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# (54) BOGIE FOR RAILWAY VEHICLE

(57) In a bogie (1) for a railway vehicle, an air spring (6, 30) includes upper and lower opposed surfaces (11A, 13A, 31A, 33A) which are apart from each other in an up-down direction and face each other, a stopper rubber (21, 41) fixed to one opposed surface (13A, 33A) of the upper and lower opposed surfaces, and a stopper rubber receiver (22, 42) fixed to the other opposed surface (11A, 31A). A relative position between the upper and lower opposed surfaces varies from an initial state in response to a displacement of a vehicle body (7) in a front-back direction and a left-right direction allowed by the air spring. Separation distances to the one opposed surface in the up-down direction at left and right end portions (22L, 22R, 42L, 42R) of the stopper rubber receiver are shorter than that at a central portion (22M, 42M), and separation distances to the one opposed surface in the up-down direction at front and back end portions (22F, 22B, 42F, 42B) of the stopper rubber receiver are longer than that at the central portion.

FIG. 2

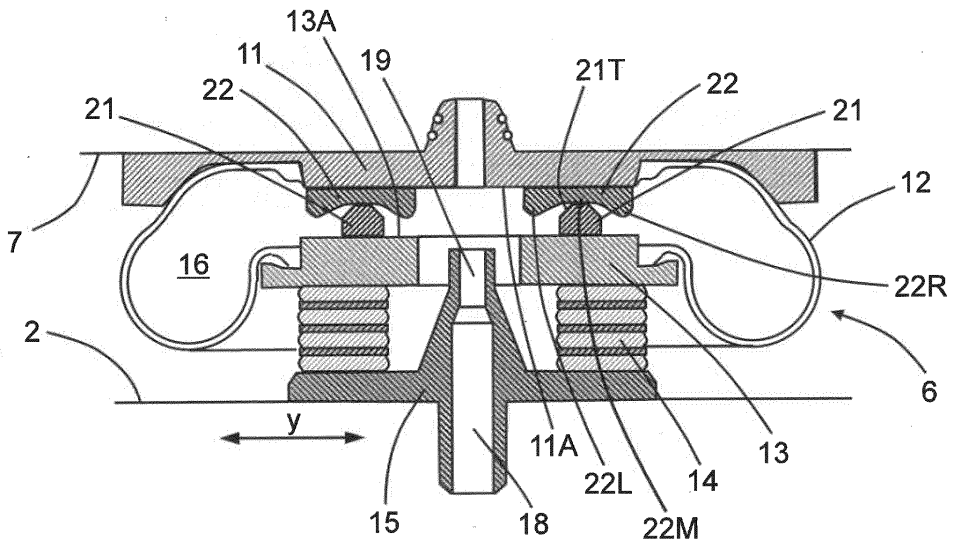


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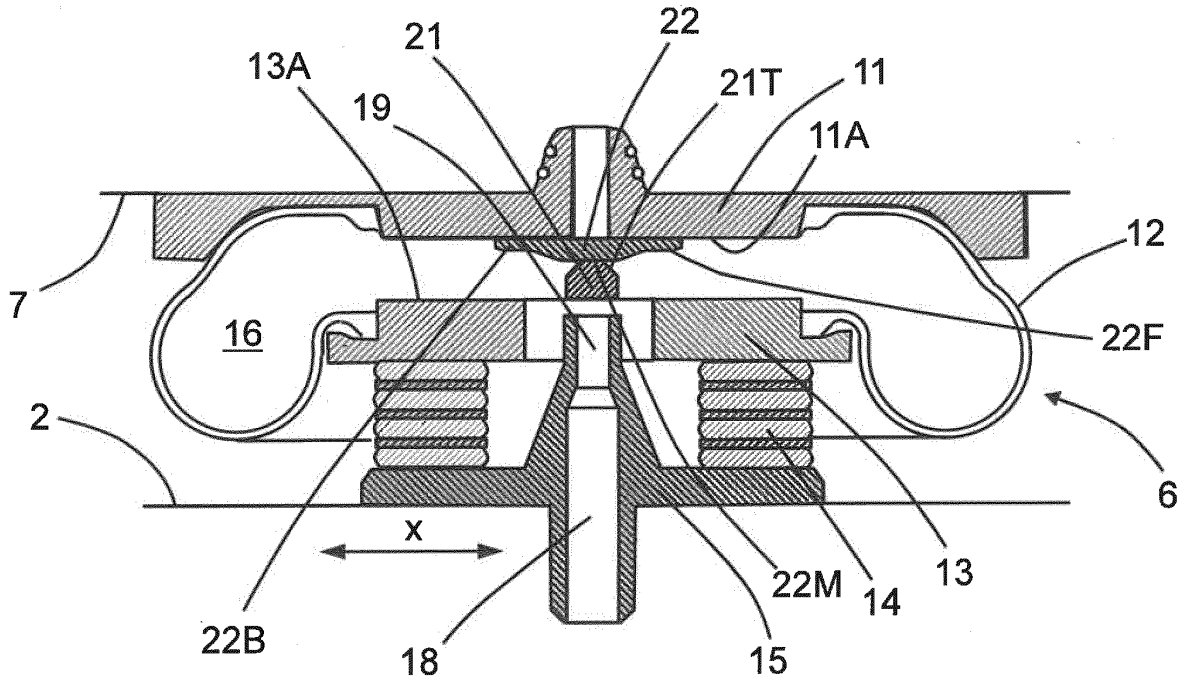
FIG. 3



## Description

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

**[0001]** The present invention relates to a bogie for a railway vehicle.

#### 2. Description of the Related Art

**[0002]** In a railway vehicle, a vehicle body is excited in a roll direction of the vehicle body by a change in a centrifugal force acting on the vehicle body when the railway vehicle travels on a curve at a high speed, roll vibration consequently occurs to the vehicle body, and passengers may feel a sense of discomfort. Moreover, the vehicle body leans toward the outside of the curve due to the centrifugal force acting on the vehicle body, a roll angle displacement of the vehicle body consequently increases, left-right stationary acceleration of the vehicle body felt by the passengers increases, and hence, the passengers may feel the sense of discomfort. The sense of discomfort felt by the passengers leads to deterioration of ride comfort, and therefore, it is preferred that the roll displacement and vibration of the vehicle body be suppressed in the state of a high speed travel on a curve, to increase the ride comfort.

**[0003]** Meanwhile, when the railway vehicle travels on a sharp curve at a low speed, roll vibration occurs to the vehicle body due to excitation caused by track irregularity in a left-right direction and the roll direction, and hence, the passengers may feel the sense of discomfort. Further, a wheel load fluctuates due to a torsional change in the track on a relaxation curve of the sharp curve, and hence, a margin for curve passage safety decreases. Therefore, it is required to reduce the roll vibration of the vehicle body and suppress the wheel load variation in the case of the passage on a sharp curve at a low speed.

