



EUROPEAN PATENT APPLICATION

②¹ Application number: 91113381.7

⑤¹ Int. Cl.⁵: **B61F 5/22**

②② Date of filing: 09.08.91

③ Priority: 13.08.90 JP 214652/90

④³ Date of publication of application:
19.02.92 Bulletin 92/08

⑧ Designated Contracting States:
DE FR GB

71 Applicant: **Kawasaki Jukogyo Kabushiki
Kaisha**
**1-1 Higashikawasakicho 3-chome Chuo-ku
Kobe-shi Hyogo 650-91(JP)**

(72) Inventor: **Kobayashi, Noboru**
27, Himurocho 1-chome, Hyogo-ku
Kobe-shi, Hyogo 652(JP)
 Inventor: **Uozumi, Yukio**
12-9, Tennoshitacho, Tarumi-ku
Kobe-shi, Hyogo 655(JP)

74 Representative: **Reinhard, Skuhra, Weise**
Friedrichstrasse 31
W-8000 München 40(DE)

⑤④ **Pendulum vehicle.**

57 A pendulum vehicle comprising: a vehicle body (1); a plurality of trucks (2) each having a truck frame (6) provided below the vehicle body (1); and a pair of transversely arranged resilient members (9) provided on the truck frame (6) for supporting the vehicle body (1); wherein axes of the resilient members (9) tilt so as to approach each other, and an uncouple point (30) of the vehicle is positioned higher than center of gravity (G) of the vehicle body (1). The uncouple point (30) is defined as a point where the vehicle body does not tilt but moves only horizontally in case that transverse load is applied to the point on the vehicle. By virtue of the simple structure of the pendulum vehicle according to the present invention, maintenance work are simplified. Further, stationary transverse acceleration felt by passengers when passing through curves can be reduced to achieve comfortable drive.

FIG. 4

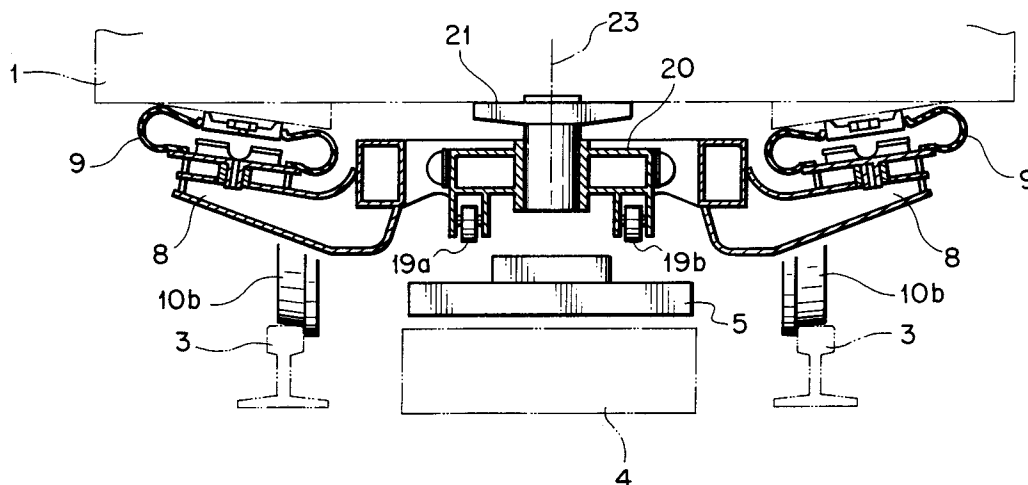
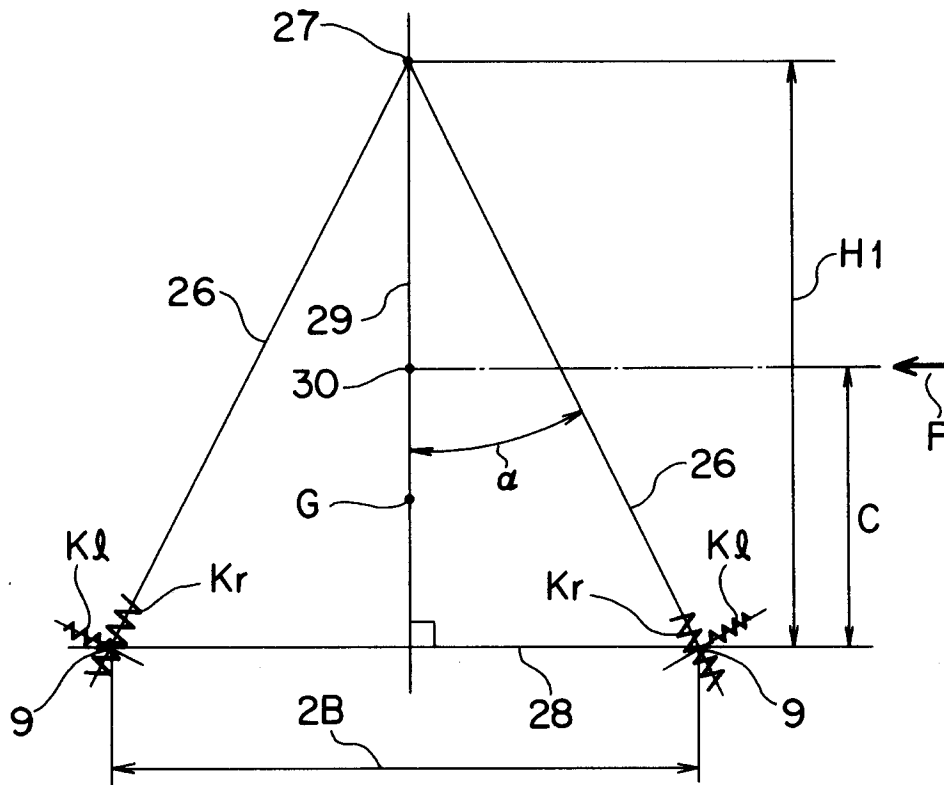


