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

(11) **EP 3 848 507 A1**

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

(43) Date of publication:
14.07.2021 Bulletin 2021/28

(21) Application number: **19857743.9**

(22) Date of filing: **06.09.2019**

(51) Int Cl.:
E01B 19/00 *(2006.01)*

(86) International application number:
PCT/KR2019/011522

(87) International publication number:
WO 2020/050670 (12.03.2020 Gazette 2020/11)

(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
KH MA MD TN

(30) Priority: **06.09.2018 KR 20180106714**

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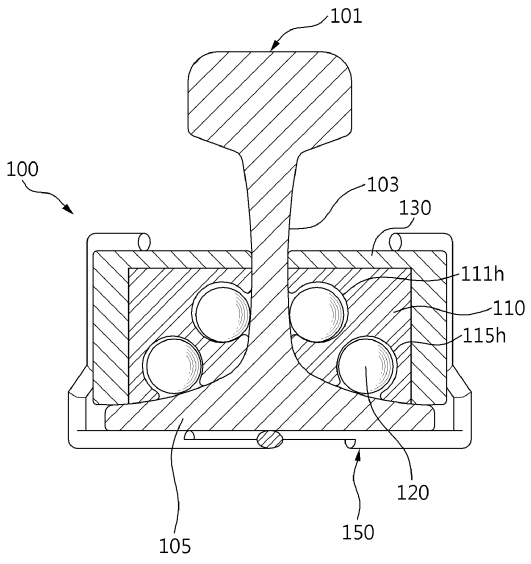
(54) VIBRATION REDUCING DEVICE

(57) The present invention relates to a vibration reduction device, and more particularly, to a vibration reduction device capable of reducing rolling noise by reducing vibration in a low-frequency region as well as vibration in a high-frequency region. A vibration reduction device according to an exemplary embodiment of the present invention includes: a pair of damper main bodies disposed at both sides with a web portion of a rail interposed therebetween, such that at least a part of the damper main body is in contact with the web portion and at least another part of the damper main body is in contact with a lower end portion of the rail which is connected to the web portion; a plurality of inelastic collision balls provided in at least two through holes formed in each of the pair of damper main bodies so as to be movable with respect to the web portion or the lower end portion; and a pair of housings configured to surround the pair of damper main bodies from the outside in order to prevent the damper main bodies from being exposed to the outside.

[FIG. 2]



EP 3 848 507 A1

Description

[Technical Field]

[0001] The present invention relates to a vibration reduction device, and more particularly, to a vibration reduction device capable of reducing rolling noise by reducing vibration in a low-frequency region as well as vibration in a high-frequency region.

[Background Art]

[0002] Recently, noise generated by a high-speed train wen the high-speed train moves has emerged as a major environmental noise issue. Among others, rolling noise is considered as a major cause of train noise. The rolling noise refers to noise generated when a rail and a wheel vibrate while a railroad vehicle moves. In order to reduce the rolling noise, various types of dampers are being developed as described above.

[0003] In general, in a cross section of the rail, a web has a smaller thickness than an upper end. For this reason, when the rail vibrates due to a movement load of the train, the upper end of the rail severely vibrates with respect to the web.

[0004] Therefore, in the related art, a web damper has been mainly used to block or reduce vibration of a railroad track, and the web damper is designed to reinforce a thickness of the web of the rail in order to increase rigidity of the rail. The installed web damper may increase frequencies of all types of vibration of the rail, thereby reducing high-frequency components of the vibration.

[0005] The web damper in the related art is effective in reducing the high-frequency components of the vibration. However, because the web increases only the thickness, there is a limitation in reducing low-frequency components of the vibration of the rail. Further, because a length of the web damper is also increased by a length of the rail, there is a problem in that material costs are increased. In addition, because a main material of the web damper is rubber, durability of the web damper deteriorates and the web damper is deformed when the web damper is exposed to an external environment over a long period of time.

[0006] Accordingly, there is a need for development of a vibration reduction damper for a rail, which has a new structure capable of implementing excellent vibration properties in the entire frequency region, minimizing an increase in costs, and preventing deformation caused by external environments.

[0007] As a related art, there is Korean Patent Application Laid-Open No. 10-2016-0020018 entitled Noise and Vibration Reduction Device (published on February 23, 2016).

[Disclosure]

[Technical Problem]

[0008] One exemplary embodiment of the present invention provides a vibration reduction device capable of reducing rolling noise by reducing vibration in a low-frequency region as well as vibration in a high-frequency region, the vibration reduction device being capable of being manufactured as a unit, instead of having a length equal to a length of a rail, such that an interval between the vibration reduction devices may be adjusted, thereby reducing manufacturing costs.

[0009] Technical problems to be solved by the present invention are not limited to the above-mentioned technical problem(s), and other technical problem(s), which are not mentioned above, may be clearly understood by those skilled in the art from the following descriptions.

[Technical Solution]

[0010] A vibration reduction device according to an exemplary embodiment of the present invention includes: a pair of damper main bodies disposed at both sides with a web portion of a rail interposed therebetween, such that at least a part of the damper main body is in contact with the web portion and at least another part of the damper main body is in contact with a lower end portion of the rail which is connected to the web portion; a plurality of inelastic collision balls provided in at least two through holes formed in each of the pair of damper main bodies so as to be movable with respect to the web portion or the lower end portion; and a pair of housings configured to surround the pair of damper main bodies from the outside in order to prevent the damper main bodies from being exposed to the outside.

[0011] In the exemplary embodiment of the present invention, surfaces of the damper main body, which are directed toward the web portion and the lower end portion, may have shapes corresponding to external shapes of the web portion and the lower end portion, and an upper surface, a lateral surface, a front surface, and a rear surface of the damper main body may be surrounded by the housing.

[0012] In the exemplary embodiment of the present invention, the plurality of inelastic collision balls may be disposed long in each of the at least two through holes so as to be in contact with one another, a first through hole, which is one of the at least two through holes, may be opened toward the web portion so that the inelastic collision balls are in contact with the web portion, and a second through hole, which is another of the at least two through holes, may be opened toward the lower end portion so that the inelastic collision balls are in contact with the lower end portion.

[0013] In the exemplary embodiment of the present invention, each of the first through hole and the second through hole may have a cross-sectional shape corre-

sponding to a shape of the inelastic collision ball, and each of the first through hole and the second through hole may be larger than the inelastic collision ball so that the inelastic collision ball is movable.

[0014] In the exemplary embodiment of the present invention, a part of the inelastic collision ball may be in contact with the web portion when the inelastic collision ball is positioned at an initial position in the first through hole, and a part of the inelastic collision ball may be in contact with the lower end portion when the inelastic collision ball is positioned at an initial position in the second through hole.

[0015] In the exemplary embodiment of the present invention, the damper main body may be made of a rubber material in order to absorb vibration generated from the rail.

[0016] In the exemplary embodiment of the present invention, the damper main body may be made of a meta material.

[0017] The vibration reduction device according to the exemplary embodiment of the present invention may further include a fixing unit configured to fix the pair of housings, which surround the pair of damper main bodies, respectively, to the rail.

[0018] In the exemplary embodiment of the present invention, the fixing unit may include a pair of fixing clips disposed in an X shape, and each of the pair of fixing clips may include: a clip lower end portion configured to be disposed on a lower surface of the rail; clip lateral portions extending upward from both ends of the clip lower end portion and configured to fix lateral portions of the housings; and clip upper end portions extending inward from upper ends of the clip lateral portions and configured to fix upper ends of the housings.

