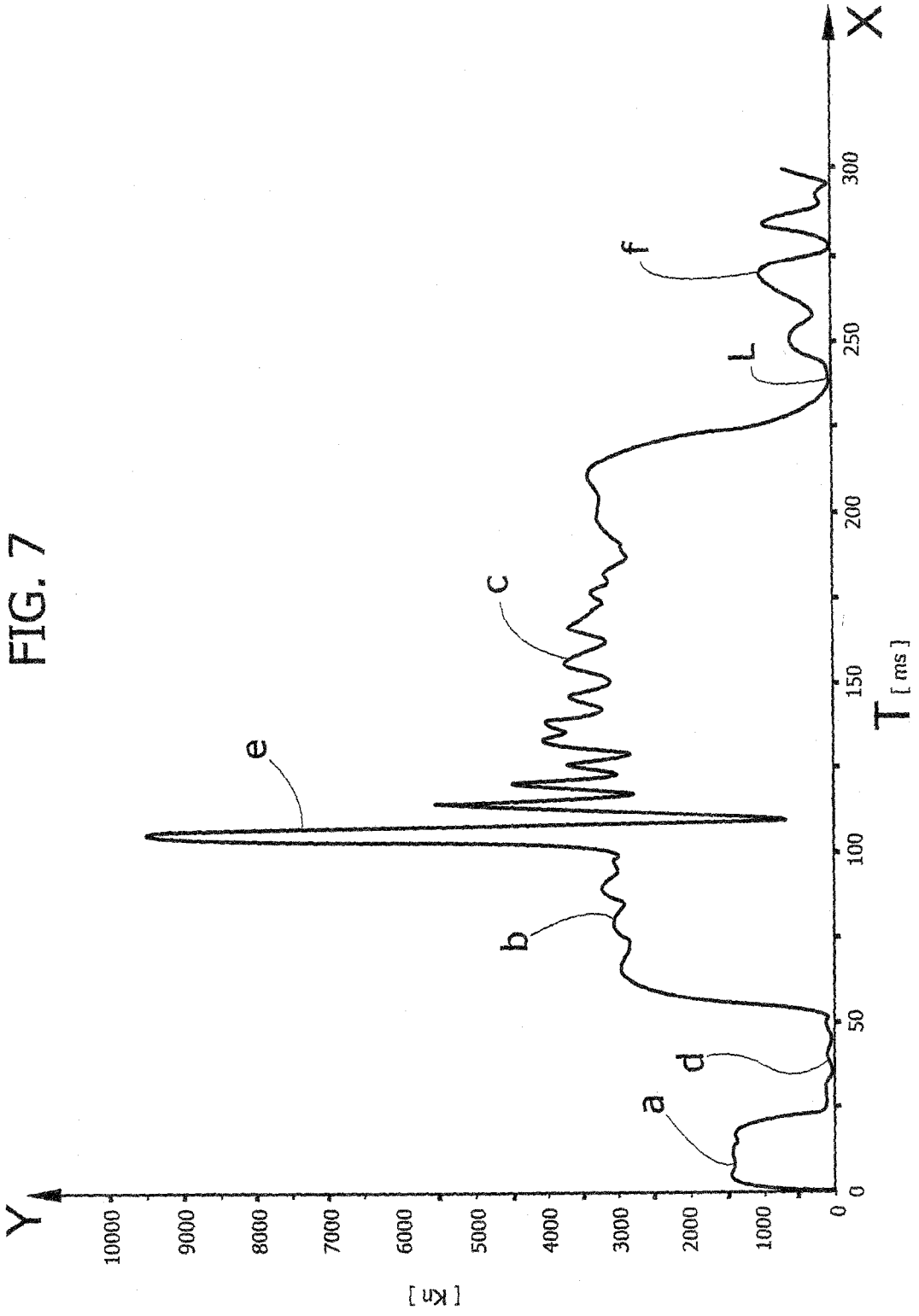


FIG. 7


Y
X
[kΩ]
T [ms]
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
50
100
150
200
250
300
a
b
c
d
e
f
L

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 12 2184

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	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 *	1-3,6,7, 9-12 8	INV. B61D15/06 B61D17/06
X	EP 0 952 062 A (DWA DEUTSCHE WAGGONBAU GMBH [DE]; DEUTSCHE BAHN AG [DE] BOMBARDIER TRA) 27 October 1999 (1999-10-27) * paragraph [0007] - paragraph [0009]; figures 1,2 *	1,4,5	
X Y	FR 2 698 840 A (DIETRICH & CIE DE [FR]) 10 June 1994 (1994-06-10) * page 2, line 22 - page 5, line 26; figures 1-6 *	1 8	
X	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 *	1,3,4	TECHNICAL FIELDS SEARCHED (IPC) B61D
X	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 *	1,13,14	
A	FR 2 879 549 A (ALSTOM TRANSP SA SA [FR]) 23 June 2006 (2006-06-23) * the whole document *	1-14	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 March 2008	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

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 07 12 2184

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 EDP 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

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0802100 A	22-10-1997	AT 205448 T	15-09-2001
		DE 69706597 D1	18-10-2001
		DE 69706597 T2	11-07-2002
		DK 802100 T3	17-12-2001
		ES 2161423 T3	01-12-2001
		FR 2747633 A1	24-10-1997
		PT 802100 T	30-01-2002
EP 0952062 A	27-10-1999	AT 303276 T	15-09-2005
		CZ 9901300 A3	17-11-1999
		DE 19817861 A1	28-10-1999
		DE 59912477 D1	06-10-2005
		PL 332362 A1	25-10-1999
		SK 52699 A3	18-01-2000
FR 2698840 A	10-06-1994	NONE	
EP 0888946 A	07-01-1999	AT 250530 T	15-10-2003
		DE 69818357 D1	30-10-2003
		DE 69818357 T2	24-06-2004
		DK 888946 T3	09-02-2004
		ES 2209091 T3	16-06-2004
		FR 2765543 A1	08-01-1999
		HK 1019723 A1	16-04-2004
		PT 888946 T	27-02-2004
EP 0655565 A	31-05-1995	CA 2120869 A1	26-05-1995
		DE 69421043 D1	11-11-1999
		DE 69421043 T2	31-05-2000
		FR 2712950 A1	02-06-1995
		JP 3734282 B2	11-01-2006
		JP 7186951 A	25-07-1995
		US 5579699 A	03-12-1996
FR 2879549 A	23-06-2006	CN 101111421 A	23-01-2008
		EP 1827943 A2	05-09-2007
		WO 2006070103 A2	06-07-2006
		KR 20070087189 A	27-08-2007

EPO FORM P0459

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