FIG. 6



BACKGROUND OF THE INVENTION

1. Field of the Invention

5 This invention relates to a pendulum vehicle, and in particular to structures for a railway vehicle having pendulum function.

2. Description of the Prior Art

10 An example of a typical prior art is disclosed in Japanese Patent Laid-Open Showa 59-143760. In the prior art, on a truck frame is provided a rotating beam which can rotate about the axis of a center pin. On the rotating beam is mounted a swing bolster by means of rollers arranged at both ends of the beam. Further, on the swing beam is supported a vehicle body by air springs.

15 In the prior art described above, the pendulum vehicle is provided with the rollers and the swing bolster, which makes the structure of the vehicle comparatively complicated, resulting in worrisome maintenance work. Further, the structure with dusttight and dipproof functions is required for the rollers, which also brings about worrisome maintenance work.

SUMMARY OF THE INVENTION

20 It is therefore the object of the present invention to provide a pendulum vehicle in which the structure and the maintenance work are simplified, and comfortable drive is guaranteed.

A pendulum vehicle according to the present invention comprises: a vehicle body; a plurality of trucks each having a truck frame provided below the vehicle body; and a pair of transversely arranged resilient members provided on the truck frame for supporting the vehicle body; wherein axes of the resilient members tilt so as to approach each other as height rises, and uncouple point, which is defined as a point where the vehicle body does not tilt but moves only horizontally in case that transverse load is applied to the point on the vehicle, is arranged at the position higher than the center of gravity of the vehicle.

30 When transverse load is applied to the point higher than the uncouple point, the portion on the vehicle which is higher than the uncouple point will tilt with displacement larger than the displacement at the uncouple point. On the other hand, when the transverse load is applied to the point lower than the uncouple point, the portion on the vehicle which is lower than the uncouple point will tilt with displacement larger than the displacement at the uncouple point.

35 In the present invention, on the truck frame supporting wheel axles is supported a vehicle body by means of resilient members such as air springs. The axles of the resilient members tilt so as to approach each other as height rises. Therefore, the point where the axles of the resilient members and the axle of the vehicle cross each other is positioned over the truck frame and the uncouple point is also formed over the truck frame.

40 In the present invention, since the uncouple point is designed so as to be positioned higher than the center of gravity of the vehicle body when transverse load because of centrifugal force is applied to the center of gravity of the vehicle body when passing through curves, the portion of the vehicle body which is lower than the uncouple point moves with displacement larger than the displacement at the uncouple point, causing the vehicle body to tilt inwardly, which permits pendulum function of the vehicle.

45 BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more apparent from the ensuing description with reference to the accompanying drawing wherein:

Figure 1 is a plan view showing one embodiment of the present invention;
 50 Figure 2 is a side view showing the embodiment of Fig. 1;
 Figure 3 is a front view of the truck 2;
 Figure 4 shows the cross section taken along the line IV-IV of Fig. 2;
 Figure 5 shows the cross section adjacent to the wheel 10a;
 Figure 6 is a diagrammatic illustration showing the configuration of the air springs 9;
 55 Figures 7A and 7B are drawings to explain spring constants of the air springs 9;
 Figure 8 is a drawing briefly illustrating the structure of the air springs 9; and
 Figure 9 is a drawing briefly showing the structure of the resilient member 9a according to another embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A preferred embodiment of a pendulum vehicle according to the present invention will now be described with reference to drawings.

Figure 1 is a plan view of the pendulum vehicle according to one embodiment of the present invention and Fig.2 is a side view of the vehicle. In a railway vehicle in accordance with the present invention, a vehicle body 1 is supported by a pair of two-axle trucks 2 arranged at both ends of the vehicle. Between a pair of rails 3 along a service route on the ground is provided reaction plates constituting a linear motor. On the truck 2 is mounted coils 5 opposing to the reaction plates to get propulsion. Over the rails 3 is arranged a substantially H-shaped truck frame 6. Adjacent to a lateral mid-portion of side beams 7 of the truck frame 6 is installed air springs 9 as a pair of transversely arranged resilient members through supporting members 8, which support the vehicle body 1.