**[0004]** In this regard, there is provided a bogie for a railway vehicle according to JP-H05-024536-A as a bogie for a railway vehicle which reduces the roll vibration of the vehicle body.

### SUMMARY OF THE INVENTION

**[0005]** In the bogie for a railway vehicle according to JP-H05-024536-A, a damping force in an up-down direction is generated by an orifice provided inside a damping member formed inside an air spring, thereby suppressing the roll vibration of the vehicle body.

**[0006]** However, the damping force generated by the damping member does not change according to a travel state such as a straight line travel and a curve travel, and the generated damping force in the up-down direction is not necessarily be optimized for the curve travel. Therefore, for example, there is such a problem that, in a case where the damping force generated by the damping member is set so as to suitably suppress the roll vibration at the time of the straight line travel, the roll vibration is not sufficiently suppressed at the time of the curve travel and hence there is a fear that the ride comfort deteriorates.

**[0007]** The present invention has been made in view of these problems and has an object to provide a bogie for a railway vehicle which uses a simple configuration to be able to reduce roll vibration of a vehicle body and vehicle body left-right stationary acceleration at the time of a curve travel, thereby increasing the ride comfort, and to further suppress a wheel load variation at the time of the curve travel, thereby securing safety.

**[0008]** In order to achieve the above-mentioned object, one representative bogie for a railway vehicle according to the present invention is a bogie for a railway vehicle, including an air spring that elastically supports a vehicle body from below. The air spring includes upper and lower opposed surfaces that are apart from each other in an up-down direction and face each other, and a stopper rubber and a stopper rubber receiver that are arranged between the upper and lower opposed surfaces. A relative position between the upper and lower opposed surfaces varies from an initial state in the up-down direction and a left-right direction in response to a displacement of the vehicle body in the up-down direction and the left-right direction allowed by the air spring. The stopper rubber is fixed to one opposed surface of the upper and lower opposed surfaces and protrudes toward the other opposed surface. The stopper rubber receiver is fixed to the other opposed surface and is apart from the one opposed surface. The stopper rubber faces a central portion of the stopper rubber receiver in the initial state. Separation distances to the one opposed surface in the up-down direction at left and right end portions of the stopper rubber receiver facing each other across the central portion are shorter than that at the central portion, and separation distances to the one opposed surface in the up-down direction at front and back end portions of the stopper rubber receiver facing each other across the central portion are longer than that at the central portion.

**[0009]** The present invention can provide a bogie for a railway vehicle which uses the simple configuration to be able to reduce the roll vibration of the vehicle body and the left-right stationary acceleration of the vehicle body at the time of a high-speed curve travel, thereby increasing the ride comfort. In this case, since the left-right stationary acceleration of the vehicle body can be suppressed low, a travel at a higher speed on a curve can be achieved without spoiling the ride comfort. Further, since the roll vibration of the vehicle body can be reduced at the time of a low-speed curve travel, it is possible to increase the ride comfort while suppressing the wheel load variation, so that a highly safe bogie for a railway vehicle can be provided.

**[0010]** Problems, configurations, and effects other than those described above will become apparent from the following description of embodiments.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0011]**

FIG. 1 is a view for showing a bogie for a railway vehicle according to a first embodiment of the present invention;
FIG. 2 is a front cross-sectional view for showing a detailed configuration example of an air spring of the bogie for a railway vehicle according to the first embodiment of the present invention;
FIG. 3 is a side cross-sectional view for showing the detailed configuration example of the air spring of the bogie for a railway vehicle according to the first embodiment of the present invention;
FIG. 4 is a view for showing an arrangement of stopper rubbers inside the air spring of the bogie for a railway vehicle according to the first embodiment of the present invention;
FIG. 5 is a graph for showing a relation of an up-down force of the stopper rubber of the bogie for a railway vehicle according to the first embodiment of the present invention;
FIG. 6 is a graph for showing the relation of the up-down force of the stopper rubber of the bogie for a railway vehicle according to the first embodiment of the present invention;
FIG. 7 is a front cross-sectional view for showing a detailed configuration example of an air spring of the bogie for a railway vehicle according to a second embodiment of the present invention;
FIG. 8 is a side cross-sectional view for showing the detailed configuration example of the air spring of the bogie for a railway vehicle according to the second embodiment of the present invention; and
FIG. 9 is a view for showing an arrangement of a stopper rubber inside the air spring of the bogie for a railway vehicle according to the second embodiment of the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

[First Embodiment]

**[0012]** A description is now given of a first embodiment of the present invention with reference to FIG. 1, FIG. 2, and FIG. 3. FIG. 1 is a view for showing a bogie 1 for a railway vehicle according to the first embodiment of the present invention. FIG. 2 and FIG. 3 are views for showing a detailed configuration example of an air spring 6 of the bogie 1 for a railway vehicle according to the first embodiment of the present invention.

**[0013]** The air spring 6 according to the present embodiment is arranged in the bogie 1 for a railway vehicle shown in FIG. 1, and the bogie 1 for a railway vehicle mainly includes a bogie frame 2, an axle box 3, a wheelset 4, an axle box support device 5, and the air spring 6. The wheelset 4 is supported by the axle box 3 via bearings (not shown) in a rotatable state, and the axle box 3 and the bogie frame 2 are coupled to each other by the axle box support device 5. The air spring 6 is interposed between the bogie frame 2 and a vehicle body 7, and the vehicle body 7 is elastically supported by the air spring 6 from below.

**[0014]** A detailed configuration of the air spring 6 is shown in FIG. 2 and FIG. 3. FIG. 2 is a front cross-sectional view of the air spring 6, and FIG. 3 is a side cross-sectional view of the air spring 6. In FIG. 2, an arrow "y" indicates a left-right direction, and in FIG. 3, an arrow "x" indicates a front-back direction. Note that, in FIG. 2, the air spring 6 is shown on a cross section taken along line A-A of FIG. 4 to be described later. In FIG. 3, portions which are of the air spring 6 and are other than a stopper rubber 21 and a stopper rubber receiver 22 to be described later are shown on a cross section taken along line B-B of FIG. 4, and the stopper rubber 21 and the stopper rubber receiver 22 are shown on a cross section taken along line C-C of FIG. 4.

**[0015]** The air spring 6 mainly includes an upper surface plate 11, a bellows 12, a lower surface plate 13, laminated rubber 14, and an air spring seat 15. The upper surface plate 11 and the lower surface plate 13 are coupled to each other via the bellows 12. The upper surface plate 11 is coupled to the vehicle body 7, and the lower surface plate 13 is coupled to the bogie frame 2 via the laminated rubber 14 and the air spring seat 15.