[0019] In the exemplary embodiment of the present invention, the pair of fixing clips, which is retracted inward, may be disposed on the lower surface of the rail, and then the pair of fixing clips may be spread outward, such that the fixing unit may fix the pair of damper main bodies.

[0020] A vibration reduction device according to another exemplary embodiment of the present invention includes: a pair of damper main bodies disposed at both sides with a web portion of a rail interposed therebetween, such that at least a part of the damper main body is in contact with the web portion and at least another part of the damper main body is in contact with a lower end portion of the rail which is connected to the web portion; and a plurality of inelastic collision balls provided in at least two through holes formed in each of the pair of damper main bodies so as to be movable with respect to the web portion or the lower end portion, in which the plurality of inelastic collision balls is disposed long in each of the at least two through holes so as to be in contact with one another, a first through hole, which is one of the at least two through holes, is opened toward the web portion so that the inelastic collision balls are in contact with the web portion, and a second through hole, which is another of the at least two through holes, is opened toward the lower end portion so that the inelastic collision balls are in contact with the lower end portion.

[0021] In the exemplary embodiment of the present invention, a part of the inelastic collision ball may be in contact with the web portion when the inelastic collision ball is positioned at an initial position in the first through hole, and a part of the inelastic collision ball may be in contact with the lower end portion when the inelastic collision ball is positioned at an initial position in the second through hole.

[0022] Other detailed matters of the exemplary embodiment are included in the detailed description and the accompanying drawings.

[Advantageous Effects]

[0023] According to the exemplary embodiment of the present invention, the vibration reduction device may reduce rolling noise by reducing vibration in a low-frequency region as well as vibration in a high-frequency region, and the vibration reduction device may be manufactured as a unit, instead of having a length equal to a length of a rail, such that an interval between the vibration reduction devices may be adjusted, thereby reducing manufacturing costs.

[Description of Drawings]

[0024]

FIG. 1 is a perspective projection view illustrating a vibration reduction device according to an exemplary embodiment of the present invention when viewed from one side.

FIG. 2 is a vertical cross-sectional view of FIG. 1.

FIG. 3 is a front projection view of FIG. 2 when viewed from one side.

FIG. 4 is a top plan projection view of FIG. 1 when viewed from the top side.

FIG. 5 is a perspective view illustrating a pair of damper main bodies illustrated in FIG. 1.

FIG. 6 is a perspective view of a fixing unit illustrated in FIG. 1.

FIG. 7 is a view schematically illustrating a state in which the vibration reduction devices illustrated in FIG. 1 are installed on a simple rail.

FIGS. 8A and 8B are graphs illustrating results of experiments on the simple rail.

FIGS. 9A and 9B are graphs illustrating results of experiments on an actual rail.

[Description of Main Reference Numerals of Drawings]

[0025]

100: Vibration reduction device
101: Rail

103: Web portion
105: Lower end portion
110: Damper main body
111h: First through hole
115h: Second through hole
120: Inelastic collision ball
130: Housing
150: Fixing unit

[Best Mode]

[0026] Advantages and/or features of the present invention and methods of achieving the advantages and features will be clear with reference to exemplary embodiments described in detail below together with the accompanying drawings. However, the present invention is not limited to the exemplary embodiments disclosed herein but will be implemented in various forms. The exemplary embodiments of the present invention are provided so that the present invention is completely disclosed, and a person with ordinary skill in the art can fully understand the scope of the present invention. The present invention will be defined only by the scope of the appended claims. Like reference numerals indicate like constituent elements throughout the specification.

[0027] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[0028] FIG. 1 is a perspective projection view illustrating a vibration reduction device according to an exemplary embodiment of the present invention when viewed from one side, FIG. 2 is a vertical cross-sectional view of FIG. 1, FIG. 3 is a front projection view of FIG. 2 when viewed from one side, FIG. 4 is a top plan projection view of FIG. 1 when viewed from the top side, FIG. 5 is a perspective view illustrating a pair of damper main bodies illustrated in FIG. 1, and FIG. 6 is a perspective view of a fixing unit illustrated in FIG. 1.

[0029] Referring to FIGS. 1 to 4, vibration reduction devices 100 according to the exemplary embodiment of the present invention are provided at preset intervals on a rail 101 and remove vibration of the rail 101, thereby removing rolling noise. The vibration reduction device 100 may include a pair of damper main bodies 110 symmetrically disposed at both sides with a web portion 103 of the rail 101 interposed therebetween, a plurality of inelastic collision balls 120 provided in a damper main body 110 and configured to collide with the web portion 103 or a lower end portion 105 of the rail 101 to reduce vibration, a pair of housings 130 configured to surround the pair of damper main bodies 110, and a fixing unit 150 configured to fix the above-mentioned components to the rail 101.

[0030] With the above-mentioned configuration, it is possible to excellently reduce rolling noise by reducing vibration in a low-frequency region as well as vibration in a high-frequency region, and it is possible to reduce discomfort that people living around the rail 101 and passengers on board of the train receive due to noise.

[0031] The respective components will be described. First, as illustrated in FIG. 2, the pair of damper main bodies 110 is disposed at both sides with the web portion 103 of the rail 101 interposed therebetween. One portion of a part of the damper main body 110, which is directed toward the rail 101, is in surface contact with the web portion 103 of the rail 101, and the other portion of the part of the damper main body 110 is in surface contact with the lower end portion 105 of the rail 101.

[0032] That is, a shape of the part of the damper main body 110, which is directed toward the rail 101, corresponds to a curved shape defined by the web portion 103 and the lower end portion 105 of the rail 101, such that the damper main body 110 is accurately fitted with the rail 101.

[0033] Referring to FIG. 5, the damper main body 110 has two through holes 111h and 115h formed in a longitudinal direction thereof. The two through holes 111h and 115h have shapes opened in lateral directions, such that the inelastic collision balls 120 disposed in the through holes 111h and 115h may be exposed to the opened portions of the through holes 111h and 115h.

[0034] However, the laterally opened portions of the through holes 111h and 115h have a smaller size than a diameter of the inelastic collision ball 120, and as a result, it is possible to prevent the inelastic collision ball 120 from being withdrawn from the opened portion. The inelastic collision ball 120 is provided in the form of a bead, and the through holes 111h and 115h are filled with the inelastic collision balls 120 in the longitudinal direction. As the through holes 111h and 115h are fully filled with the inelastic collision balls 120, the inelastic collision balls 120 cannot be moved in the longitudinal direction of the through holes 111h and 115h even though the inelatic collision balls 120 may move in the lateral directions.

[0035] Referring to FIGS. 2 and 5, the through holes 111h and 115h each have a slightly larger size than the inelastic collision ball 120. For example, when the inelastic collision balls 120 are in the state illustrated in FIG. 2, separation spaces of approximately 1 to 2 mm are present between the inelastic collision balls 120 and the through holes 111h and 115h. Therefore, the inelastic collision balls 120 may move in the through holes 111h and 115h.

[0036] With the above-mentioned configuration, when the rail 101 vibrates, vibrational energy of a track of the rail 101 is transmitted, as kinetic energy, to the inelastic collision balls 120. This process may be continuously and repeatedly performed to reduce the vibration of the rail 101, thereby reducing the rolling noise.

[0037] In particular, referring to FIGS. 2 and 5, the through holes 111h and 115h are opened in the lateral directions, but the opened portions of the through holes 111h and 115h are directed in different directions. That is, the first through hole 111h of the two through holes 111h and 115h, which is disposed at the upper side, is

directed toward the web portion 103 of the rail 101, and the second through hole 115h disposed at the lower side is directed toward the lower end portion 105 of the rail 101.