Figure 3 is a front view of the truck 2 and Fig. 4 shows a cross-section taken along the line IV-IV of Fig. 2. Figure 5 shows a cross-section of the portion adjacent to wheels 10a. The wheels 10a are fixed to axles 11, which are supported on bearings 12 in cylindrical bearing boxes 13a adjacent to the wheels 10a. At the axial mid-portion of the bearing body 13a is formed a shaft 14a projecting upward. The shaft 14a is rotatably mounted in a supporting hole 16 which is formed on a mounting member 15. To the mounting member 15 is fixed the reaction plate 5. The side beam 7 of the truck frame 6 is supported by abrasion plate or resilient member 17a such as springs which is positioned between the beam and the bearing box 13a in the vicinity of the bearing 12. Another wheel 10b has the same structure as the wheel 10a and the portions of the wheel 10b corresponding to those of the wheel 10a are described by the same reference number with a subscript b. Propulsion, which is applied to the coil 5 on the vehicle, is transmitted to the truck frame 6 via a propulsion transmitting means 18, and is further transmitted to the vehicle body 1 via a propulsion transmitting link device 50. The propulsion transmitting link device 50 comprises links 19a and 19b, a tracking beam 20, and a center pin 21. When the vehicle body does not move laterally, vertical axis of the center pin 21 substantially corresponds to the center of the truck. At both ends of the link 19a are arranged spherical bearings or resilient members. One end of the link 19a is rotatably connected to a front side-beam 6a and the other end is to the right side of the tracking beam 20 of the truck frame 6 by means of spherical bearings or resilient members. One end of the link 19b is also rotatably connected to a rear side-beam 6b and the other end is to the left side of the tracking beam 20 of the truck frame in the same manner as the link 19a. Both links 19a and 19b are arranged so as to be parallel to each other. The center pin 21, which is positioned at the middle of the links 19a and 19b arranged at both ends the tracking beam 20, rotatably connects the vehicle body 1 to the tracking beam 20 about the vertical axis 23 of the center pin 21.

By virtue of the propulsion transmitting link device 50 of the structure described above, propulsion, braking force or the like is transmitted in the longitudinal direction between the vehicle body 1 and truck frame 6 while permitting relative transverse disposition and rotation between them.

Figure 6 is a diagrammatic illustration showing the arrangement of the air springs 9 and others. The axes 26 of the pair of air springs 9 tilt in the same vertical plane so that the axes approach to each other to cross at intersection 27 as height rises under the condition that the vehicle passes through horizontally liner truck. This intersection 27 is the geometrical center of the air spring in the direction of the axis of the air spring. The center of gravity of the vehicle body is located in the vicinity of the perpendicular bisector 29 of the line 28 passing through the centers of the pair of air springs 9. The uncouple point 30, which corresponds to the center of oscillation of this pendulum vehicle, is on the perpendicular bisector 29. Even when load P as a transverse load is applied to the uncouple point 30, the vehicle body 1 moves only horizontally and does not tilt. This transverse load comprises centrifugal force and the like, which acts on a vehicle when passing through curves. In the present invention, the uncouple point is designed so as to be higher than the center of gravity of the vehicle body 1.

Referring to Figs. 7A and 7B, where spring constant of the air spring 9 in the direction of the axis 26 is defined as K_r and that of the spring 9 in the direction perpendicular to the axis 26 is defined as K_l , and further, spring constant of the air spring 9 in the direction parallel to the perpendicular bisector 29 is determined as K_x and that of the spring in the direction parallel to the line 28 is K_y , the following formula holds. In the formula, the distance between the line 28 and the intersection 27 is H_1 ; the distance between the centers of the pair of air springs is $2B$; and the angle between the axis 26 and the perpendicular bisector 29 is α .

$$H_1 = B / \tan \alpha \quad (1)$$

$$K_x = K_r \cdot \cos^2 \alpha + K_l \cdot \sin^2 \alpha \quad (2)$$

$$K_y = K_r \cdot \sin^2 \alpha + K_l \cdot \cos^2 \alpha \quad (3)$$

5

Therefore, the height C of the uncouple point 30, that is, the distance between the point 30 and the line 28 is determined by formula 4.

10

$$C = \frac{\left(1 - \frac{K_l}{K_r}\right) \cot \alpha}{1 + \frac{K_l}{K_r} \cot^2 \alpha} \cdot B \quad \dots (4)$$

15

The spring constant K_x described above is determined so as to have around 1 Hz of characteristic frequency of the vehicle body, as an example. The transverse spring constant K_l of the air spring 9 is selected so as to be comparatively small. Further, the axial spring constant K_r is determined in such a manner that the spring constant K_x as described above is to be obtained.

