



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
02.10.2019 Bulletin 2019/40

(51) Int Cl.:
B61F 5/24 (2006.01)

(21) Application number: **17873478.6**

(86) International application number:
PCT/JP2017/041731

(22) Date of filing: **21.11.2017**

(87) International publication number:
WO 2018/097111 (31.05.2018 Gazette 2018/22)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(72) Inventors:
• **IHO, Hiyori**
Tokyo 100-8071 (JP)
• **TANIMINE, Teruhiko**
Tokyo 100-8071 (JP)
• **SHIMOKAWA, Yoshiyuki**
Tokyo 100-8071 (JP)

(30) Priority: **24.11.2016 JP 2016227734**

(74) Representative: **Zimmermann & Partner**
Patentanwälte mbB
Postfach 330 920
80069 München (DE)

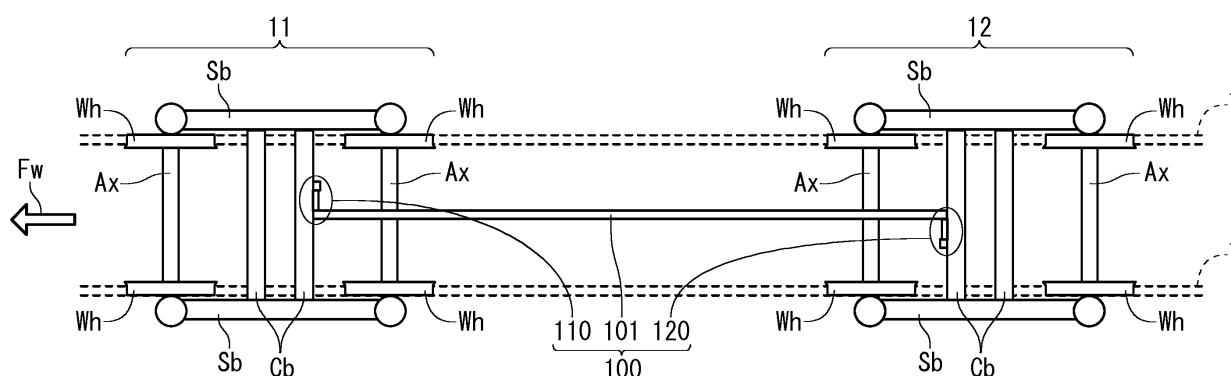
(71) Applicant: **NIPPON STEEL CORPORATION**
Tokyo (JP)

(54) **YAWING SUPPRESSION DEVICE FOR RAILWAY VEHICLE AND RAILWAY VEHICLE INCLUDING SAME**

(57) Disclosed is a yawing suppression device (100) of a railway vehicle which includes: a torsion bar (101); a first connecting member (110) which connects a first bogie (11) and a first portion of the torsion bar (101) with each other; and a second connecting member (120) which connects a second bogie (12) and a second portion of the torsion bar (101) with each other. The first and second connecting members (110, 120) connect the torsion bar (101) with the respective first and second bogies (11, 12) such that torsion in a circumferential direction is

generated in the torsion bar (101) in a state where a relative position of the first bogie (11) in a horizontal direction with respect to a center line of the vehicle body (13) in a width direction is out of alignment with a relative position of the second bogie (12) in the horizontal direction with respect to the center line of the vehicle body (13) in the width direction. The yawing suppression device (100) can be manufactured at lower cost and has high reliability.

FIG. 1



Description**TECHNICAL FIELD**

[0001] The present invention relates to a yawing suppression device of a railway vehicle, and a railway vehicle including the same.

BACKGROUND ART

[0002] Vehicle body motion, such as oscillating motion, is generated in a railway vehicle with the travel of the railway vehicle. The vehicle body motion may be swing or yawing, for example. Yawing is oscillating motion of a vehicle body about an axis of a vehicle in the vertical direction.

[0003] Generation of the above-mentioned vehicle body motion deteriorates riding comfort. Accordingly, to improve riding comfort, it is necessary to suppress vehicle body motion. As a technique which suppresses vehicle body motion, various techniques have been conventionally proposed.

[0004] Japanese Patent Application Publication No. 2004-90849 (Patent Literature 1) discloses a technique for reducing oscillation of a railway vehicle. A railway vehicle adopting this technique includes a member which blocks air flow across an underfloor area. Japanese Patent Application Publication No. 2007-139100 (Patent Literature 2) discloses a vehicle vibration damper which includes a cushion rubber which attenuates vibration transmission and impact. Japanese Patent Application Publication No. 2009-149304 (Patent Literature 3) discloses an anti-rolling device for a railway vehicle. This anti-rolling device includes an ON/OFF switching mechanism.

[0005] Japanese Patent Application Publication No. 2012-19661 (Patent Literature 4) discloses a railway vehicle oscillation control device which includes a linear actuator. The oscillation control device includes the linear actuator, and a control device which actively controls the driving of the linear actuator. A device for controlling the linear actuator is inevitable for the oscillation control device which uses the linear actuator. Accordingly, such an oscillation control device is expensive. Further, there is a possibility that such an oscillation control device does not function properly when vehicle body motion is not correctly detected.

CITATION LIST**PATENT LITERATURE****[0006]**

Patent Literature 1: Japanese Patent Application Publication No. 2004-90849

Patent Literature 2: Japanese Patent Application Publication No. 2007-139100

Patent Literature 3: Japanese Patent Application Publication No. 2009-149304

Patent Literature 4: Japanese Patent Application Publication No. 2012-19661

SUMMARY OF INVENTION**TECHNICAL PROBLEM**

[0007] In view of the above-mentioned circumstances, recently, there has been a demand for a yawing suppression device which can be manufactured at lower cost and which does not depend on electrical control. It is an objective of the present invention to provide a yawing suppression device of a railway vehicle which can be manufactured at lower cost and which has high reliability.

SOLUTION TO PROBLEM

[0008] A yawing suppression device according to one embodiment of the present invention is a yawing suppression device of a railway vehicle for suppressing yawing of a vehicle body of the railway vehicle including a first bogie and a second bogie. The device includes: a torsion bar; a first connecting member which connects the first bogie and a first portion of the torsion bar with each other; and a second connecting member which connects the second bogie and a second portion of the torsion bar with each other. The first and second connecting members connect the torsion bar with the respective first and second bogies such that torsion in a circumferential direction is generated in the torsion bar in a state where a relative position of the first bogie in a horizontal direction with respect to a center line of the vehicle body in a width direction is out of alignment with a relative position of the second bogie in the horizontal direction with respect to the center line.