[0038] Therefore, when the inelastic collision balls 120 are positioned at initial positions in the first through hole 111h, that is, when no vibration occurs, the inelastic collision balls 120 remain in contact with the web portion 103 of the rail 101. In contrast, when the inelastic collision balls 120 are positioned at initial positions in the second through hole 115h, the inelastic collision balls 120 remain in contact with the lower end portion 105 of the rail 101.

[0039] With the above-mentioned configuration, when the rail 101 vibrates, the inelastic collision balls 120 in the first through hole 111h may vibrate in a horizontal direction in the first through hole 111h and thus collide with the web portion 103 of the rail 101 in an inelastic manner, thereby reducing the horizontal vibration of the rail 101.

[0040] Meanwhile, when the rail 101 vibrates, the inelastic collision balls 120 in the second through hole 115h may vibrate in a vertical direction in the second through hole 115h and thus collide with the lower end portion 105 of the rail 101 in an inelastic manner, thereby reducing the vertical vibration of the rail 101.

[0041] As such, in the present exemplary embodiment, the inelastic collision balls 120 in the first through hole 111h may reduce the horizontal vibration of the rail 101, and the inelastic collision balls 120 in the second through hole 115h may reduce the vertical vibration of the rail 101, thereby reducing the rolling noise.

[0042] Further, the inelastic collision between the inelastic collision balls 120 and the rail 101 may particularly reduce the vibration in the high-frequency region among the types of vibration of the rail 101.

[0043] Meanwhile, the above-mentioned damper main body 110 may be made of a rubber material having its own weight. Therefore, the vibration of the rail 101 is absorbed by the damper main body 110 to some extent, thereby reducing the vibration. In this case, the damper main body 110 may effectively reduce the vibration in the low-frequency region among the types of vibration of the rail 101.

[0044] However, the damper main body 110 may also be made of a meta material. The meta material is an aggregate of composite elements arranged in a repetitive pattern. The meta material has properties made by a structure thereof, and the meta material designed to reduce vibration may interfere with electromagnetic waves or sound in such a way that an object is not observed. Therefore, since the damper main body 110 is made of the meta material, it is possible to reduce rolling noise and inverter noise as well as the vibration of the rail 101.

[0045] Meanwhile, in the present exemplary embodiment, the housings 130 surround the damper main bodies 110, and more accurately, the housings 130 surround upper surfaces, lateral surfaces, front surfaces, and rear surfaces of the damper main bodies 110, thereby preventing the damper main bodies 110 from being exposed to the outside.

[0046] The housings 130 are structured to be simply assembled with the damper main bodies 110. That is, the upper and lateral surfaces of the damper main body 110 define a right angle therebetween, and the front and rear surfaces also define right angles with respect to the upper and lateral surfaces. The housing 130 also has an inner surface having a shape corresponding to the shape of the damper main body 110, and an external shape of the housing 130 entirely corresponds to a part of rectangular parallelepiped shape.

[0047] With the above-mentioned configuration, when the housings 130 are coupled to the damper main bodies 110 as illustrated in FIG. 2, all the exposed portions of the damper main bodies 110 may be covered, thereby preventing the corrosion of the damper main bodies 110 and also preventing the inelastic collision balls 120 from being withdrawn from the through holes 111h and 115h.

[0048] Meanwhile, in the present exemplary embodiment, the fixing unit 150 is provided to fix the pair of damper main bodies 110 and the housings 130, which surround the pair of damper main bodies 110, to the rail 101. As illustrated in FIGS. 1 and 6, the fixing unit 150 may include a pair of fixing clips disposed in an X shape.

[0049] Each of the pair of fixing clips may include a clip lower end portion 151 configured to be disposed on a lower surface of the rail 101, clip lateral portions 153 extending upward from both ends of the clip lower end portion 151 and configured to fix lateral portions of the housings 130, and clip upper end portions 155 extending inward from upper ends of the clip lateral portions 153 and configured to fix upper ends of the housings 130.

[0050] The clip lower end portions of the pair of fixing clips are structured to intersect each other, such that the pair of fixing clips may be retracted inward or spread outward about the intersection point.

[0051] Therefore, the pair of fixing clips, which is retracted inward, is disposed on the lower surface of the rail 101, and then the pair of fixing clips is spread outward, such that the fixing unit 150 may fix the pair of housings 130.

[0052] That is, because the fixing unit 150, which is retracted inward, has a larger width than the lower end of the rail 101, the fixing unit 150 may be easily disposed on the rail 101. Further, when the fixing unit 150 is spread outward, the clip upper end portions are disposed on the upper surfaces of the housings 130, such that the pair of housings 130 may be securely fixed to the rail 101.

[0053] Meanwhile, hereinafter, how the vibration reduction effect is implemented will be described with reference to the drawings while comparing a case in which the vibration reduction device 100 of the present exemplary embodiment is installed on a simple rail 101 and a case in which the vibration reduction device 100 is installed on an actual rail 101.

[0054] FIG. 7 is a view schematically illustrating a state in which the vibration reduction devices illustrated in FIG.

1 are installed on the simple rail, and FIG. 8A and FIG. 8B are graphs illustrating a result of an experiment on the simple rail.

[0055] For example, as illustrated in FIG. 7, a total of ten vibration reduction devices 100 were installed at an equal interval on the rail 101 having a length of 6 m, and vibration mounts 180 were installed at portions spaced apart from both ends of the rail 101 by about 0.6 m, such that a free end condition was satisfied. Further, the vibration reduction effect on both ends of the rail 101 was evaluated using an accelerometer.

[0056] In addition, during the experiment, UIC 60, which is an actual high-speed railroad track, was used in accordance with STARDAMP (standardization of damping technologies for the reduction of railway noise) in order to measure vibration reduction performance.

[0057] As a result of the evaluation, as illustrated in FIG. 8A and 8B, it can be seen that a damping coefficient of a transfer function for each mode is greatly increased in a low-frequency region, and a transfer function is greatly decreased in a high-frequency band.

[0058] Further, as a result of the evaluation in terms of band gaps, it can be seen that in a band of 500 to 2,000 Hz at which the rolling noise particularly often occurs, the frequency response is greatly decreased, and thus the value of the damping factor in accordance with the distance is greatly improved.

[0059] Meanwhile, FIGS. 9A and 9B are graphs illustrating results of experiments on the actual rail.

[0060] As a result of experiments performed by installing a total of 50 vibration reduction devices 100, which were verified in the laboratory, on a slab track of the actual rail 101, the damping effect associated with the damping factor in accordance with the distance of the vibration reduction device 100 on the slab track of the actual rail 101 existed not only in the band of the rolling noise but also in the high-frequency region. In particular, the damping factor of maximum 5 dB/m was measured in the frequency band of 1,000 Hz, and the damping factor of maximum 3.5 dB/m was measured in the horizontal direction.

[0061] As for a measurement method, referring to the BS EN 15461_2008_A1_2010 standard, the accelerometer was set at a point spaced apart from the end of the rail by 6 m, and then FRF (natural frequency analysis) of the slab track was measured by moving an impact hammer.

[0062] It can be seen from these experiments that the vibration reduction device 100 of the present exemplary embodiment may significantly reduce horizontal vibration and vertical vibration of the actual rail 101 in comparison with the case in which the vibration reduction device 100 is not provided.

[0063] As described above, according to the exemplary embodiment of the present invention, the vibration reduction device may reduce the vibration in the low-frequency region as well as the vibration in the high-frequency, thereby reducing the rolling noise.