**[0016]** An air chamber 16 filled with air is defined in the bellows 12, compressibility of the air provides elastic support between the vehicle body 7 and the bogie frame 2 in an up-down direction, and an elastic action of rubber provides elastic support between the vehicle body 7 and the bogie frame 2 in a horizontal direction. That is, the air spring 6 allows displacements in the up-down direction and the horizontal direction (the front-back direction and the left-right direction) of the vehicle body 7 with respect to the bogie frame 2. A communication opening 18 is provided inside the air spring seat 15, and the air chamber 16 and an auxiliary air chamber (auxiliary tank), not shown, are caused to communicate with each other via the communication opening 18. An orifice 19 is provided in an upper portion of the communication opening 18, and a damping force is generated in the up-down direction of the air spring 6 by a resistance effect exhibited at the time of passage of air between the air chamber 16 and the auxiliary air chamber. The laminated rubber 14 provides elastic support between the vehicle body 7 and the bogie frame 2 in the up-down direction and the horizontal direction in a state in which the bellows 12 is deflated by a puncture or the like. In the present embodiment, there is provided such a configuration that the auxiliary tank is formed on the bogie frame 2 side, but there may be provided such a configuration that the auxiliary tank is mounted on the vehicle body 7 side and the air chamber 16 and the auxiliary tank are caused to communicate with each other via a communication opening and an orifice.

**[0017]** The upper surface plate 11 has a lower surface 11A in a circular flat surface shape exposed in the air chamber 16. The lower surface plate 13 has an upper surface 13A which is in a circular flat surface shape, is exposed in the air chamber 16, and faces the lower surface 11A of the upper surface plate 11 from below. The lower surface 11A of the upper surface plate 11 and the upper surface 13A of the lower surface plate 13 constitute opposed surfaces which are apart from each other in the up-down direction inside the air chamber 16 and which face each other. A position of the lower surface 11A of the upper surface plate 11 with respect to the upper surface 13A of the lower surface plate 13 (a relative position between the upper and lower opposed surfaces) varies from an initial state in the front-back direction and the left-right direction in response to a displacement of the vehicle body 7 in the front-back direction and the left-right direction allowed by the air spring 6. The initial state here means a state in which no load in the horizontal direction is acting from the vehicle body 7 to the air spring 6.

**[0018]** A pair of left and right stopper rubbers 21 are arranged on and fixed to the upper surface 13A of the lower surface plate 13. A pair of left and right stopper rubber receivers 22 are arranged on and fixed to the lower surface 11A of the upper surface plate 11. A side cross-sectional view of one of the stopper rubbers 21 and one of the stopper rubber receivers 22 is shown in FIG. 3. The stopper rubber 21 protrudes upward from the upper surface 13A of the lower surface plate 13 toward the lower surface 11A of the upper surface plate 11. The stopper rubber receiver 22 faces downward from the lower surface 11A of the upper surface plate 11. The stopper rubber 21 faces a central portion 22M of the stopper rubber receiver 22 in the initial state. The stopper rubber receiver 22 is in a plate form body having a cross shape extending from the central portion 22M in the front-back direction and the left-right direction in a plan view. One of the stopper rubber 21 and the stopper rubber receiver 22 is formed of a soft elastic body such as rubber, and the other is formed of a hard member (hard non-elastic body). While, in the present embodiment, the stopper rubber 21 is formed of a soft elastic body such as rubber and the stopper rubber receiver 22 is formed of a hard member, conversely, a component corresponding to the stopper rubber 21 may be formed of a hard member and a component corresponding to the stopper rubber receiver 22 may be formed of an elastic body such as rubber, which can provide an equivalent effect.

**[0019]** FIG. 4 is a plan view for showing an arrangement of the pair of stopper rubbers 21 on the lower surface plate 13 and an arrangement of the pair of stopper rubber receivers 22 on the upper surface plate 11. The stopper rubber receivers 22 are indicated by broken lines in FIG. 4. In the present embodiment, the left and right pair of stopper rubbers 21 are arranged with respect to a center of the upper surface 13A of the lower surface plate 13, and the left and right pair of stopper rubber receivers 22 are arranged with respect to a center of the lower surface 11A (see FIG. 2) of the upper surface plate 11. Note that, as for the stopper rubbers 21 and the stopper rubber receivers 22, the stopper rubber receivers 22 may be arranged on the upper surface 13A of the lower surface plate 13, and the stopper rubbers 21 may be arranged on the lower surface 11A of the upper surface plate 11.

**[0020]** As shown in FIG. 2, each stopper rubber receiver 22 has such a shape in the left-right direction that a gap between the stopper rubber receiver 22 and the upper surface 13A of the lower surface plate 13 is wide at the central portion 22M in a flat surface shape and the gap between the stopper rubber receiver 22 and the upper surface 13A of the lower surface plate 13 is narrow at end portions (left end portion 22L and right end portion 22R). That is, at the left and right end portions 22L and 22R of the stopper rubber receiver 22 facing each other across the central portion 22M, a plate thickness (thickness in the up-down direction) of the stopper rubber receiver 22 is larger than that at the central portion 22M, and a separation distance in the up-down direction from the stopper rubber receiver 22 to the' upper surface 13A of the lower surface plate 13 is shorter than that at the central portion 22M.

**[0021]** Moreover, as shown in FIG. 3, the stopper rubber receiver 22 has such a shape in the front-back direction that the gap between the stopper rubber receiver 22 and the upper surface 13A of the lower surface plate 13 is narrow at the central portion 22M and the gap between the stopper rubber receiver 22 and the upper surface 13A of the lower surface plate 13 is wide at end portions (front end portion 22F and back end portion 22B). That is, at the front and back end portions 22F and 22B of the stopper rubber receiver 22 facing each other across the central portion 22M, the plate thickness of the stopper rubber receiver 22 is thinner than that at the central portion 22M, and the separation distance in the up-down direction from the stopper rubber receiver 22 to the upper surface 13A of the lower surface plate 13 is longer than that at the central portion 22M.

**[0022]** A lower surface of the central portion 22M and lower surfaces of the left and right end portions 22L and 22R of the stopper rubber receiver 22 are continuous to each other via left and right inclined surfaces, and the plate thickness of the stopper rubber receiver 22 gradually increases from the central portion 22M toward the left and right end portions 22L and 22R. The lower surface of the central portion 22M and lower surfaces of the front and back end portions 22F and 22B of the stopper rubber receiver 22 are continuous to each other via front and back inclined surfaces, and the plate thickness of the stopper rubber receiver 22 gradually decreases from the central portion 22M toward the front and back end portions 22F and 22B. The stopper rubber 21 is in a column shape (for example, a circular column shape) standing up in the up-down direction, and a distal end portion (upper end portion in the present embodiment) 21T of the stopper rubber 21 is in a tapered or semispherical shape

tapering upward toward the upper surface plate 11.