[0009] The railway vehicle according to one embodiment of the present invention includes: a vehicle body; first and second bogies configured to support the vehicle body; and the yawing suppression device of the present invention.

ADVANTAGEOUS EFFECTS OF INVENTION

[0010] According to the present invention, it is possible to acquire a yawing suppression device of a railway vehicle which can be manufactured at lower cost and which has high reliability.

BRIEF DESCRIPTION OF DRAWINGS**[0011]**

FIG. 1 is a top plan view schematically showing one example of the relationship between a yawing suppression device of a first embodiment and bogies. FIG. 2 is a perspective view schematically showing

one example of a first connecting member included in the yawing suppression device of the first embodiment.

FIG. 3 is a top plan view for describing a function of the yawing suppression device of the first embodiment.

FIG. 4 is a perspective view schematically showing a function of the first connecting member in a state shown in FIG. 3.

FIG. 5 is a perspective view schematically showing a function of a second connecting member in a state shown in FIG. 3.

FIG. 6 is a perspective view schematically showing another example of the first connecting member included in the yawing suppression device of the first embodiment.

FIG. 7 is a side view schematically showing one example of a railway vehicle of a second embodiment.

FIG. 8 is a graph showing results of analysis of variation with time of yawing acceleration of a vehicle body.

FIG. 9 is a graph showing results of analysis of power spectral density (PSD) of yawing of a vehicle body.

DESCRIPTION OF EMBODIMENTS

[0012] Inventors of the present invention have made extensive studies and, as a result, have newly found that yawing of a vehicle body of a railway vehicle can be particularly suppressed by the specific structure. The present invention is based on this new finding.

[0013] Hereinafter, embodiments of the present invention are described. In the description made hereinafter, the embodiments of the present invention are described by taking examples. However, the present invention is not limited to the examples described below. In the description made hereinafter, specific numerical values or materials may be exemplified. However, provided that advantageous effects of the present invention can be acquired, other numerical values or materials may be used.

[0014] A yawing suppression device of this embodiment is a yawing suppression device of a railway vehicle. The yawing suppression device can suppress yawing of a vehicle body of the railway vehicle including a first bogie and a second bogie. The yawing suppression device includes: a torsion bar; a first connecting member which connects the first bogie and a first portion of the torsion bar with each other; and a second connecting member which connects the second bogie and a second portion of the torsion bar with each other. In the description made hereinafter, a relative position of the first bogie in a horizontal direction with respect to a center line of the vehicle body in a width direction may be referred to as "relative position P1", and a relative position of the second bogie in the horizontal direction with respect to the center line of the vehicle body in the width direction may be referred to as "relative position P2". The first and second connecting members connect the torsion bar with the respective

first and second bogies such that torsion in a circumferential direction is generated in the torsion bar in a state where the relative position P1 and the relative position P2 are out of alignment with each other.

[0015] The center line of the vehicle body in the width direction is a line which passes the center of the vehicle body in the width direction (the direction perpendicular to the longitudinal direction of the vehicle body) as viewed from above. Hereinafter, the center line of the vehicle body in the width direction may be referred to as "center line CT". Further, the center line of the first bogie in the width direction may be referred to as "center line C1", and the center line of the second bogie in the width direction may be referred to as "center line C2". The relative position P1 can be acquired by the position of the center line C1 (the center line of the first bogie) in the horizontal direction with respect to the center line CT (the center line of the vehicle body). In the same manner, the relative position P2 can be acquired by the position of the center line C2 (the center line of the second bogie) in the horizontal direction with respect to the center line CT (the center line of the vehicle body).

[0016] With the larger positional difference between the relative position P1 and the relative position P2, larger yawing of the vehicle is generated. In the above-mentioned yawing suppression device, torsion in the circumferential direction is generated in the torsion bar when the relative position P1 and the relative position P2 are out of alignment with each other. At this point of operation, a force is applied to the first and second bogies so as to cancel the torsion due to a reaction force caused by the torsion bar. In other words, when a positional difference between the relative position P1 and the relative position P2 increases, a force which reduces the positional difference is generated by the torsion bar. Therefore, according to the device of this embodiment, yawing of the vehicle can be suppressed. The device of this embodiment does not require an electrical control device and hence, the device is characterized by having high reliability and allowing low manufacturing cost.

[0017] The torsion bar typically has a circular columnar shape. However, the torsion bar may have a prismatic shape, or may partially have a circular columnar shape. Alternatively, the torsion bar may have a cylindrical shape, or may partially have a cylindrical shape. For example, in the case where the torsion bar is supported by a support member in a rotatable state in the circumferential direction, only a portion of the torsion bar to be supported by the support member may have a circular columnar shape or a cylindrical shape.

[0018] In the yawing suppression device of this embodiment, yawing can be suppressed by a reaction force against a force applied to the torsion bar. Accordingly, a torsion bar which generates a reaction force capable of suppressing yawing is used as the torsion bar. One example of such a torsion bar may be a round bar having a diameter of 100 mm or more (within a range from 100 mm to 200 mm, for example), being made of SUP9 (hav-

ing a modulus of rigidity of 78450N/mm²) according to the JIS Standard, for example. However, the torsion bar used in this embodiment is not limited to such a round bar. For example, a material for forming the torsion bar may be spring steel (SUP3, SUP6, SUP7, SUP9, SUP10, SUP12 or the like according to the JIS Standard).

[0019] The configurations of the first and second bogies are not particularly limited provided that the configurations can acquire advantageous effects of the present invention. In the same manner as a known bogie, the first and second bogies may include structural members (side beams, cross beams, other structural members), suspensions (towing device, support device, spring device, other devices), and other members and devices. Usually, the first and second connecting members are respectively connected to structural members of the first and second bogies. For example, the first and second bogies may respectively include cross beams, and the first and second connecting members may be connected to these cross beams.

[0020] The first connecting member may include a first arm fixed to the first portion (torsion bar), and a bearing (a spherical bearing, for example) forming at least a portion of a mechanism which connects the first arm and the first bogie with each other. In the same manner, the second connecting member may include a second arm fixed to the second portion (torsion bar), and a bearing (a spherical bearing, for example) forming at least a portion of a mechanism which connects the second arm and the second bogie with each other. Each of the first connecting member and the second connecting member may include a rubber bush or the like.