[0064] In addition, the vibration reduction device may be manufactured as a unit, instead of having a length equal to a length of the rail 101, such that an interval between the vibration reduction devices may be adjusted, thereby reducing manufacturing costs. Further, it is possible to effectively reduce vibration in a specific frequency by adjusting mass or rigidity of the damper main body 110 or the housing 130.

[0065] Finally, the reduction in rolling noise resulting from the reduction in vibration may solve the inconvenience for people around the rail 101 or may improve ride quality of passengers.

[0066] While the specific exemplary embodiments according to the present invention have been described above, various modifications may be made without departing from the scope of the present invention. Therefore, the scope of the present invention should not be limited to the described exemplary embodiments, and should be defined by not only the claims to be described below, but also those equivalent to the claims.

[0067] While the present invention has been described above with reference to the limited exemplary embodiments and the drawings, the present invention is not limited to the exemplary embodiments and may be variously modified and altered from the disclosure by those skilled in the art to which the present invention pertains. Therefore, the spirit of the present invention should be defined only by the appended claims, and all modifications, equivalents, and alternatives fall within the scope and spirit of the present invention.

Claims

1. A vibration reduction device 100 comprising:

   a pair of damper main bodies 110 disposed at both sides with a web portion of a rail interposed therebetween, such that at least a part of the damper main body is in contact with the web portion and at least another part of the damper main body is in contact with a lower end portion of the rail which is connected to the web portion;
   a plurality of inelastic collision balls 120 provided in at least two through holes formed in each of the pair of damper main bodies so as to be movable with respect to the web portion or the lower end portion; and
   a pair of housings 130 configured to surround the pair of damper main bodies from the outside in order to prevent the damper main bodies from being exposed to the outside.

2. The vibration reduction device of claim 1, wherein surfaces of the damper main body, which are directed toward the web portion 103 and the lower end portion 105, have shapes corresponding to external shapes of the web portion and the lower end portion, and an upper surface, a lateral surface, a front sur-

face, and a rear surface of the damper main body are surrounded by the housing.

3. The vibration reduction device of claim 2, wherein the plurality of inelastic collision balls is disposed long in each of the at least two through holes so as to be in contact with one another,
wherein a first through hole 111h, which is one of the at least two through holes, is opened toward the web portion so that the inelastic collision balls are in contact with the web portion, and
wherein a second through hole 115h, which is another of the at least two through holes, is opened toward the lower end portion so that the inelastic collision balls are in contact with the lower end portion.

4. The vibration reduction device of claim 3, wherein each of the first through hole and the second through hole has a cross-sectional shape corresponding to a shape of the inelastic collision ball, and each of the first through hole and the second through hole is larger than the inelastic collision ball so that the inelastic collision ball is movable.

5. The vibration reduction device of claim 4, wherein a part of the inelastic collision ball is in contact with the web portion 103 when the inelastic collision ball is positioned at an initial position in the first through hole, and a part of the inelastic collision ball is in contact with the lower end portion 105 when the inelastic collision ball is positioned at an initial position in the second through hole.

6. The vibration reduction device of claim 1, wherein the damper main body is made of a rubber material in order to absorb vibration generated from the rail.

7. The vibration reduction device of claim 1, wherein the damper main body is made of a meta material.

8. The vibration reduction device of claim 1, further comprising:
a fixing unit 150 configured to fix the pair of housings, which surround the pair of damper main bodies, respectively, to the rail.

9. The vibration reduction device of claim 8, wherein the fixing unit comprises a pair of fixing clips disposed in an X shape, and
wherein each of the pair of fixing clips comprises:

a clip lower end portion configured to be disposed on a lower surface of the rail;
clip lateral portions extending upward from both ends of the clip lower end portion and configured to fix lateral portions of the housings; and
clip upper end portions extending inward from upper ends of the clip lateral portions and configured to fix upper ends of the housings.

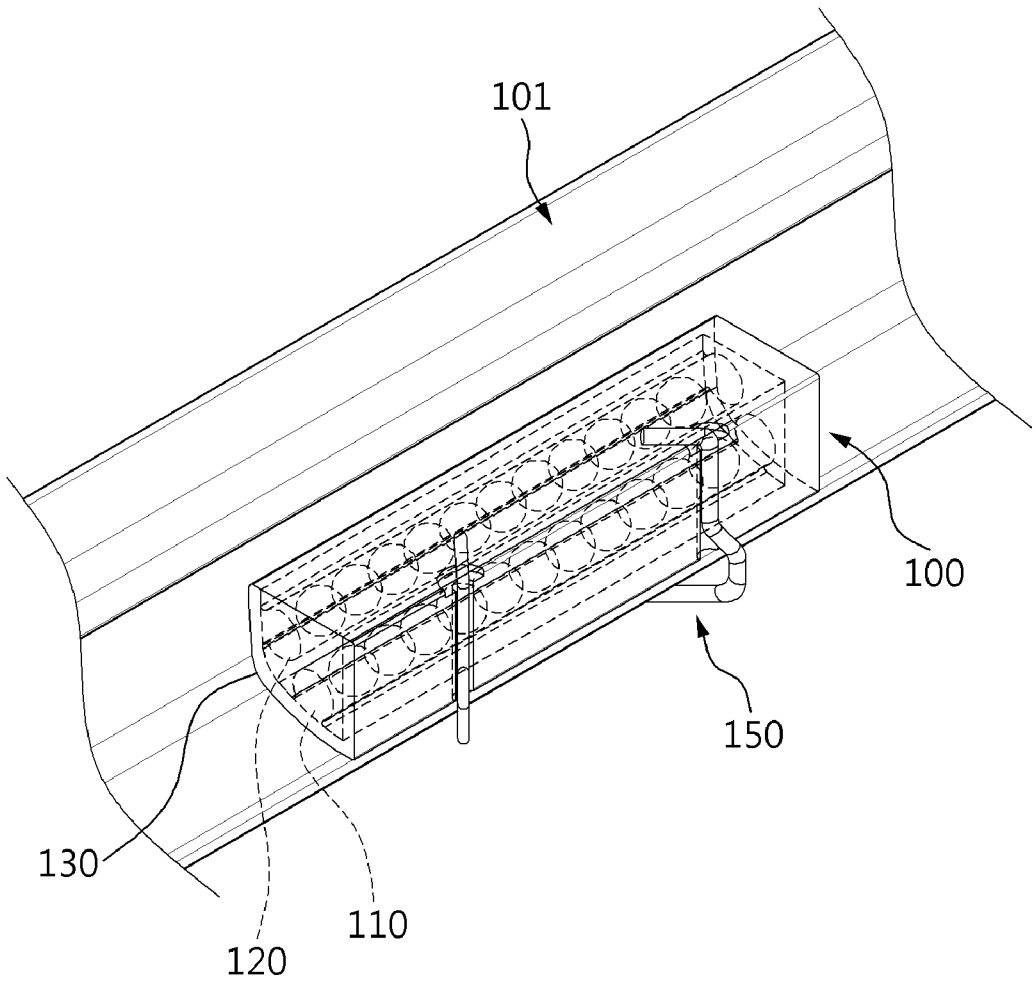
10. The vibration reduction device of claim 9, wherein the pair of fixing clips, which is retracted inward, is disposed on the lower surface of the rail, and then the pair of fixing clips is spread outward, such that the fixing unit fixes the pair of damper main bodies.