20

As shown in Fig. 8, the air spring 9 described above is realized with the structure in which a pair of substantially flat supporting plates 32 and 33 are provided on upper and lower surfaces of air-filled bag 31 with resiliency by rubber or the like, and auxiliary air chamber 36. The structure permits the air spring 9 to have the axial spring constant K_r and the transverse spring constant K_l thereof with the following relation with ease.

25

$$K_r > K_l \quad (5)$$

30

The transverse load because of the centrifugal force described above acts on the center of gravity of the vehicle body 1. Since the uncouple point is positioned higher than the center of gravity of the vehicle body 1, when transverse load acts on the vehicle when passing through curves, the vehicle body tilts inwardly with respect to the uncouple point 30, which can reduce transverse acceleration felt by passengers by the pendulum function.

35

As another embodiment of the present invention, springs 9a may be used in place of the air springs 9a. The springs 9a are formed by accumulating a plurality of resilient pieces 34 made of thin rubber or the like and interposing stiff flat plates 35 such as steel plates each between the resilient pieces.

Other structure may be applied to attain the object instead of the air springs 9 and the resilient members shown in Fig. 9.

40

In the present invention as described above, since a pair of transversely arranged resilient members, of which axes tilt so as to approach each other as height rises, support a vehicle body on a truck frame and uncouple point formed by the above structure is designed in such a manner as to be higher than the center of gravity of the vehicle body, pendulum function of the vehicle body is obtained without rollers and a swing bolster disclosed in the prior art. Therefore, the structure and maintenance work are simplified. Further, stationary transverse acceleration felt by passengers when passing through curves can be reduced to achieve comfortable drive, which improves the vehicle speed on a curved track.

45

Claims

50

1. A pendulum vehicle comprising:

a vehicle body;

a plurality of trucks each having a truck frame provided below said vehicle body; and

a pair of transversely arranged resilient members provided on said truck frame for supporting said vehicle body; wherein axes of the resilient members tilt so as to approach each other as height rises, and an uncouple point of the vehicle is positioned higher than center of gravity of the vehicle body.

55

2. A pendulum vehicle as claimed in claim 1, wherein said pair of resilient members include air springs.

3. A pendulum vehicle as claimed in claim 1, wherein said pair of resilient members include springs formed by accumulating a plurality of resilient pieces made of thin rubber and interposing stiff flat plates made of steel plates each between the resilient pieces.