[0021] In the yawing suppression device of this embodiment, the first connecting member may include: a first arm fixed to the first portion (torsion bar); a first bearing mounted on the first arm; a first coupling member supported on the first bearing; and a second bearing configured to connect the first coupling member and the first bogie with each other. The second connecting member may include: a second arm fixed to the second portion (torsion bar); a third bearing mounted on the second arm; a second coupling member supported on the third bearing; and a fourth bearing configured to connect the second coupling member and the second bogie with each other. With such a configuration, torsion in the circumferential direction can be generated in the torsion bar when the relative position P1 and the relative position P2 are out of alignment with each other. In such a configuration, at least one bearing selected from the first bearing and the second bearing may be formed of a spherical bearing, and at least one bearing selected from the third bearing and the fourth bearing may be formed of a spherical bearing. For example, each of the first and third bearings may be formed of a spherical bearing. Alternatively, each of the second and fourth bearings may be formed of a spherical bearing.

[0022] It is sufficient that each of the first to fourth bearings is a bearing which changes an angle made by two

members, which are connected by the bearing, in a plane perpendicular to the direction of the center line CT of the vehicle body. An example of the bearing includes a sliding bearing, a rolling bearing, and other bearings. However, to cope with the case where a distance between two bogies changes, it is preferable that at least one of the first to fourth bearings be formed of a spherical bearing.

[0023] For each of the first and second coupling members, a member which can transmit transfer motion of the bogie to the torsion bar is used. For example, a rod-like member made of a steel material (example: rolled steel material for general structure defined in JIS G 3101 (example: SS400)) is used. The same applies for the first and second arms.

[0024] In the yawing suppression device of this embodiment, at least one of the first and second coupling members may include a damper. For example, each of the first and second coupling members may include a damper. With the use of the damper, yawing can be suppressed more effectively. The damper is not particularly limited, and a known damper may be used.

[0025] In the yawing suppression device of this embodiment, the torsion bar may be supported on the vehicle body in a rotatable state in the circumferential direction. In this case, the yawing suppression device includes one or more support members (the plurality of support members, for example) for supporting the torsion bar on the vehicle body in a rotatable state in the circumferential direction. The support member may be a support member having a through hole through which the torsion bar passes, for example. A bearing or the like may be disposed in the through hole.

[0026] The railway vehicle of this embodiment includes a vehicle body, first and second bogies configured to support the vehicle body, and the yawing suppression device of this embodiment. With such a configuration, yawing of the vehicle body can be suppressed. The railway vehicle includes the vehicle body, and a plurality of (two, for example) bogies which support the vehicle body. The bogies run along a track. The vehicle body transports passengers and freight.

[0027] Embodiments of the present invention are described hereinafter with reference to drawings.

(First embodiment)

[0028] In a first embodiment, one example of a yawing suppression device of the present invention is described. FIG. 1 is a top plan view schematically showing a yawing suppression device of the first embodiment and bogies.

[0029] The yawing suppression device 100 of the first embodiment (hereinafter, the yawing suppression device 100 may be referred to as "device 100") is a device for suppressing yawing of a vehicle body of a railway vehicle. The railway vehicle includes a first bogie 11, a second bogie 12, a vehicle body 13 (see FIG. 7), and the device 100.

[0030] The device 100 includes a torsion bar 101, a

first connecting member 110, and a second connecting member 120. The first connecting member 110 connects the first bogie 11 (to be more specific, a bogie frame) and one end portion 101a (first portion) of the torsion bar 101 with each other (see FIG. 2). The second connecting member 120 connects the second bogie 12 (to be more specific, a bogie frame) and the other end portion 101b (second portion) of the torsion bar 101 with each other (see FIG. 5). The first and second connecting members 110 and 120 connect the torsion bar 101 with the respective first and second bogies 11 and 12 such that torsion in the circumferential direction is generated in the torsion bar 101 when a relative position P1 and a relative position P2 are out of alignment with each other. As described above, the relative position P1 is a relative position of the first bogie 11 in the horizontal direction with respect to the center line of the vehicle body in the width direction, and the relative position P2 is a relative position of the second bogie 12 in the horizontal direction with respect to the center line of the vehicle body in the width direction.

[0031] In FIG. 1, a bogie on the traveling direction Fw (arrow Fw) side of a vehicle is assumed as the first bogie 11. Each of the first bogie 11 and the second bogie 12 includes a plurality of (two, for example) axles Ax. Two wheels Wh are provided to each axle Ax. The axle Ax is connected to a structural member of the vehicle body by way of side beams Sb, cross beams Cb, suspensions (not shown in the drawing) and the like. FIG. 1 shows one example where the structural member (bogie frame) of each of the bogies 11 and 12 includes the side beams Sb and the cross beams Cb. However, the present invention is not limited to such a configuration.

[0032] Each of the first bogie 11 and the second bogie 12 runs on rails 1. The first bogie 11 and the second bogie 12 support and tow the vehicle body by way of the suspensions and the like.

[0033] FIG. 2 is a perspective view schematically showing the first connecting member 110. The first connecting member 110 includes: a first arm 111 fixed to the end portion 101a of the torsion bar 101; a first bearing 111a mounted on the first arm 111; a first coupling member 112 supported on the first bearing 111a; and a second bearing 112a which connects the first coupling member 112 and the first bogie 11 with each other. In one example shown in FIG. 2, the first coupling member 112 is connected to the cross beam Cb of the bogie 11 by way of the second bearing 112a.

[0034] The first arm 111 is fixed to the end portion 101a of the torsion bar 101. Accordingly, when the angle of the first arm 111 changes in a plane perpendicular to the traveling direction, the first arm 111 rotates about the center axis of the torsion bar 101. In other words, in such a case, a rotational motion with the center of rotation along the center axis of the torsion bar 101 is generated in the first arm 111.

[0035] On the other hand, the first arm 111 and the first coupling member 112 are supported by the first bearing 111a in a rotatable manner. To be more specific, the first

arm 111 is supported in a rotatable manner with respect to the first coupling member 112 in a plane perpendicular to the traveling direction. Further, the first coupling member 112 is supported by the second bearing 112a in a rotatable manner with respect to the bogie 11 (cross beam). To be more specific, the first coupling member 112 is supported in a rotatable manner with respect to the bogie 11 in a plane perpendicular to the traveling direction.