11. A vibration reduction device comprising:

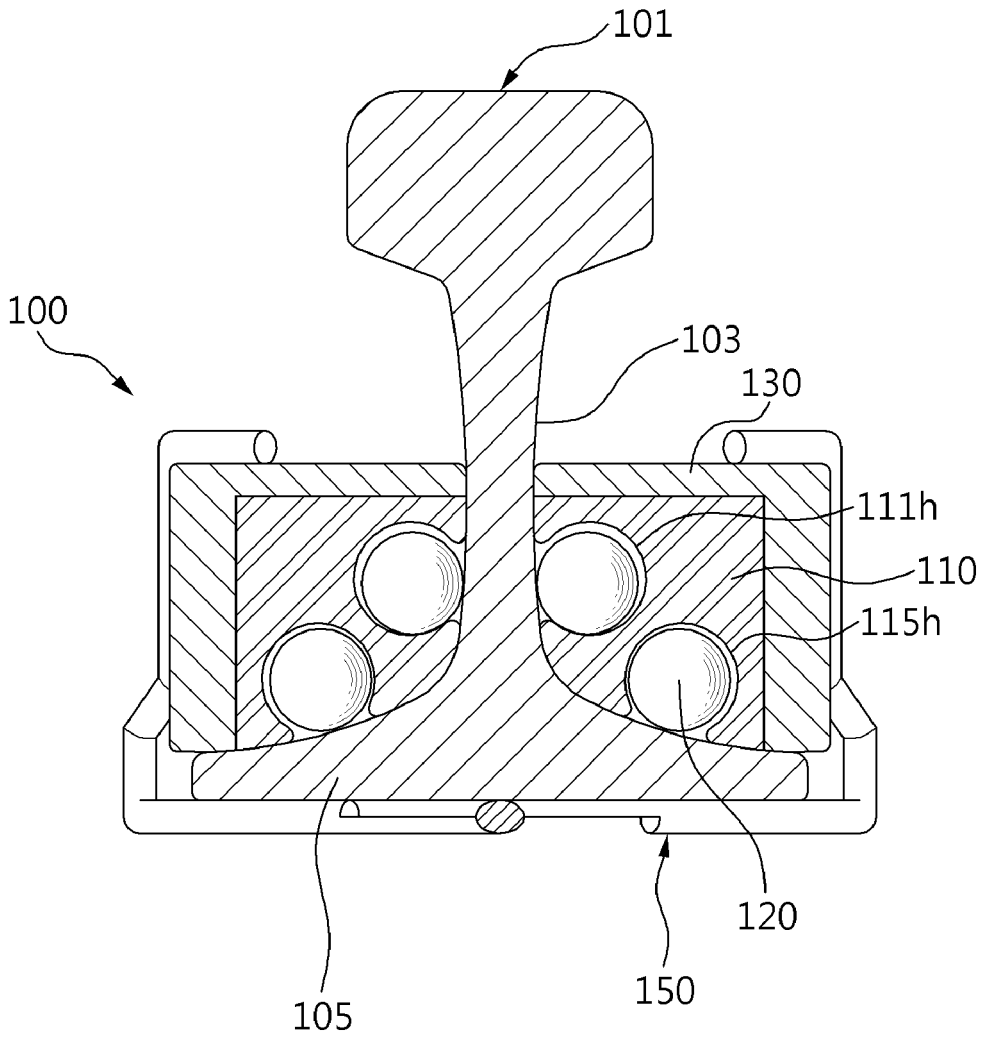
a pair of damper main bodies disposed at both sides with a web portion of a rail interposed therebetween, such that at least a part of the damper main body is in contact with the web portion and at least another part of the damper main body is in contact with a lower end portion of the rail which is connected to the web portion; and
a plurality of inelastic collision balls provided in at least two through holes formed in each of the pair of damper main bodies so as to be movable with respect to the web portion or the lower end portion,
wherein the plurality of inelastic collision balls is disposed long in each of the at least two through holes so as to be in contact with one another,
wherein a first through hole, which is one of the at least two through holes, is opened toward the web portion so that the inelastic collision balls are in contact with the web portion, and
wherein a second through hole, which is another of the at least two through holes, is opened toward the lower end portion so that the inelastic collision balls are in contact with the lower end portion.

12. The vibration reduction device of claim 11, wherein a part of the inelastic collision ball is in contact with the web portion when the inelastic collision ball is positioned at an initial position in the first through hole, and a part of the inelastic collision ball is in contact with the lower end portion when the inelastic collision ball is positioned at an initial position in the second through hole.

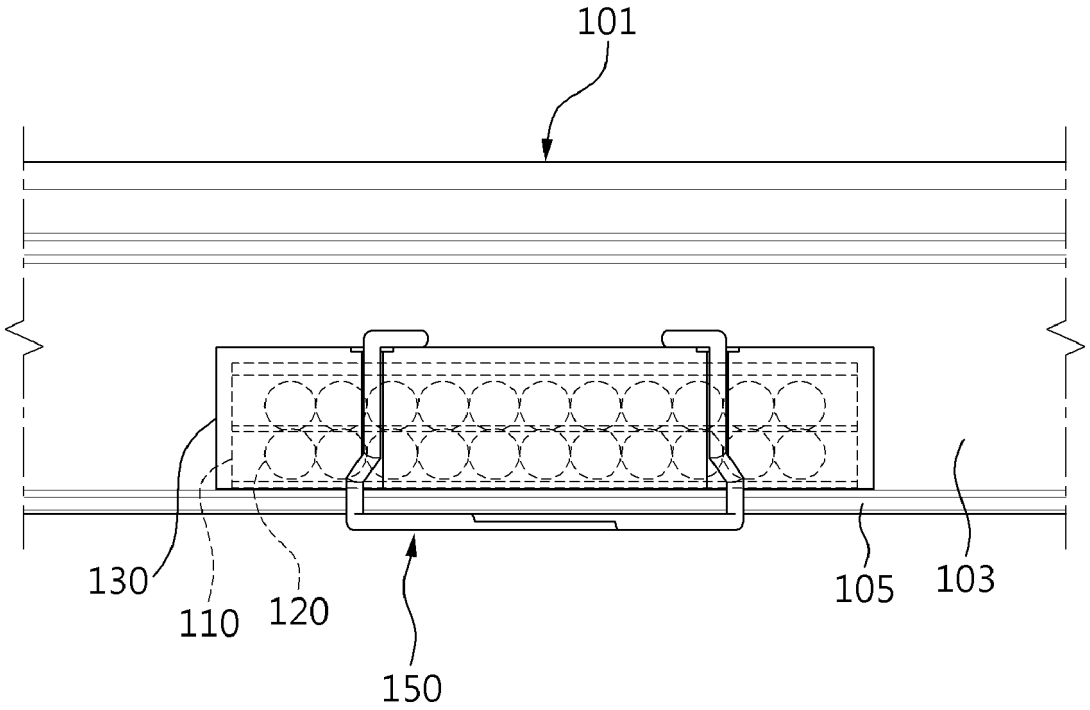
[FIG. 1]