**[0023]** With reference to FIG. 2 and FIG. 5, a description is now given of an operation at the time when the bogie 1 for a railway vehicle travels on a curve at a high speed. In FIG. 5, there is shown a relation between a left-right relative displacement "y" between the stopper rubber 21 and the stopper rubber receiver 22 and an up-down force Fz which is generated in the stopper rubber 21.

**[0024]** When a large centrifugal force acts on the vehicle body 7 at the time of a high speed travel on a curve, the vehicle body 7 displaces in the left-right direction (left or right outside) from the initial state with respect to the bogie frame 2. The upper surface plate 11 and the stopper rubber receiver 22, along with the vehicle body 7, also relatively displace from the initial state toward the left or right outside of the curve, and as a result, there is brought about such a state that the stopper rubber 21 and the stopper rubber receiver 22 come in contact with each other in the region (the left end portion 22L or the right end portion 22R of the stopper rubber receiver 22) in which the gap between the stopper rubber receiver 22 and the lower surface plate 13 is narrow. In this state, the stopper rubber 21 is brought into a state in which the stopper rubber 21 is compressed in the up-down direction. In FIG. 5, the left-right relative displacement "y" between the stopper rubber 21 and the stopper rubber receiver 22 is at y0 before the bogie 1 for a railway vehicle enters the curve, and displaces to y1 at the time of the curve travel. At the left-right relative displacement y1, the stopper rubber 21 in the state of being compressed in the up-down direction is switched to a state in which a gradient of the up-down force Fz is large, that is, a state in which up-down rigidity kz is high. As described above, the up-down rigidity kz of the stopper rubber 21 increases, and the air spring 6 provides the support between the vehicle body 7 and the bogie frame 2 in the state in which total up-down rigidity is high, and as a result, comes to support the vehicle body 7 in a state in which roll rigidity between the vehicle body 7 and the bogie frame 2 is high.

**[0025]** With reference to FIG. 3 and FIG. 6, a description is now given of an operation at the time when the bogie 1 for a railway vehicle travels on a sharp curve at a low speed. In FIG. 6, there is shown a relation between a front-back relative displacement "x" between the stopper rubber 21 and the stopper rubber receiver 22 and the up-down force Fz which is generated in the stopper rubber 21.

**[0026]** When the bogie 1 for a railway vehicle traveling on a sharp curve at a low speed enters the curve, a yaw angle between the vehicle body 7 and the bogie frame 2 increases, and in the air spring 6 portion, the vehicle body 7 displaces from the initial state in the front-back direction with respect to the bogie frame 2. The upper surface plate 11 and the stopper rubber receiver 22, along with the vehicle body 7, also relatively displace from the initial state in the front-back direction, and as a result, there is brought about such a state that the stopper rubber 21 and the stopper rubber receiver 22 come in contact with each other in a region (the front end portion 22F or the back end portion 22B of the stopper rubber receiver 22) in which the gap between the stopper rubber receiver 22 and the lower surface plate 13 is wide. In this state, the stopper rubber 21 is brought into a state in which the stopper rubber 21 is not compressed in the up-down direction. In FIG. 6, the front-back relative displacement "x" between the stopper rubber 21 and the stopper rubber receiver 22 is at x0 before the bogie 1 for a railway vehicle enters the curve, and displaces to x1 at the time of the curve travel. At the front-back relative displacement x1, the stopper rubber 21 in the state of not being compressed in the up-down direction is switched to a state in which the gradient of the up-down force Fz is small, that is, a state in which the up-down rigidity kz is low. As described above, the up-down rigidity kz of the stopper rubber 21 decreases, and the air spring 6 provides the support between the vehicle body 7 and the bogie frame 2 in the state in which the total up-down rigidity is low, and as a result, comes to support the vehicle body 7 in a state in which the roll rigidity between the vehicle body 7 and the bogie frame 2 is low.

**[0027]** As described above, in the bogie 1 for a railway vehicle according to the present embodiment, the vehicle body 7 can be supported in the state in which the vehicle body roll rigidity is high at the time of a high-speed curve travel, and hence, vehicle body roll vibration and wobbling caused by a change in an excess centrifugal force acting at the time of the curve travel can be reduced, so that the ride comfort relating to the roll can be increased. Moreover, the outward-falling roll displacement of the vehicle body caused by the excess centrifugal force acting at the time of the curve travel can be reduced, and hence, vehicle body left-right stationary acceleration sensed by passengers can be reduced, so that the ride comfort at the time of the high-speed curve travel can be increased. In this case, since the left-right stationary acceleration of the vehicle body can be suppressed low, a travel at a higher speed on a curve can be achieved without spoiling the ride comfort.

**[0028]** Further, in the bogie 1 for a railway vehicle according to the present embodiment, since the vehicle body 7 can be supported in the state in which the vehicle body roll rigidity is low at the time of a low-speed sharp curve travel, vibration transmissibility in the roll direction between the vehicle body 7 and the bogie frame 2 at the time of the curve travel is reduced, so that a vehicle body roll vibration response to excitation input in the left-right and roll directions due to track irregularity can be reduced, thereby enabling an increase in the ride comfort relating to the roll. Moreover, since roll support rigidity between the vehicle body 7 and the bogie frame 2 is low, the bogie 1 for a railway vehicle, easily follows a change in truck on a relaxation curve at the time of the curve travel, so that a wheel load variation at the time of the curve travel can be suppressed, thereby enabling provision of the highly safe bogie 1 for a railway vehicle.

**[0029]** Moreover, the bogie 1 for a railway vehicle according to the present embodiment has such a simple configuration that the combinations of the stopper rubbers 21 and the stopper rubber receivers 22 are provided to the air spring 6, and hence, the highly reliable bogie 1 for a railway vehicle can be provided at a low cost.

**[0030]** Moreover, the lower surface of the central portion 22M and the lower surfaces of the left and right end portions 22L and 22R of the stopper rubber receiver 22 are continuous to each other via the left and right inclined surfaces, the lower surface of the central portion 22M and the lower surfaces of the front and back end portions 22F and 22B are continuous to each other via the front and back inclined surfaces, and the distal end portion 21T of the stopper rubber 21 is in a tapered or semispherical shape tapering upward toward the lower surface 11A of the upper surface plate 11. Therefore, when the stopper rubber 21 and the stopper rubber receiver 22 displace relative to each other from the initial state, the distal end portion 21T of the stopper rubber 21 can smoothly be moved relatively in the front-back direction and the left-right direction from the position facing the central portion 22M of the stopper rubber receiver 22.