[0036] The function of the device 100 is described with reference to FIG. 3. FIG. 3 is a top plan view of the bogies 11 and 12 as viewed from above. FIG. 3 shows the profile of the vehicle body 13, and a center line CT of the vehicle body 13. As shown in FIG. 3, it is preferable that the center axis of the torsion bar 101 and the center line CT of the vehicle body are parallel to each other. It is also preferable that, as shown in FIG. 3, the torsion bar 101 is disposed on the center line CT of the vehicle body.

[0037] Assume a case where, as shown in FIG. 3, the bogie 11 moves to the right side with respect to the traveling direction Fw, and the bogie 12 moves to the left side with respect to the traveling direction Fw. FIG. 3 shows the center line CT of the vehicle body 13 in the width direction, a center line C1 of the first bogie 11 in the width direction, and a center line C2 of the second bogie 12 in the width direction. In this case, a positional difference in the horizontal direction between the center line CT of the vehicle body 13 and the center line C1 of the bogie 11 determines the relative position P1 of the bogie 11. In the same manner, a positional difference in the horizontal direction between the center line CT of the vehicle body 13 and the center line C2 of the bogie 12 determines the relative position P2 of the bogie 12. In the case of FIG. 3, the relative position P1 and the relative position P2 are out of alignment with each other. In FIG. 3, the relative position P1 of the bogie 11 with respect to the center line CT is indicated by an arrow P1', and the relative position P2 of the bogie 12 with respect to the center line CT is indicated by an arrow P2'.

[0038] The relationship between the angle of the first arm 111 and rotation of the torsion bar 101 in the case of FIG. 3 is schematically shown in FIG. 4. The cross beam Cb moves in the direction indicated by a solid arrow with the movement of the bogie 11. In this case, the angle of the first arm 111 changes as shown in FIG. 4, and torsion in the direction indicated by an arrow R1 is applied to the torsion bar 101 accordingly. To be more specific, a force is applied to the torsion bar 101 such that the torsion bar 101 rotates counterclockwise with respect to the traveling direction Fw.

[0039] The operation of the second connecting member 120 in the case of FIG. 3 is schematically shown in FIG. 5. The second connecting member 120 includes: a second arm 123 fixed to the end portion 101b of the torsion bar 101; a third bearing 123a mounted on the second arm; a second coupling member 124 supported on the third bearing 123a; and a fourth bearing 124a which connects the second coupling member 124 and the second

bogie 12 with each other. In one example shown in FIG. 5, the second coupling member 124 is connected to the cross beam Cb of the bogie 12 by way of the fourth bearing 124a. The third bearing 123a and the fourth bearing 124a respectively have functions equal to those of the first bearing 111a and the second bearing 112a.

[0040] Referring to FIG. 5, in the case where the bogie 12 moves as shown in FIG. 3, the cross beam Cb of the bogie 12 moves in the direction indicated by a solid arrow with the movement of the bogie 12. In this case, the angle of the second arm 123 changes as shown in FIG. 5, and torsion in the direction indicated by an arrow R2 is applied to the torsion bar 101 accordingly. To be more specific, a force is applied to the torsion bar 101 such that the torsion bar 101 rotates clockwise with respect to the traveling direction Fw.

[0041] The configuration of the first connecting member 110 and the configuration of the second connecting member 120 may be completely equal to each other. With such configurations, generation of torsion in the torsion bar 101 can be easily prevented when the relative position P1 and the relative position P2 are in alignment with each other. In such a case, however, the direction of mounting of the first connecting member 110 and the direction of mounting of the second connecting member 120 are made opposite to each other. To be more specific, it is preferable to dispose the second connecting member 120 in a state obtained by rotating the first connecting member 110 by 180° about an axis vertical to the vehicle body (see FIG. 1). By disposing the second connecting member 120 in such a manner, torsion can be generated in the torsion bar 101 when the bogie 11 and the bogie 12 move in directions opposite to each other with respect to the center line CT.

[0042] Provided that the above-mentioned rotation can be performed, the bearings 111a, 112a, 123a, and 124a are not particularly limited, and known bearings may be used. At least one of these bearings may be formed of a spherical bearing. For example, each of the bearings 112a and 124a may be formed of a spherical bearing. With the use of the spherical bearing, it is possible to easily cope with the case where a distance between the bogie 11 and the bogie 12 changes.

[0043] As described above, in the case where the first bogie 11 and the second bogie 12 move in directions opposite to each other with respect to the center line CT, the direction of rotation applied to the torsion bar 101 by the first connecting member 110 is opposite to the direction of rotation applied to the torsion bar 101 by the second connecting member 120. Accordingly, torsion in the circumferential direction is generated in the torsion bar 101. In this case, a reaction force against the torsion is generated in the torsion bar 101. The reaction force acts so as to reduce a positional difference between the relative position P1 and the relative position P2. As a result, according to the yawing suppression device of the present invention, it is possible to reduce a positional difference between the relative position P1 and the rel-

ative position P2.

[0044] In the case where the second bogie 12 moves to the right side with respect to the traveling direction by an amount equal to the amount by which the first bogie 11 moves, the relative position P1 and the relative position P2 are in alignment with each other. In this case, the direction and angle of rotation applied to the torsion bar 101 by the first arm 111 and the direction and angle of rotation applied to the torsion bar 101 by the second arm 123 are equal to each other. Accordingly, in such a case, torsion is not generated in the torsion bar 101 so that a reaction force caused by torsion of the torsion bar 101 is also not generated. In other words, in the yawing suppression device 100, with a larger positional difference between the relative position P1 and the relative position P2, a larger reaction force due to the torsion bar 101 is generated. As a result, yawing can be effectively suppressed.

[0045] Each of the first and second connecting members 110 and 120 may include a damper. For example, each of the first coupling member 112 and the second coupling member 124 may include a damper. One example of the first connecting member 110 where the first coupling member 112 includes a damper is shown in FIG. 6. The first connecting member 110 shown in FIG. 6 is equal to the connecting member 110 shown in FIG. 2 except for that the first coupling member 112 includes a damper 112d. In the same manner as the first connecting member 110 shown in FIG. 6, the second connecting member 120 may also include a damper.