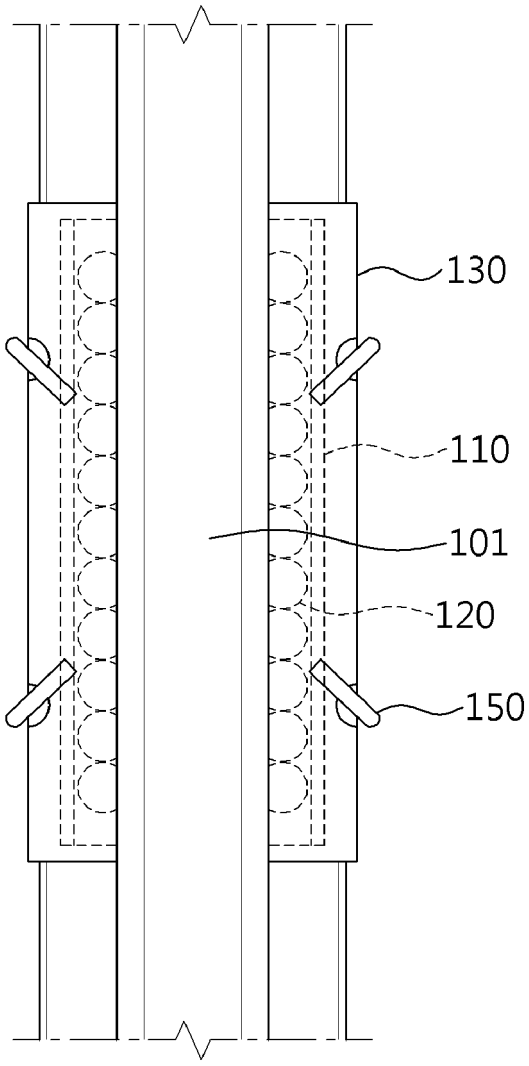
[FIG. 2]



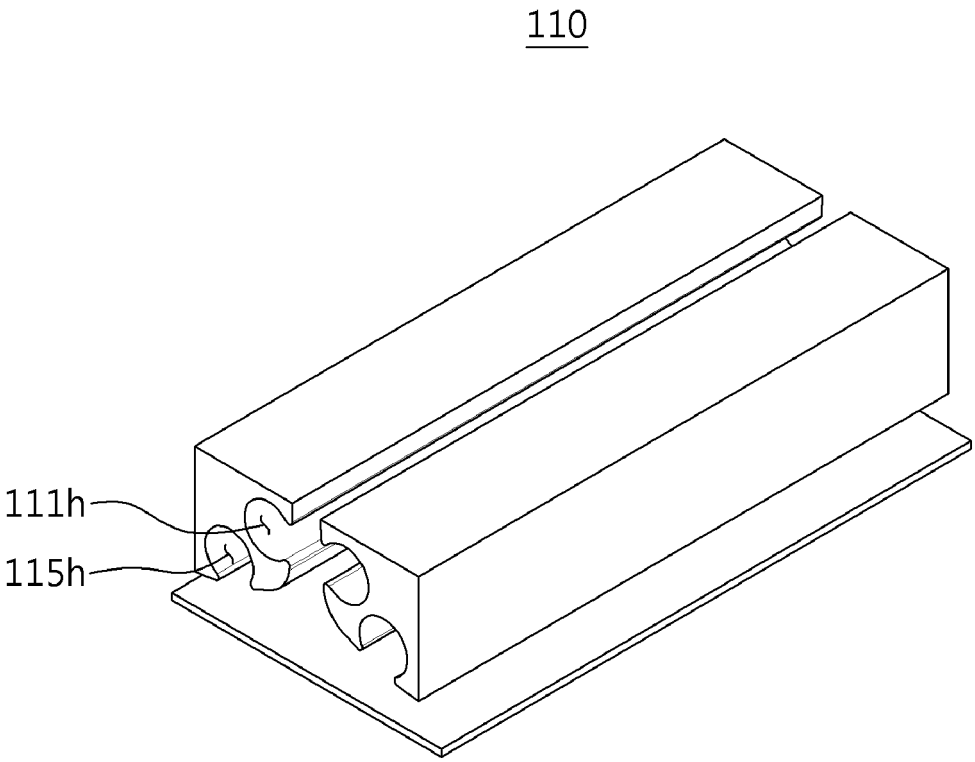
[FIG. 3]



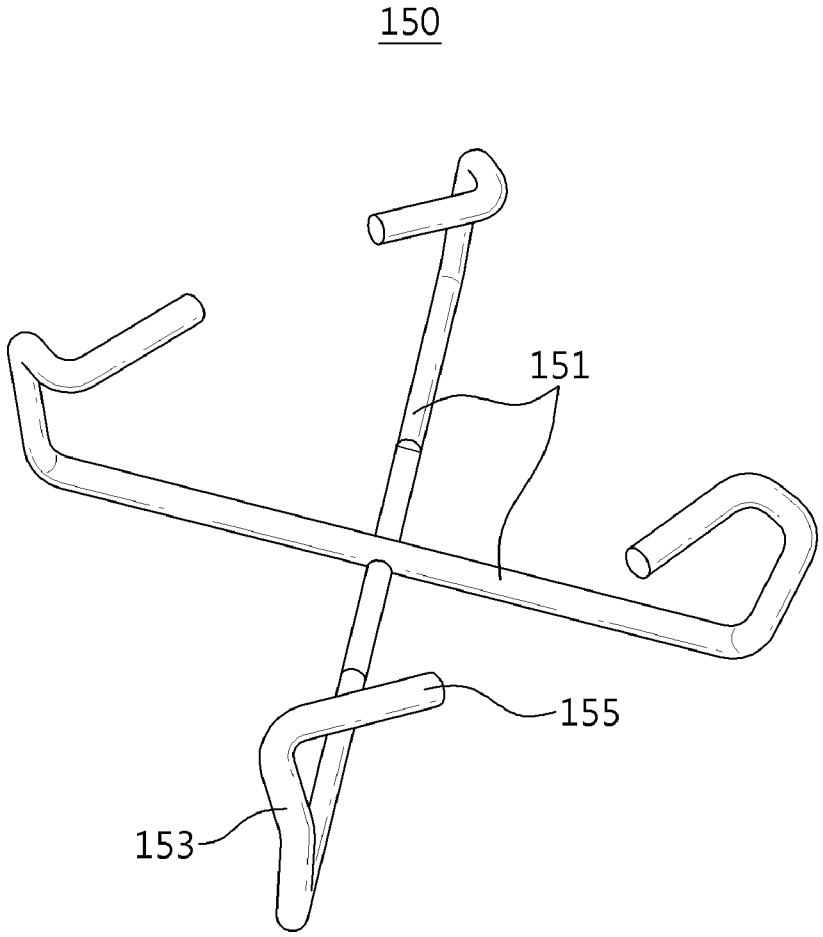
[FIG. 4]



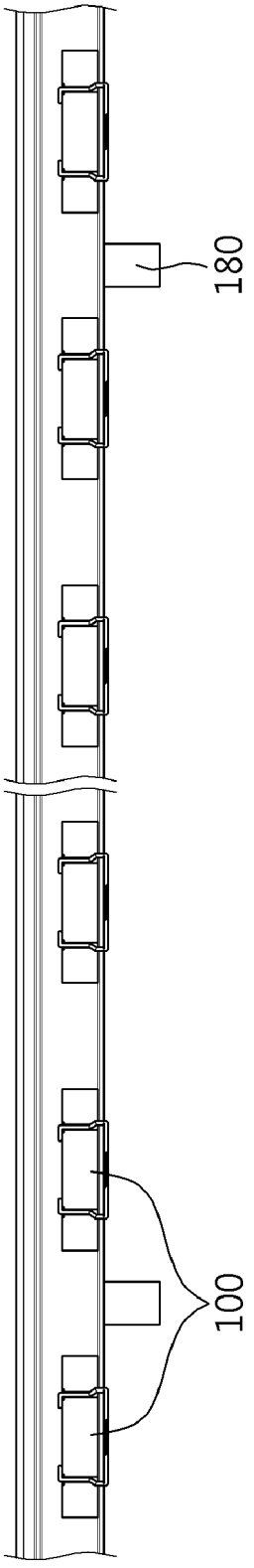
[FIG. 5]