**[0031]** Note that, in the present embodiment, the one pair of stopper rubbers 21 and the one pair of stopper rubber receivers 22 are arranged in the left-right direction with respect to the centers of the upper surface plate 11 and the lower surface plate 13, but the one pair of stopper rubbers 21 and the one pair of stopper rubber receivers 22 may be arranged in the front-back direction with respect to the centers of the upper surface plate 11 and the lower surface plate 13, which can provide an effect equivalent to that of the present embodiment.

[Second Embodiment]

**[0032]** A description is now given of a second embodiment of the present invention with reference to FIG. 7, FIG. 8, and FIG. 9. In FIG. 7, FIG. 8, and FIG. 9, members having functions same as those in the first embodiment are denoted by reference symbols same as those in FIG. 2 and FIG. 3. FIG. 7 and FIG. 8 show a form example of an air spring 30 configured such that a stopper rubber 41 and a stopper rubber receiver 42 are arranged at a center of a lower surface plate 33 and a center of an upper surface plate 31. Note that, in FIG. 7, the air spring 30 is shown on a cross section taken along line D-D of FIG. 9, and in FIG. 8, the air spring 30 is shown on a cross section taken along line E-E of FIG. 9.

**[0033]** A detailed configuration of the air spring 30 is shown in FIG. 7 and FIG. 8. FIG. 7 is a front cross-sectional view of the air spring 30, and FIG. 8 is a side cross-sectional view of the air spring 30. In FIG. 7, an arrow "y" indicates the left-right direction, and in FIG. 8, an arrow "x" indicates the front-back direction.

**[0034]** The air spring 30 mainly includes the upper surface plate 31, the bellows 12, the lower surface plate 33, the laminated rubber 14, and an air spring seat 35. The upper surface plate 31 and the lower surface plate 33 are coupled to each other via the bellows 12, and the air spring 30 provides, as with the air spring 6 in the first embodiment, elastic support between the vehicle body 7 and the bogieframe 2 in the up-down direction and the horizontal direction. A communication opening 38 is provided inside the upper surface plate 31, and the air chamber 16 and an auxiliary tank, which is mounted to the vehicle body 7 and is not shown, are caused to communicate with each other via the communication opening 38. An orifice 39 is formed in the communication opening 38, and a damping force is generated in the up-down direction of the air spring 30 by a resistance effect exhibited at the time of passage of air between the air chamber 16 and the auxiliary tank. While, in the present embodiment, there is provided such a configuration that the auxiliary tank is mounted on the vehicle body 7 side, there may otherwise be provided such a configuration that the auxiliary tank is provided on the bogie frame 2 side and the air chamber 16 and the auxiliary tank are caused to communicate with each other via a communication opening and an orifice.

**[0035]** The upper surface plate 31 has a lower surface 31A in a circular flat surface shape exposed in the air chamber 16. The lower surface plate 33 has an upper surface 33A which is in a circular flat surface shape, is exposed in the air chamber 16, and faces the lower surface 31A of the upper surface plate 31 from below. The lower surface 31A of the upper surface plate 31 and the upper surface 33A of the lower surface plate 33 constitute opposed surfaces which are apart from each other in the up-down direction in the air chamber 16 and which face each other. A position of the lower surface 31A of the upper surface plate 31 with respect to the upper surface 33A of the lower surface plate 33 (a relative position between the upper and lower opposed surfaces) varies from the initial state in the front-back direction and the left-right direction in response to a displacement of the vehicle body 7 in the front-back direction and the left-right direction allowed by the air spring 30.

**[0036]** The stopper rubber 41 and the stopper rubber receiver 42 are arranged on and fixed to the center of the upper surface 33A of the lower surface plate 33 and the center of the lower surface 31A of the upper surface plate 31, respectively. In FIG. 7, front cross-sectional views of the stopper rubber 41 and the stopper rubber receiver 42 are shown, and in FIG. 8, side cross-sectional views of the stopper rubber 41 and the stopper rubber receiver 42 are shown. FIG. 9 is a plan view for showing an arrangement of the stopper rubber 41 on the lower surface plate 33 and an arrangement of the stopper rubber receiver 42 on the upper surface plate 31. The stopper rubber receiver 42 is indicated by broken lines in FIG. 9. The stopper rubber 41 and the stopper rubber receiver 42 have shapes same as those of the stopper rubber 21 and the stopper rubber receiver 22 in the first embodiment.

**[0037]** That is, as shown in FIG. 7, the stopper rubber

receiver 42 has such a shape in the left-right direction that a gap between the stopper rubber receiver 42 and the upper surface 33A of the lower surface plate 33 is wide at a central portion 42M in a flat surface shape and the gap between the stopper rubber receiver 42 and the upper surface 33A of the lower surface plate 33 is narrow at end portions (left end portion 42L and right end portion 42R). Moreover, as shown in FIG. 8, the stopper rubber receiver 42 has such a shape in the front-back direction that the gap between the stopper rubber receiver 42 and the upper surface 33A of the lower surface plate 33 is narrow at the central portion 42M and the gap between the stopper rubber receiver 42 and the upper surface 33A of the lower surface plate 33 is wide at end portions (front end portion 42F and back end portion 42B).

**[0038]** An operation of the bogie 1 for a railway vehicle according to the present embodiment at the time of traveling at a high speed on a curve is the same as that in the first embodiment. That is, when a centrifugal force in the left-right direction acts on the vehicle body 7 on the curve, a left-right relative displacement between the stopper rubber 41 and the stopper rubber receiver 42 occurs, and there is brought about such a state that the stopper rubber 41 and the stopper rubber receiver 42 come in contact with each other in the region (the left end portion 42L or the right end portion 42R of the stopper rubber receiver 42) in which the gap between the stopper rubber receiver 42 and the lower surface plate 33 is narrow. In this state, the stopper rubber 41 is brought into a state of being compressed in the up-down direction, and up-down rigidity of the stopper rubber 41 becomes high. Therefore, the vehicle body 7 is supported in the state in which the roll rigidity between the vehicle body 7 and the bogie frame 2 is high.

**[0039]** When the bogie 1 for a railway vehicle traveling on a sharp curve at a low speed enters the curve, the yaw angle between the vehicle body 7 and the bogie frame 2 increases, and a front-back relative displacement between the stopper rubber 41 and the stopper rubber receiver 42 occurs. There is thus brought about such a state that the stopper rubber 41 and the stopper rubber receiver 42 come in contact with each other in the region (the front end portion 42F or the back end portion 42B of the stopper rubber receiver 42) in which the gap between the stopper rubber receiver 42 and the lower surface plate 33 is wide. In this state, the stopper rubber 41 is brought into a state of not being compressed in the up-down direction, and the up-down rigidity of the stopper rubber 41 becomes low. Therefore, the vehicle body 7 is supported in the state in which the roll rigidity between the vehicle body 7 and the bogie frame 2 is low.