(Second embodiment)

[0046] In a second embodiment, one example of a railway vehicle which includes the yawing suppression device of the present invention is described. The railway vehicle of the second embodiment is schematically shown in FIG. 7. The railway vehicle 10 shown in FIG. 7 includes a first bogie 11, a second bogie 12, a vehicle body 13, and the yawing suppression device 100 of the present invention. As shown in FIG. 7, the yawing suppression device 100 of the present invention may include support members 102 for mounting a torsion bar 101 to the vehicle body 13 in a rotatable manner. The support members 102 are fixed to a structural member 13a of the vehicle body. The torsion bar 101 is supported by the support members 102 in a rotatable manner. The railway vehicle 10 in the second embodiment includes the yawing suppression device of the present invention. Accordingly, yawing of the vehicle body 13 can be suppressed.

EXAMPLE

[0047] The present invention is described in more detail with an example. In this example, to verify advantageous effects of the yawing suppression device of the present invention, an analysis was performed using a railway vehicle motion analysis tool (Simpack Rail). In

this analysis, it was assumed that the mass of the bogie was 5684 kg. It was also assumed that the torsion bar 101 was a round bar having a diameter of 150 mm. It was assumed that the round bar was made of SUP9 (having a modulus of rigidity of 78450N/mm²).

[0048] In this example, with respect to the case where the yawing suppression device of the present invention is used (Inventive Example) and the case where the yawing suppression device of the present invention is not used (Comparative Example), variation with time of yawing acceleration of a vehicle body, and power spectral density (PSD) of yawing of the vehicle body were acquired. The results of the variation with time and PSD are shown in FIG. 8 and FIG. 9.

[0049] As shown in FIG. 8 and FIG. 9, yawing acceleration and PSD in the Inventive Example were remarkably smaller than those in the Comparative Example. The results indicate that the yawing suppression device of the present invention can effectively suppress yawing.

INDUSTRIAL APPLICABILITY

[0050] The present invention can be utilized as a yawing suppression device of a railway vehicle and in a railway vehicle which uses the yawing suppression device.

REFERENCE SIGNS LIST

[0051]

10	railway vehicle
11	first bogie
12	second bogie
13	vehicle body
100	yawing suppression device
101	torsion bar
102	support member
101a	end portion (first portion)
101b	end portion (second portion)
110	first connecting member
111	first arm
111a	first bearing
112	first coupling member
112a	second bearing
112d	damper
120	second connecting member
123	second arm
123a	third bearing
124	second coupling member
124a	fourth bearing
CT	center line of vehicle body in the width direction
P1'	arrow showing relative position
P2'	arrow showing relative position

Claims

1. A yawing suppression device of a railway vehicle for

suppressing yawing of a vehicle body of the railway vehicle including a first bogie and a second bogie, the yawing suppression device comprising:

5 a torsion bar;
a first connecting member which connects the first bogie and a first portion of the torsion bar with each other; and
10 a second connecting member which connects the second bogie and a second portion of the torsion bar with each other, wherein the first and second connecting members connect the torsion bar with the respective first and second bogies such that torsion in a circumferential direction is generated in the torsion bar in a state where a relative position of the first bogie in a horizontal direction with respect to a center line of the vehicle body in a width direction is out of alignment with a relative position of the second bogie in the horizontal direction with respect to the center line.

2. The yawing suppression device according to claim 1, wherein the first connecting member includes a first arm fixed to the first portion, a first bearing mounted on the first arm, a first coupling member supported on the first bearing, and a second bearing configure to connect the first coupling member and the first bogie with each other, and
30 the second connecting member includes a second arm fixed to the second portion, a third bearing mounted on the second arm, a second coupling member supported on the third bearing, and a fourth bearing configure to connect the second coupling member and the second bogie with each other.

3. The yawing suppression device according to claim 2, wherein at least one bearing selected from the first bearing and the second bearing is formed of a spherical bearing, and
40 at least one bearing selected from the third bearing and the fourth bearing is formed of a spherical bearing.

4. The yawing suppression device according to claim 2 or 3, wherein each of the first coupling member and the second coupling member includes a damper.

5. The yawing suppression device according to any one of claims 1 to 4, wherein the torsion bar is supported on the vehicle body in a rotatable state in the circumferential direction.

6. A railway vehicle comprising:
55 a vehicle body:

first and second bogies configured to support the vehicle body; and

the yawing suppression device according to any one of claims 1 to 5.