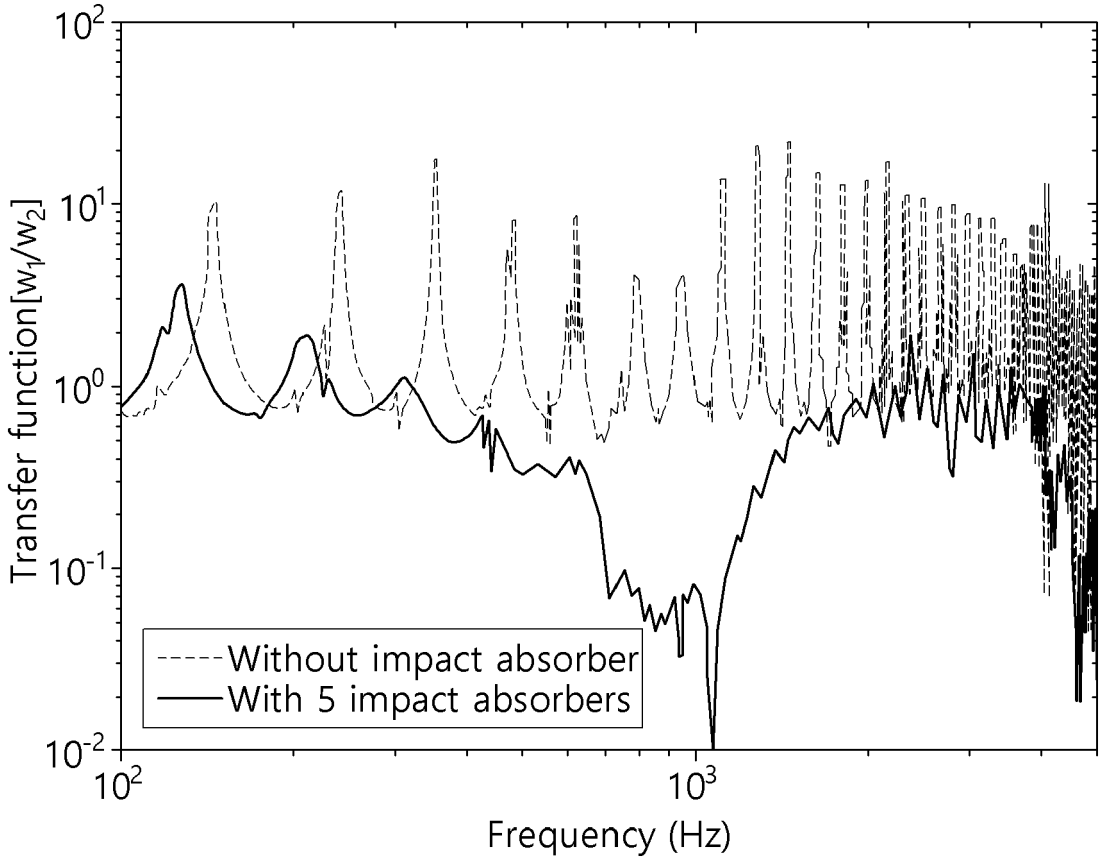
[FIG. 6]



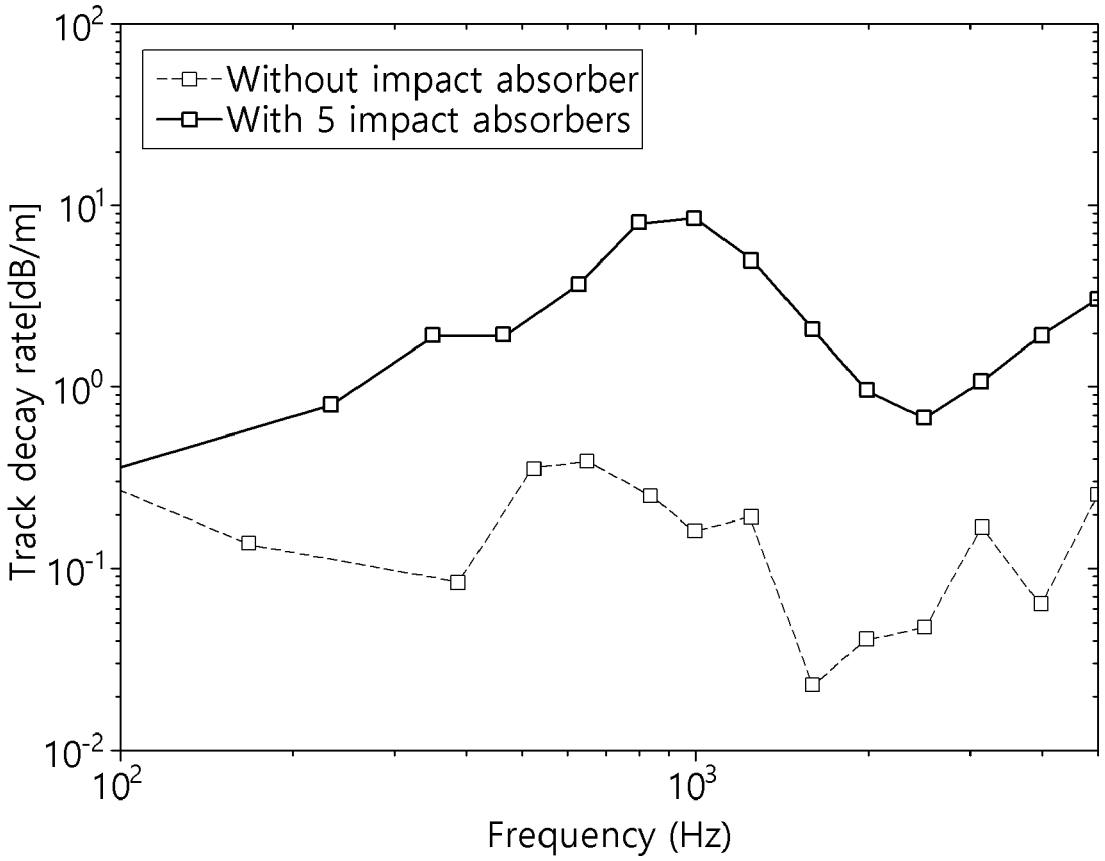
[FIG. 7]