**[0040]** In the bogie 1 for a railway vehicle according to the present embodiment described above, the vehicle body 7 can be supported in the state in which the vehicle body roll rigidity is high at the time of a high-speed curve travel, and hence, the ride comfort relating to the roll at the time of the curve travel can be increased, and moreover, left-right ride comfort at the time of the curve travel can be increased.

**[0041]** Further, in the bogie 1 for a railway vehicle according to the present embodiment, the vehicle body 7 can be supported in the state in which the vehicle body roll rigidity is low at the time of a low-speed sharp curve travel, and hence, the ride comfort relating to the roll can be increased by reducing the vehicle body roll vibration response to excitation input due to track irregularity at the time of the curve travel, and moreover, a wheel load variation on a relaxation curve at the time of the curve travel can be suppressed.

**[0042]** As described above, in the present embodiment, it is possible to achieve the reduction in the vehicle body roll vibration/vehicle body left-right stationary acceleration and the suppression of the wheel load variation, as with the first embodiment, through use of such a configuration that the one set of the stopper rubber 41 and the stopper rubber receiver 42 is provided to the air spring 30, which is simple and involves the small number of components.

**[0043]** Note that the present invention is not limited to the embodiments described above and includes various modification examples. For example, the embodiments described above are detailed for the sake of an easy-to-understand description of the present invention, and the present invention is not necessarily limited to the embodiments including all the described configurations. Moreover, a part of a configuration of a certain embodiment can be replaced by a configuration of another embodiment, and to a configuration of a certain embodiment, a configuration of another embodiment can be added. Further, for a part of a configuration of each embodiment, addition, deletion, and replacement of another configuration can be made.

**[0044]** The present specification includes the following disclosure of the invention.

(First Form)

**[0045]** A bogie for a railway vehicle, including:

an air spring that elastically supports a vehicle body from below,

in which the air spring includes upper and lower opposed surfaces that are apart from each other in an up-down direction and face each other, and a stopper rubber and a stopper rubber receiver that are arranged between the upper and lower opposed surfaces,

a relative position between the upper and lower opposed surfaces varies from an initial state in the up-down direction and a left-right direction in response to a displacement of the vehicle body in the up-down direction and the left-right direction allowed by the air spring,

the stopper rubber is fixed to one opposed surface of the upper and lower opposed surfaces and protrudes toward the other opposed surface,

the stopper rubber receiver is fixed to the other opposed surface and is apart from the one opposed surface,
the stopper rubber faces a central portion of the stopper rubber receiver in the initial state,
separation distances to the one opposed surface in the up-down direction at left and right end portions of the stopper rubber receiver facing each other across the central portion are shorter than that at the central portion, and
separation distances to the one opposed surface in the up-down direction at front and back end portions of the stopper rubber receiver facing each other across the central portion are longer than that at the central portion.

(Second Form)

**[0046]** The bogie for a railway vehicle according to the first form, in which the stopper rubber is provided as a pair of left and right stopper rubbers or a pair of front and back stopper rubbers arranged with respect to a center of the one opposed surface of the upper and lower opposed surfaces, and the stopper rubber receiver is correspondingly provided as a pair of left and right stopper rubber receivers or a pair of front and back stopper rubber receivers arranged with respect to a center of the other opposed surface of the upper and lower opposed surfaces.

(Third Form)

**[0047]** The bogie for a railway vehicle according to the first form, in which the stopper rubber is arranged at a center of the one opposed surface of the upper and lower opposed surfaces, and the stopper rubber receiver is arranged at a center of the other opposed surface of the upper and lower opposed surfaces.

(Fourth Form)

**[0048]** The bogie for a railway vehicle according to any one of the first form to the third form,

in which the central portion and the left and right end portions of the stopper rubber receiver are continuous to each other via left and right inclined surfaces, and
the central portion and the front and back end portions of the stopper rubber receiver are continuous to each other via front and back inclined surfaces.

(Fifth Form)

**[0049]** The bogie for a railway vehicle according to any one of the first form to the fourth form, in which the stopper rubber has a distal end portion in a tapered or semispherical shape tapering toward the other opposed surface.

(Sixth Form)

**[0050]** The bogie for a railway vehicle according to any one of the first form to the fifth form, further including:

a bogie frame that is arranged below the vehicle body,
in which the air spring is arranged between the vehicle body and the bogie frame and elastically supports the vehicle body from below,
the air spring includes an upper surface plate supported to the vehicle body and a lower surface plate supported to the bogie frame, and
a lower surface of the upper surface plate and an upper surface of the lower surface plate constitute the upper and lower opposed surfaces.

## Claims

**1.** A bogie (1) for a railway vehicle, comprising:

an air spring (6, 30) that elastically supports a vehicle body (7) from below,
wherein the air spring includes upper and lower opposed surfaces (11A, 13A, 31A, 33A) that are apart from each other in an up-down direction and face each other, and a stopper rubber (21, 41) and a stopper rubber receiver (22, 42) that are arranged between the upper and lower opposed surfaces,
a relative position between the upper and lower opposed surfaces varies from an initial state in the up-down direction and a left-right direction in response to a displacement of the vehicle body in the up-down direction and the left-right direction allowed by the air spring,
the stopper rubber is fixed to one opposed surface of the upper and lower opposed surfaces and protrudes toward the other opposed surface,
the stopper rubber receiver is fixed to the other opposed surface and is apart from the one opposed surface,
the stopper rubber faces a central portion (22M, 42M) of the stopper rubber receiver in the initial state,
separation distances to the one opposed surface in the up-down direction at left and right end portions (22L, 22R, 42L, 42R) of the stopper rubber receiver facing each other across the central portion are shorter than that at the central portion, and
separation distances to the one opposed surface in the up-down direction at front and back end portions (22F, 22B, 42F, 42B) of the stopper rubber receiver facing each other across the central portion are longer than that at the central

portion.

2. The bogie (1) for a railway vehicle according to claim 1, wherein the stopper rubber (21) is provided as a pair of left and right stopper rubbers or a pair of front and back stopper rubbers arranged with respect to a center of the one opposed surface of the upper and lower opposed surfaces, and the stopper rubber receiver (22) is correspondingly provided as a pair of left and right stopper rubber receivers or a pair of front and back stopper rubber receivers arranged with respect to a center of the other opposed surface of the upper and lower opposed surfaces.

3. The bogie (1) for a railway vehicle according to claim 1, wherein the stopper rubber (41) is arranged at a center of the one opposed surface of the upper and lower opposed surfaces, and the stopper rubber receiver (42) is arranged at a center of the other opposed surface of the upper and lower opposed surfaces.