5

10

15

20

25

30

35

40

45

50

55

FIG. 1

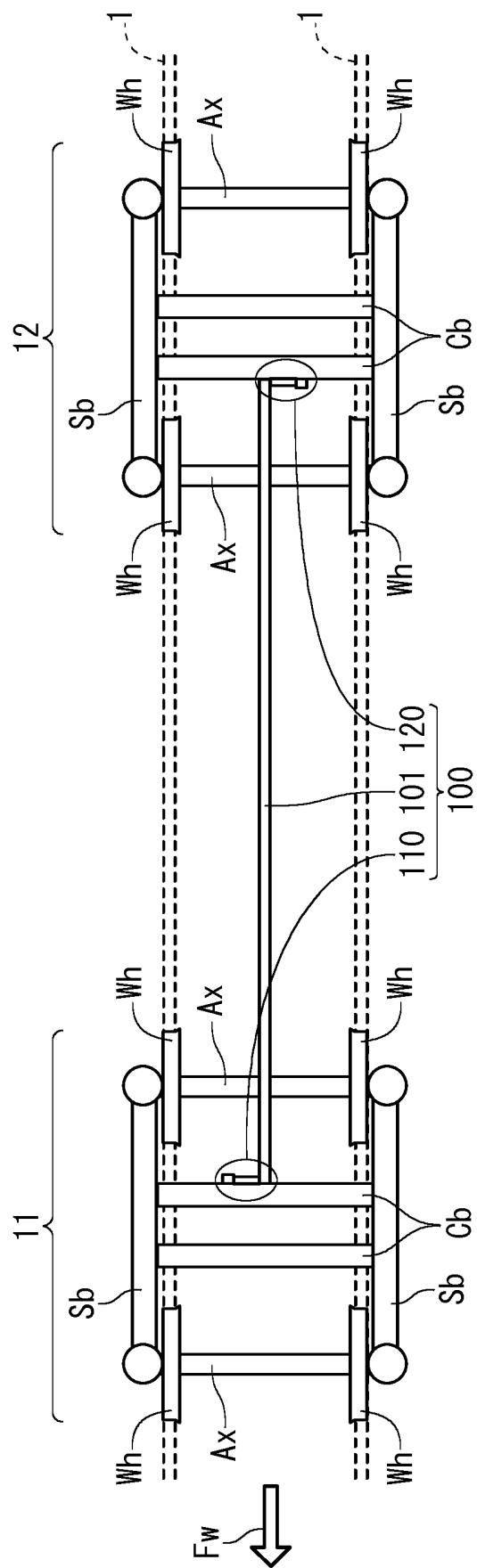


FIG. 2

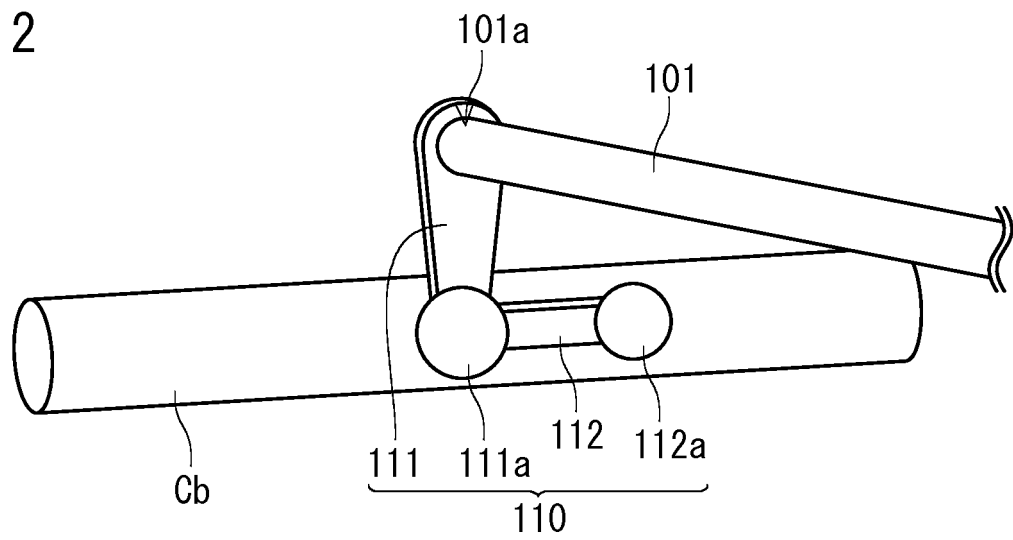


FIG. 3

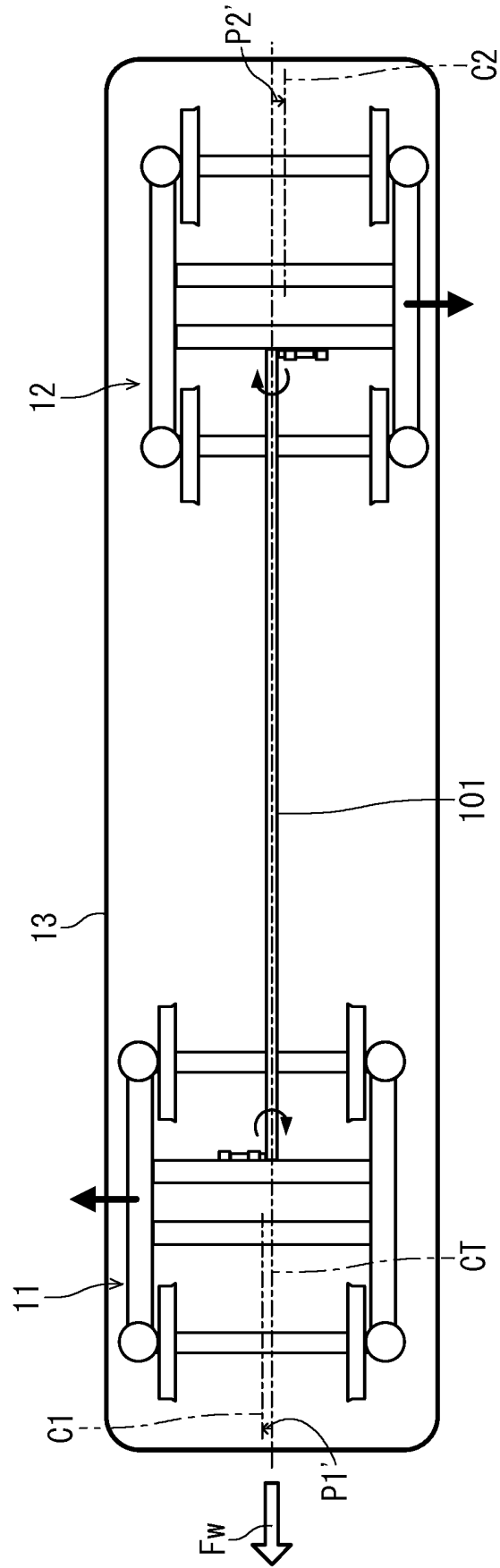


FIG. 4

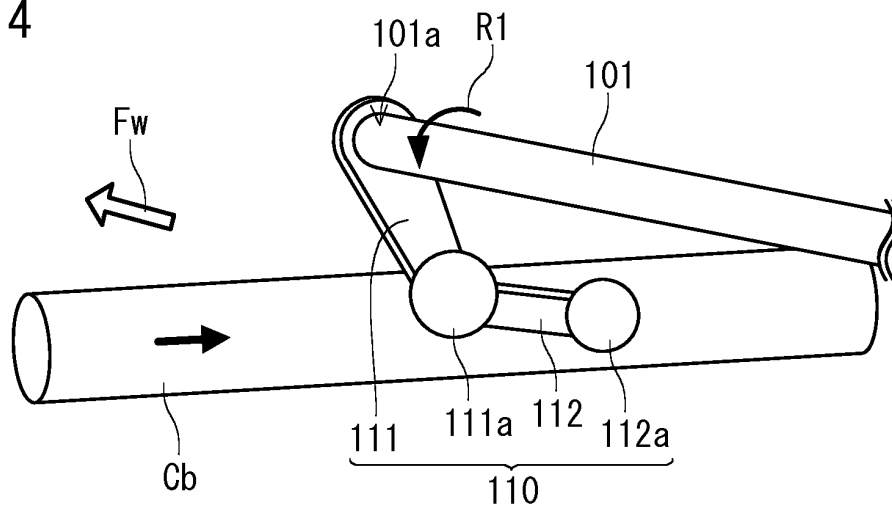


FIG. 5

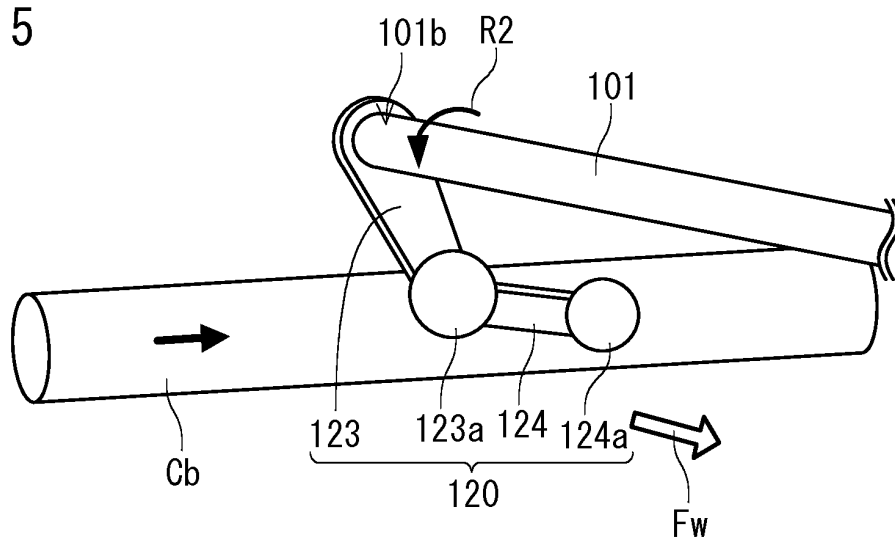


FIG. 6

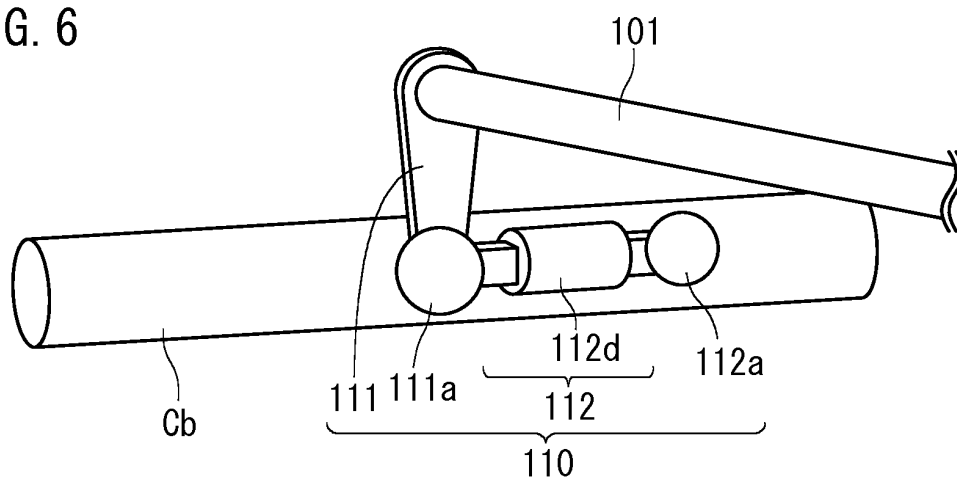


FIG. 7

10

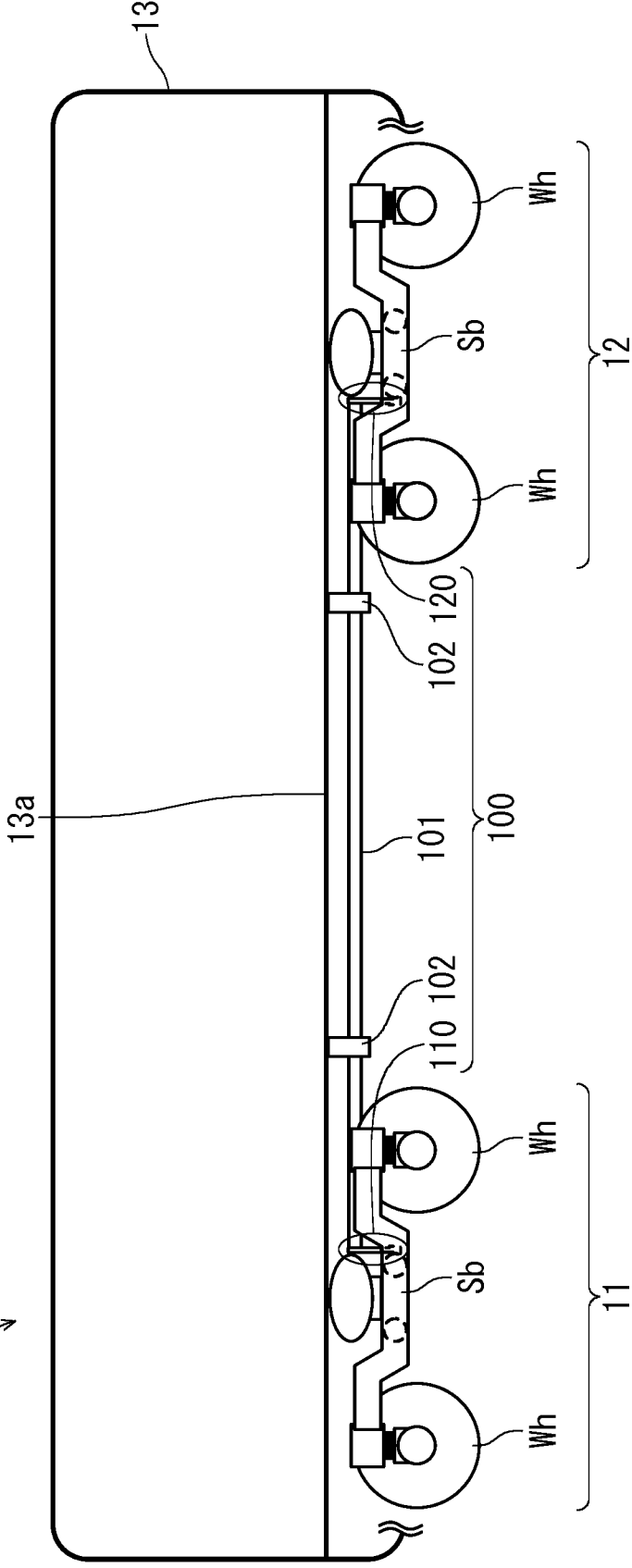


FIG. 8

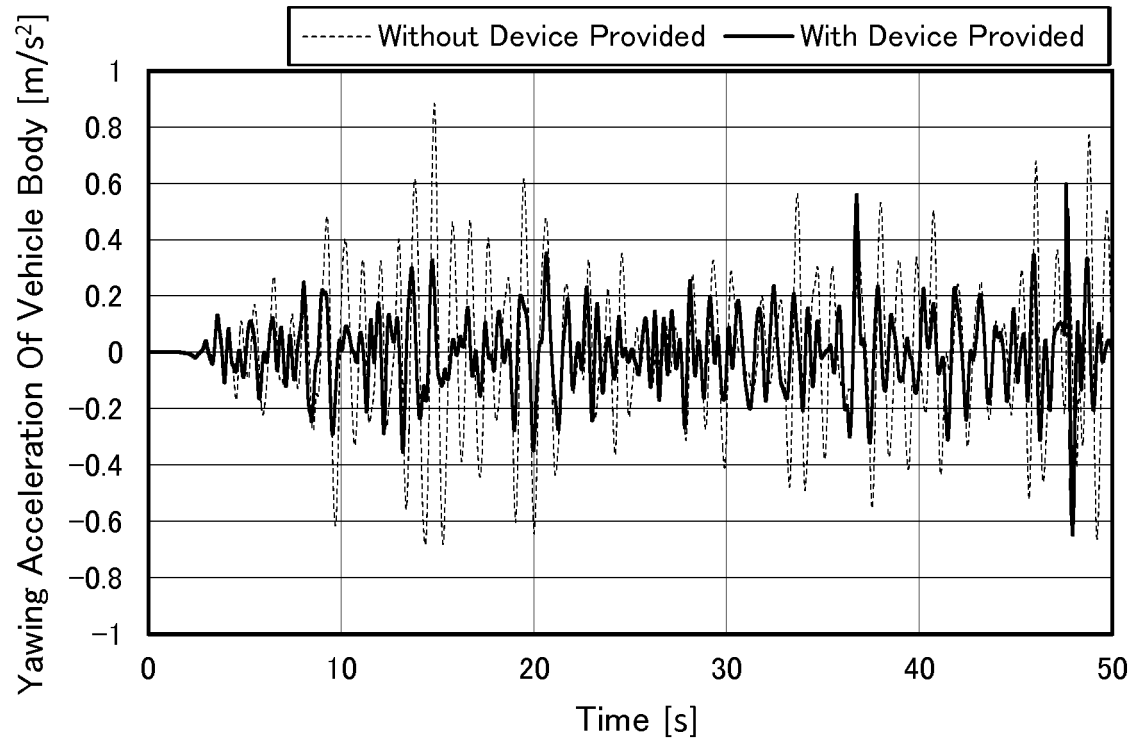
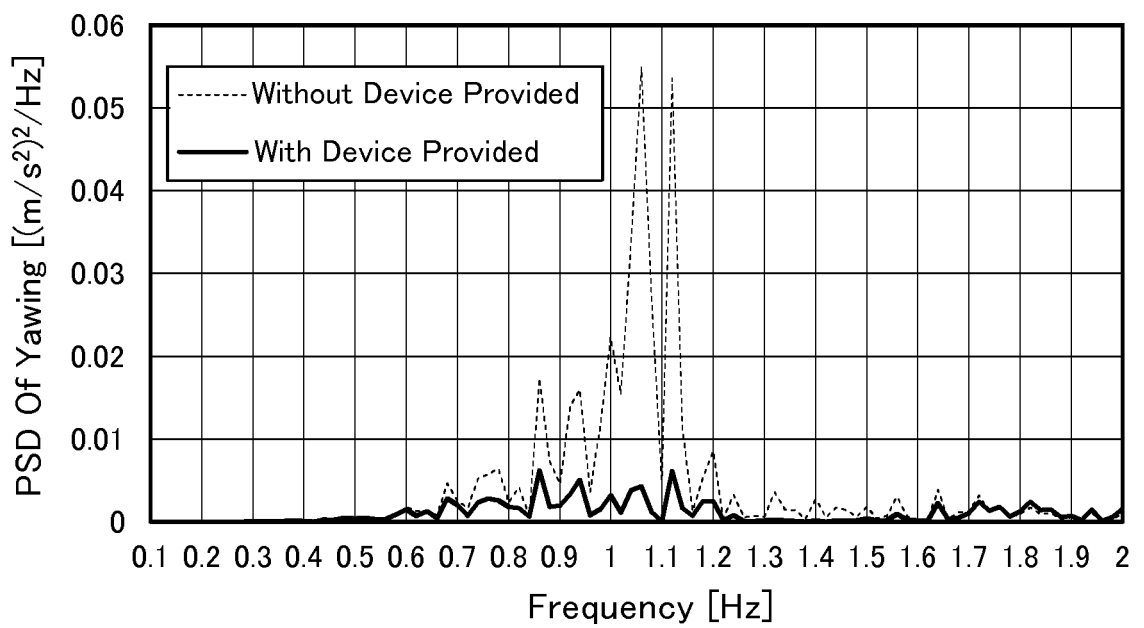


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/041731

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. B61F5/24 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. B61F5/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2014-240274 A (KAWASAKI HEAVY INDUSTRIES, LTD.) 25	1-3, 5-6
Y	December 2014, paragraphs [0020]-[0024], [0083]-[0102], fig. 1, 18-20 & US 2015/0114252 A1, paragraphs [0053]-[0057], [0116]-[0135], fig. 1, 18-20 & WO 2014/010624 A1 & EP 2873584 A1 & KR 10-2015-0013812 A & CN 104428185 A & HK 1206310 A1	4
Y	JP 2009-149304 A (SUMITOMO METAL INDUSTRIES, LTD.) 09 July 2009, paragraphs [0014]-[0019], [0023]-[0034], fig. 1-2 & JP 2005-238858 A	4

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
01 February 2018 (01.02.2018)

Date of mailing of the international search report
13 February 2018 (13.02.2018)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2004090849 A [0004] [0006]
- JP 2007139100 A [0004] [0006]
- JP 2009149304 A [0004] [0006]
- JP 2012019661 A [0005] [0006]