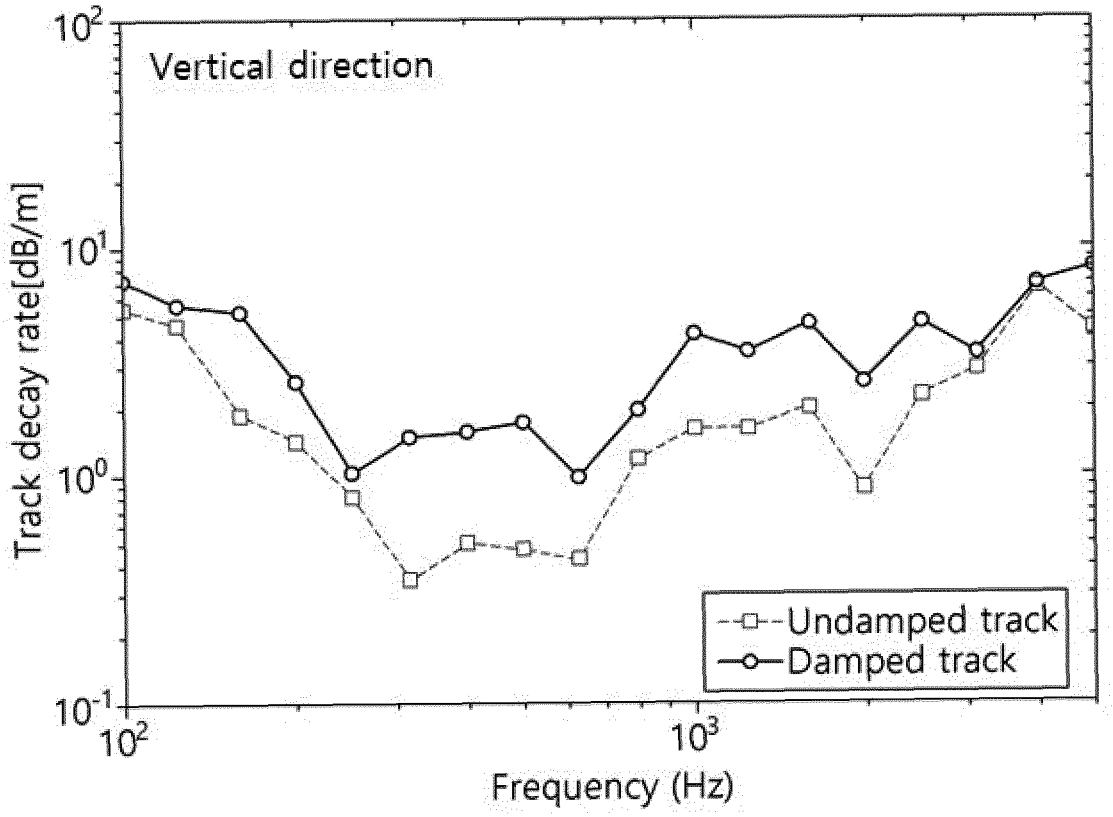
[FIG. 8A]


10^2
10^1
10^0
10^{-1}
10^{-2}
Transfer function[w_1/w_2]
10^2
10^3
Frequency (Hz)
Without impact absorber
With 5 impact absorbers

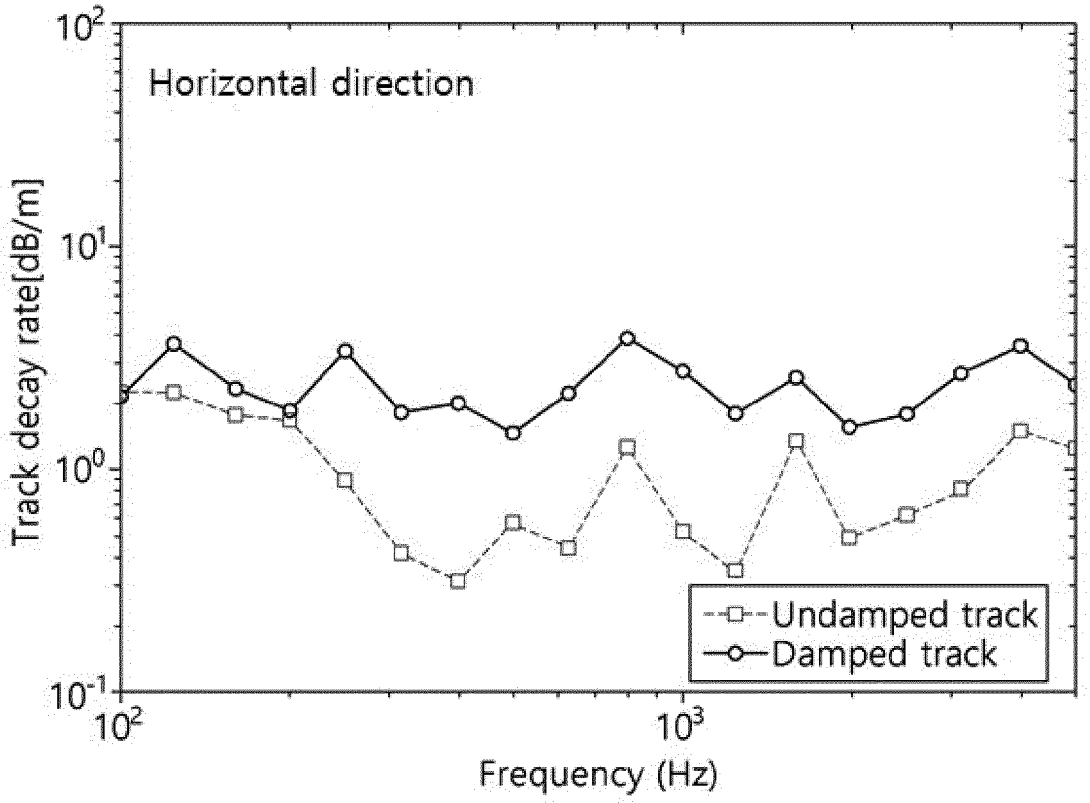
[FIG. 8B]


Without impact absorber
With 5 impact absorbers
Track decay rate[dB/m]
Frequency (Hz)
10^2
10^1
10^0
10^-1
10^-2
10^2
10^3

[FIG. 9A]


Vertical direction
Track decay rate[dB/m]
10^2
10^1
10^0
10^{-1}
10^2
10^3
Frequency (Hz)
Undamped track
Damped track

[FIG. 9B]


Horizontal direction
Track decay rate[dB/m]
Frequency (Hz)
Undamped track
Damped track

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2019/011522

A. CLASSIFICATION OF SUBJECT MATTER

E01B 19/00(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)
E01B 19/00; F16F 15/02; F16F 15/03; F16F 7/01

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models: IPC as above
Japanese utility models and applications for utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: rail, damper, inelastic impingement, housing, vibration damping device

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-1860397 B1 (KRRI) 24 May 2018 See paragraphs [0001], [0030]-[0052]; claim 1; and figures 1-3.	1-12
Y	JP 2002-357241 A (TOYO TIRE & RUBBER CO., LTD.) 13 December 2002 See paragraphs [0005]-[0006]; and figure 1.	1-12
Y	KR 10-1768996 B1 (KRRI et al.) 16 August 2017 See paragraphs [0031]-[0033]; and figures 1-2.	8-10
A	KR 10-1668790 B1 (IUCF-HYU (INDUSTRY-UNIVERSITY COOPERATION FOUNDATION HANYANG UNIVERSITY) et al.) 25 October 2016 See paragraphs [0031]-[0103]; and figures 1-9.	1-12
A	EP 1876295 A2 (CORUS UK LTD.) 09 January 2008 See paragraphs [0037]-[0057]; and figures 1-13.	1-12

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 DECEMBER 2019 (26.12.2019)	**30 DECEMBER 2019 (30.12.2019)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex Daejeon Building 4, 189, Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea Facsimile No. +82-42-481-8578	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2019/011522

Patent document cited in search report	Publication date	Patent family member	Publication date
KR 10-1860397 B1	24/05/2018	None	
JP 2002-357241 A	13/12/2002	None	
KR 10-1768996 B1	16/08/2017	None	
KR 10-1668790 B1	25/10/2016	None	
EP 1876295 A2	09/01/2008	AT 480667 T	15/09/2010
		EP 1876295 A3	21/05/2008
		EP 1876295 B1	08/09/2010
		GB 2439834 A	09/01/2008

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- KR 1020160020018 **[0007]**