4. The bogie (1) for a railway vehicle according to claim 1,

wherein the central portion (22M, 42M) and the left and right end portions (22L, 22R, 42L, 42R) of the stopper rubber receiver (22, 42) are continuous to each other via left and right inclined surfaces, and
the central portion and the front and back end portions (22F, 22B, 42F, 42B) of the stopper rubber receiver are continuous to each other via front and back inclined surfaces.

5. The bogie (1) for a railway vehicle according to claim 1, wherein the stopper rubber (21, 41) has a distal end portion (21T, 41T) in a tapered or semispherical shape tapering toward the other opposed surface.

6. The bogie (1) for a railway vehicle according to claim 1, further comprising:

a bogie frame (2) that is arranged below the vehicle body (7),
wherein the air spring (6, 30) is arranged between the vehicle body and the bogie frame and elastically supports the vehicle body from below,
the air spring includes an upper surface plate (11, 31) supported to the vehicle body and a lower surface plate (13, 33) supported to the bogie frame, and
a lower surface (11A, 31A) of the upper surface plate and an upper surface (13A, 33A) of the lower surface plate constitute the upper and lower opposed surfaces (11A, 13A, 31A, 33A).

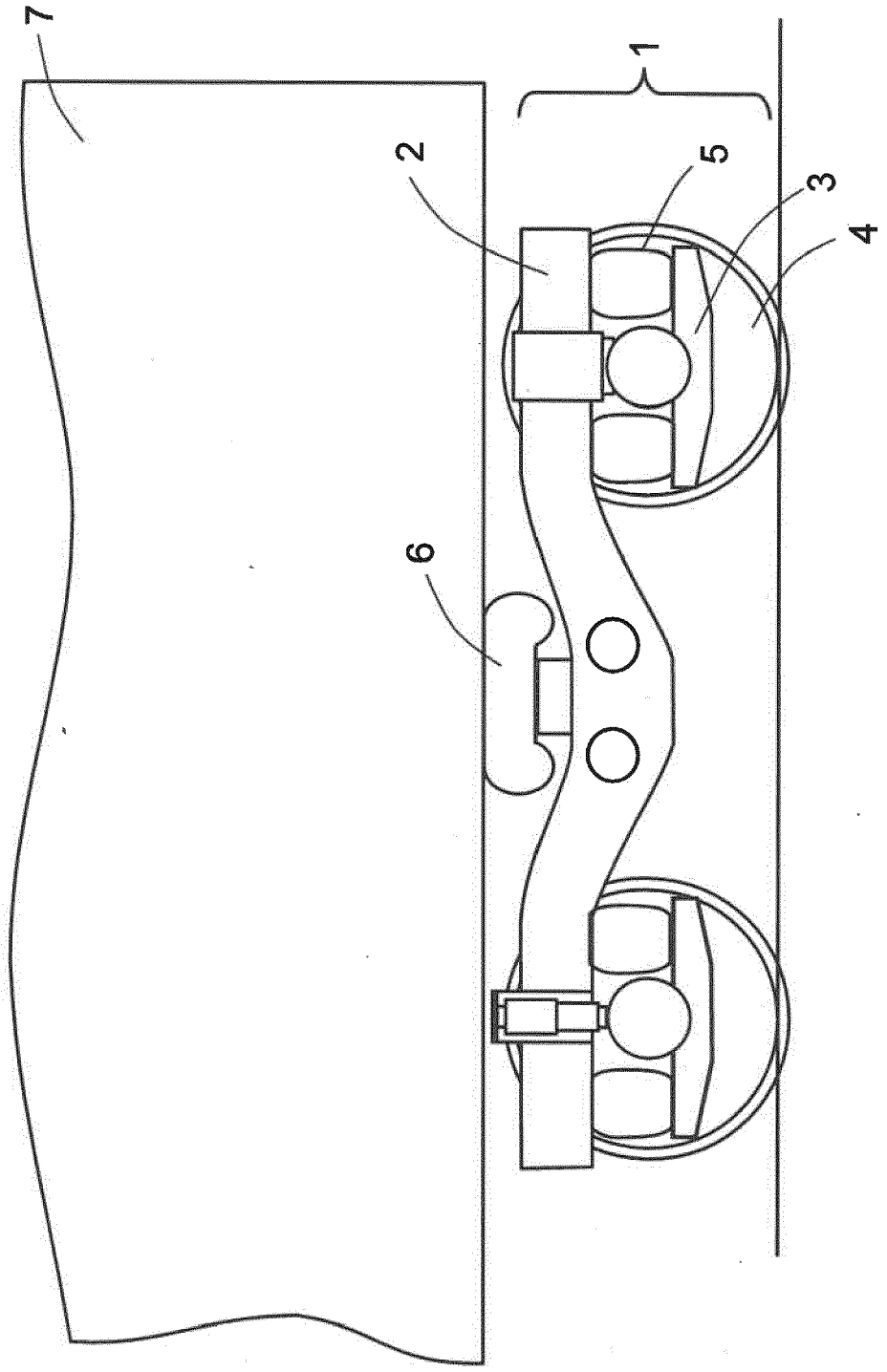
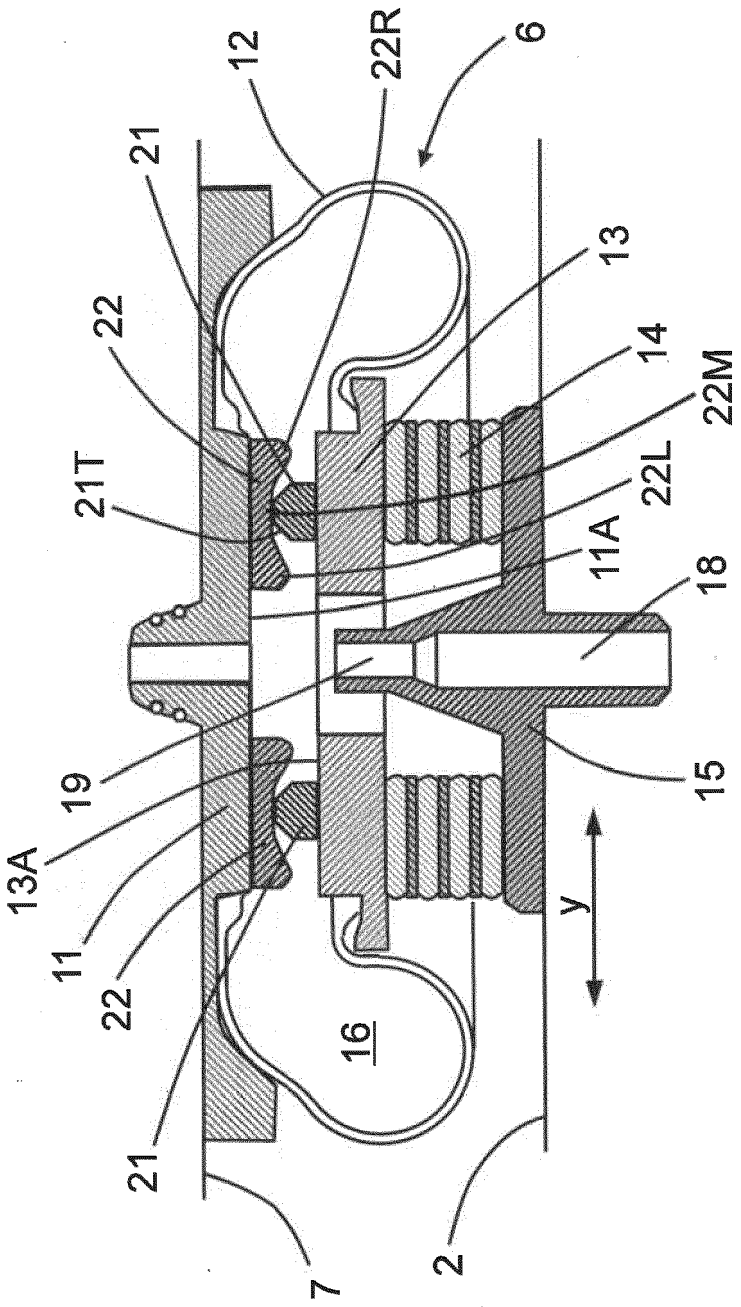