5

10

15

20

25

30

35

40

45

50

55

FIG. 1

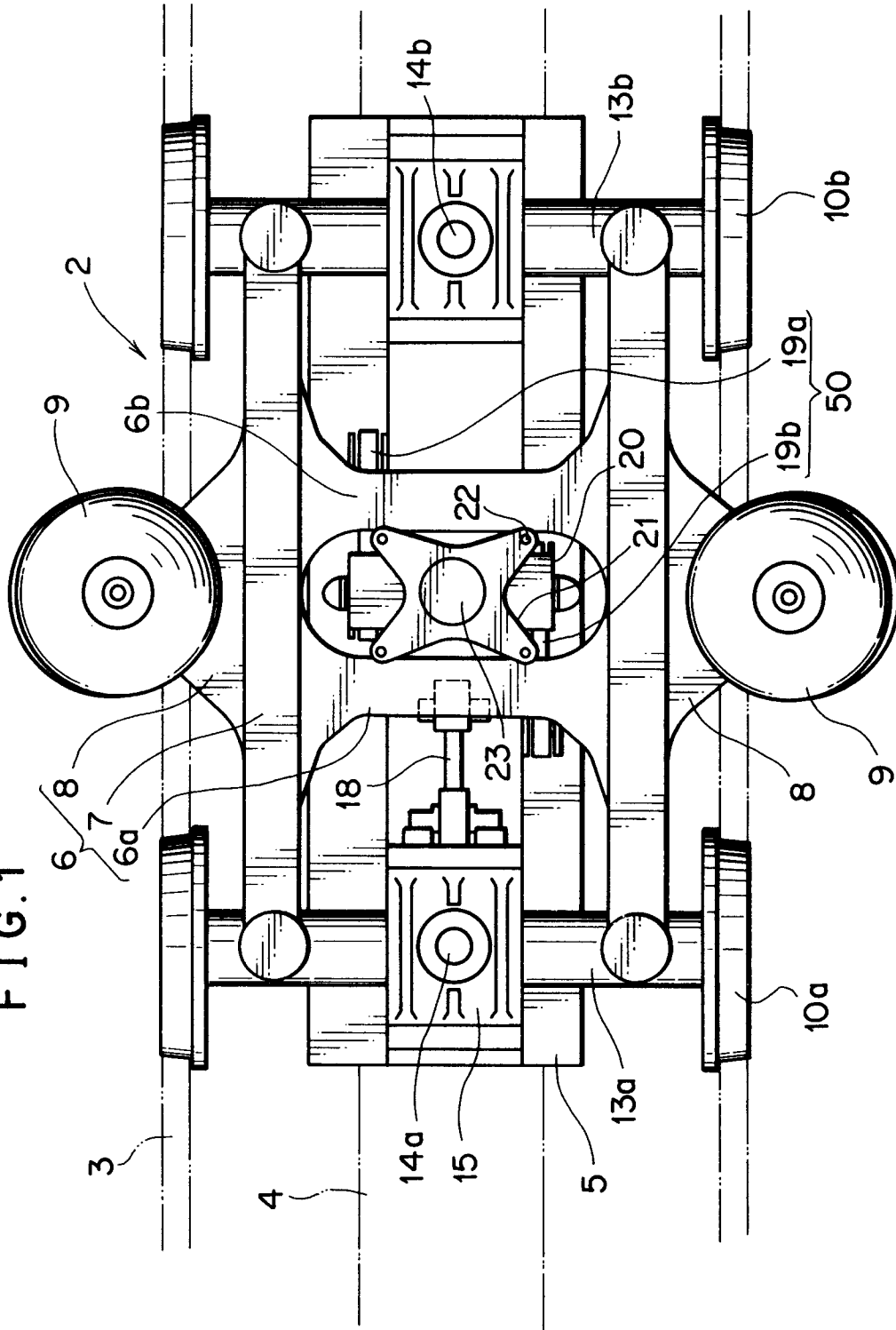


FIG. 2

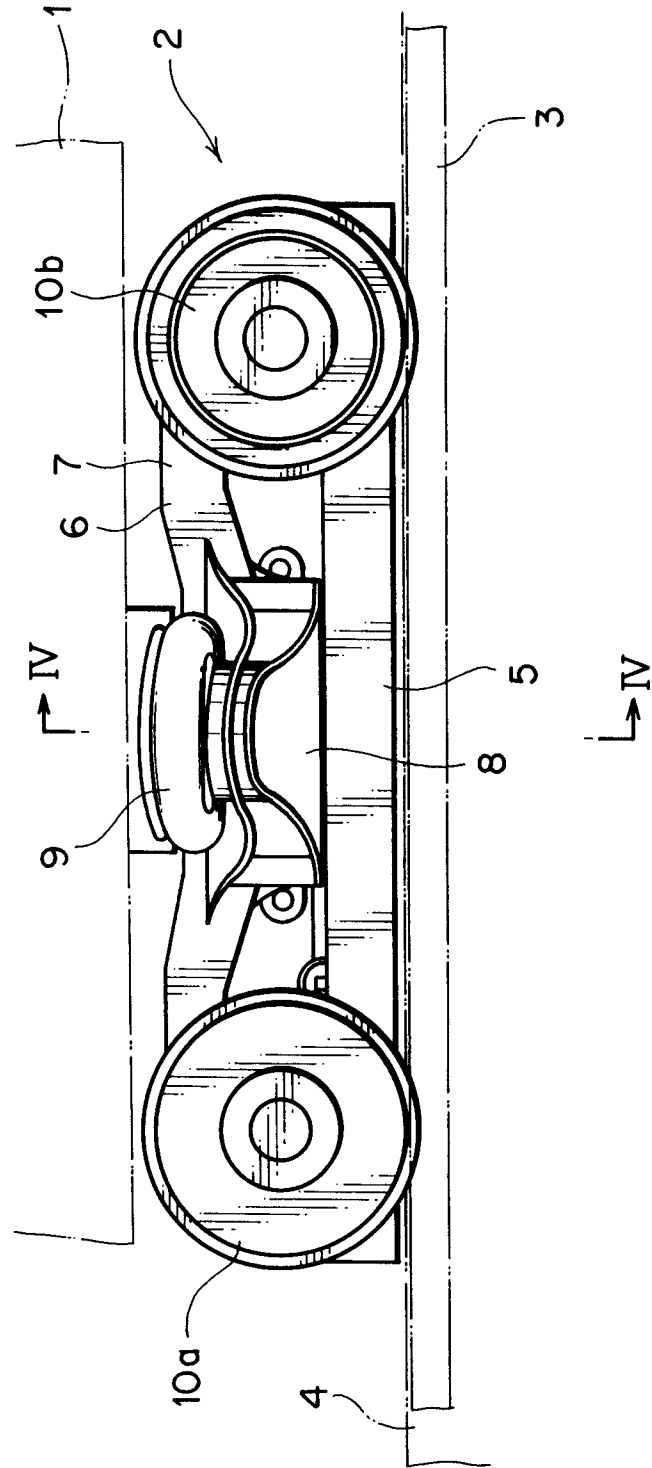


FIG. 3

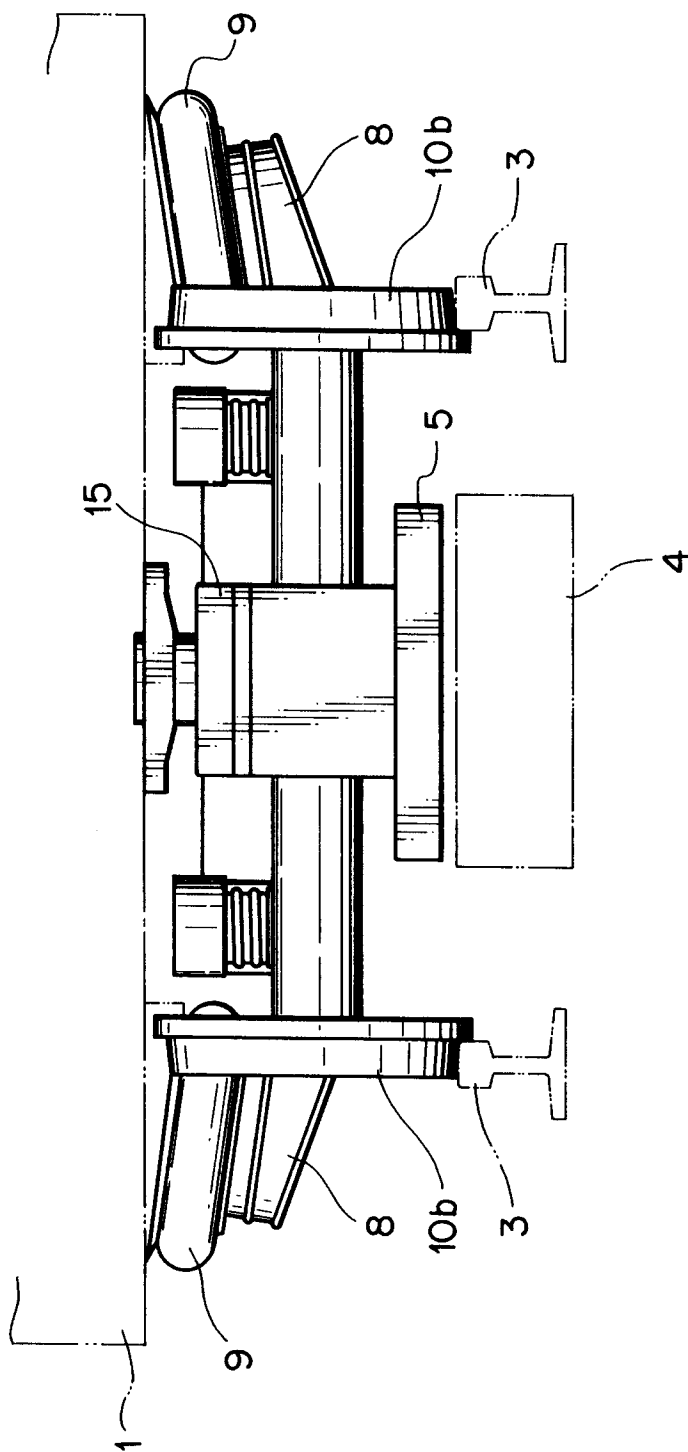


FIG. 4

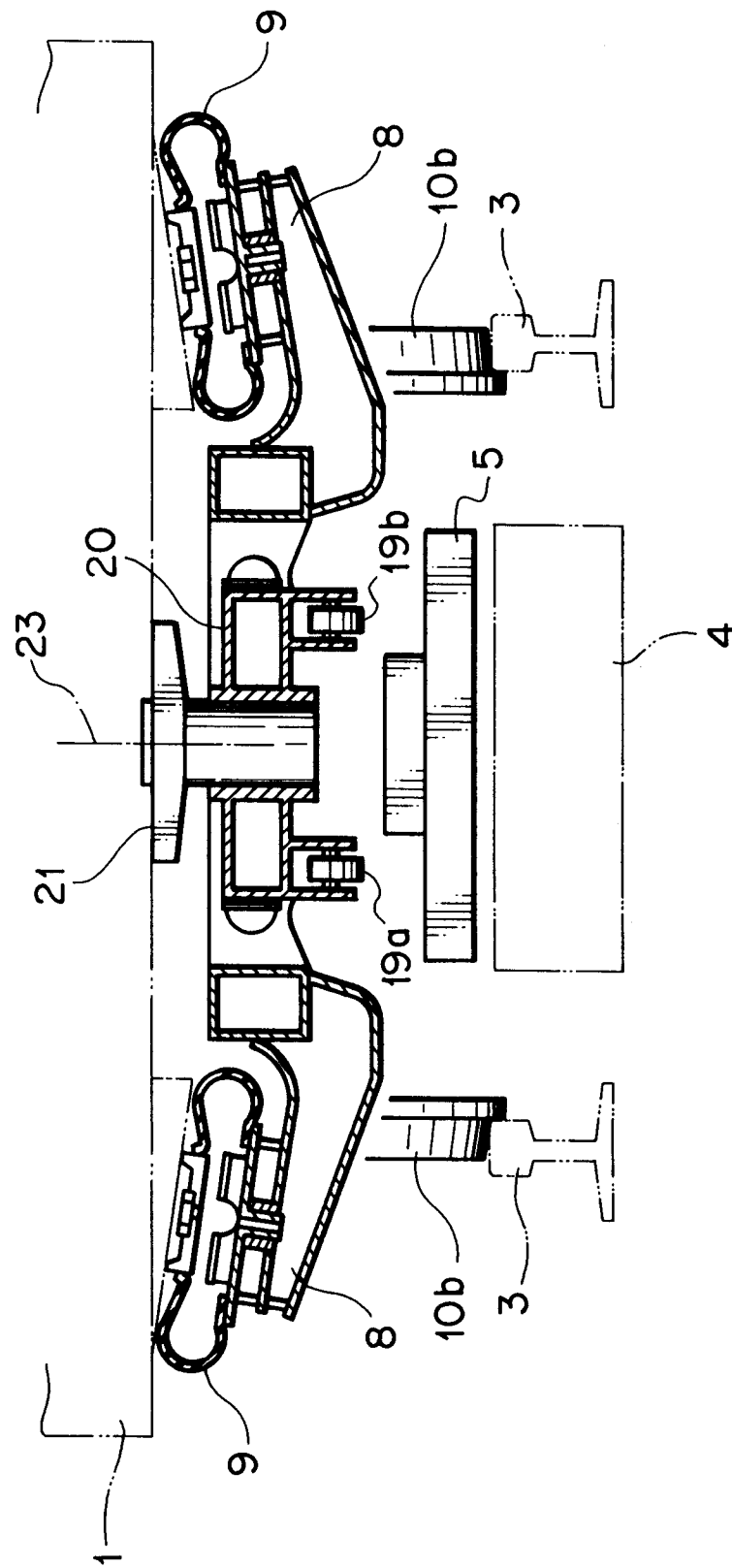


FIG. 5

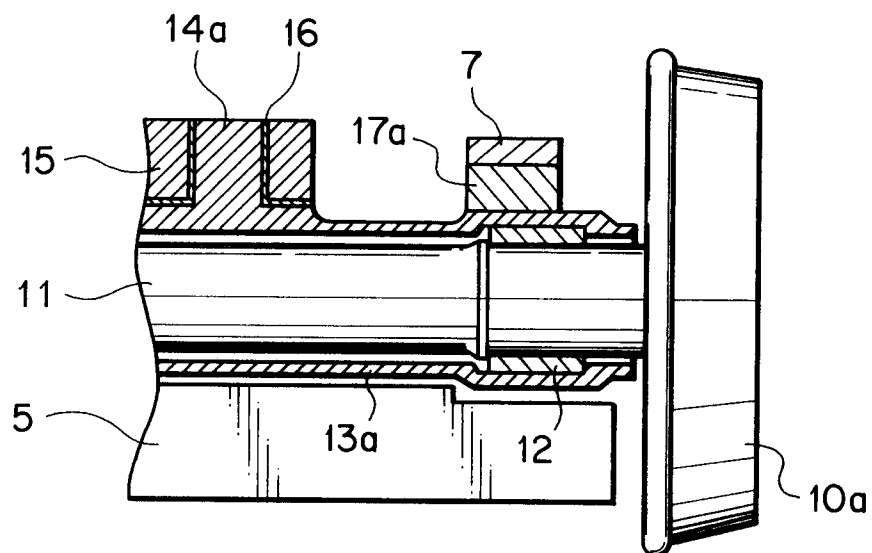


FIG. 6

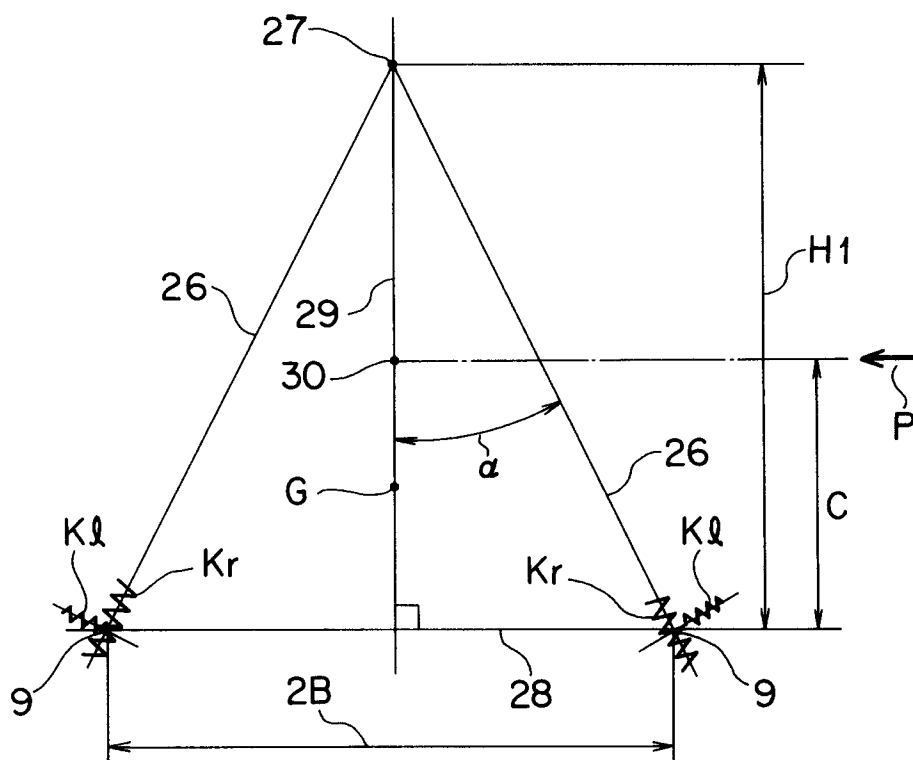


FIG. 7A

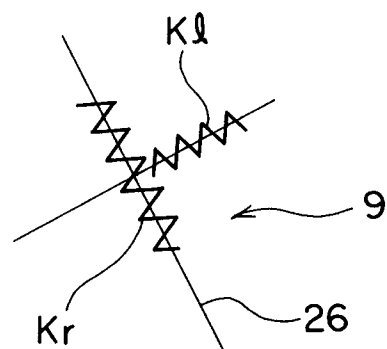


FIG. 7B

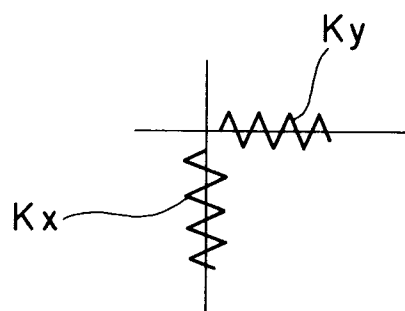


FIG. 8

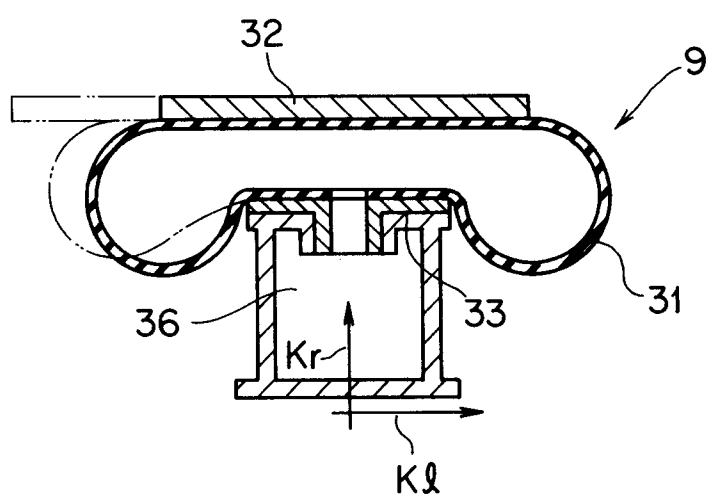
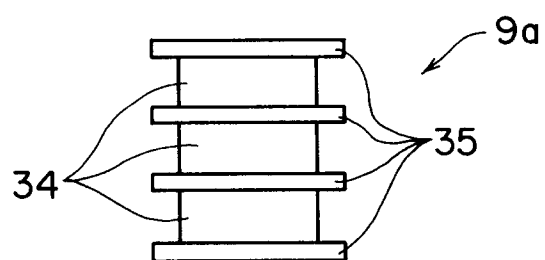


FIG. 9





European
Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 11 3381

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	FR-A-2 497 167 (BUDD) * Claims 1,2,3,7; figures 1-4 *	1	B 61 F 5/22
A	— — —	2,3	
Y	GB-A-962 822 (KREISSIG) * The whole patent *	1	
A	DE-A-2 512 008 (TALGO) * Figure 3; claims 1,3; page 3 *	1,2	
A	US-A-2 910 014 (CANDLIN et al.) * Claims 1,2; figure 2 *	1,2	
A	GB-A-525 858 (HILL) * Page 8, lines 47-60; figure 3 *	1	
A	ELEKTRISCHE BAHNEN, vol. 83, no. 5, May 1985, pages 156-162; L.M. DE ORIOL et al.: "Der Talgo Pendular" * Figure 4 *	1	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			B 61 F
Place of search		Date of completion of search	Examiner
The Hague		24 October 91	SCHMAL R.
CATEGORY OF CITED DOCUMENTS			
X: particularly relevant if taken alone		E: earlier patent document, but published on, or after the filing date	
Y: particularly relevant if combined with another document of the same category		D: document cited in the application	
A: technological background		L: document cited for other reasons	
O: non-written disclosure		&: member of the same patent family, corresponding document	
P: intermediate document			
T: theory or principle underlying the invention			