FIG. 1

FIG. 2



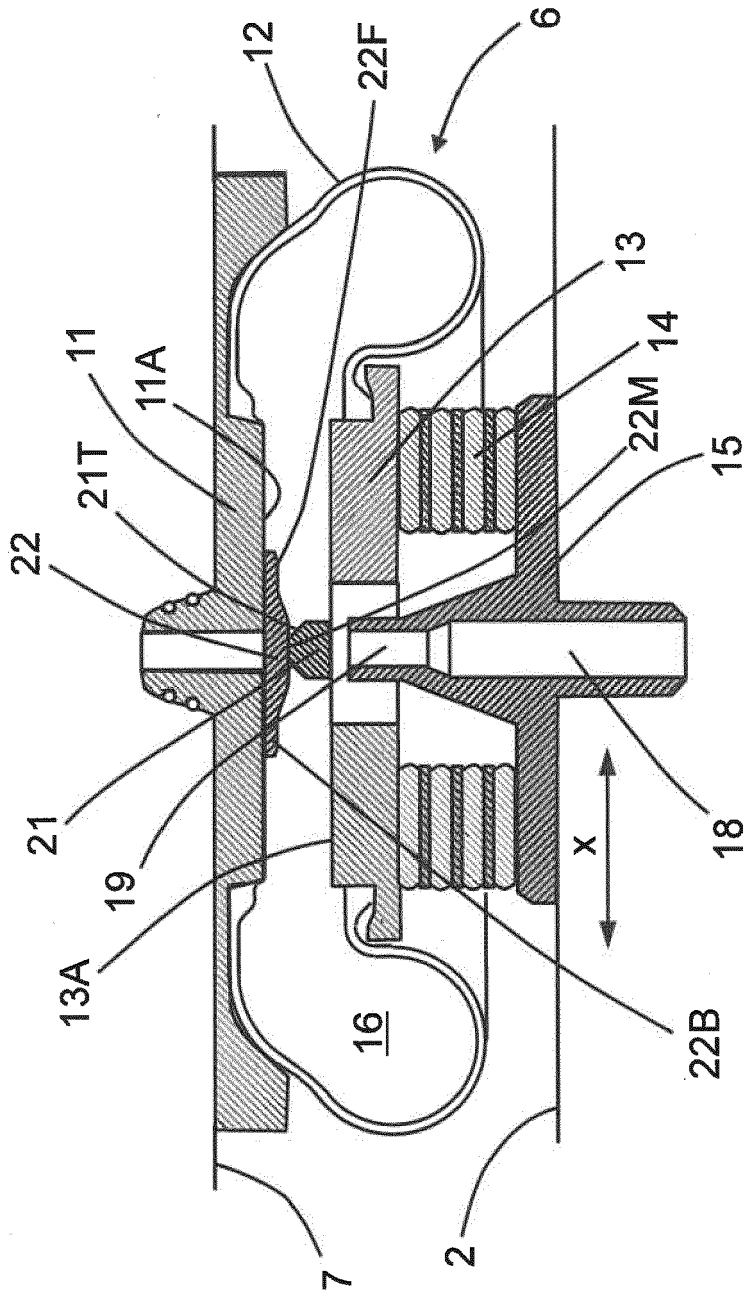



FIG. 3

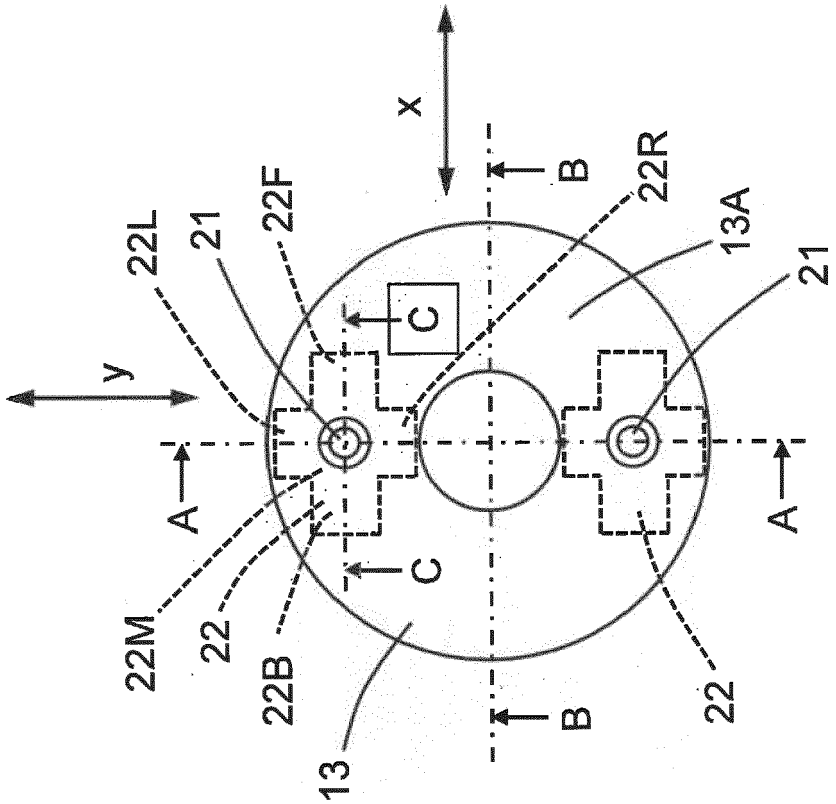
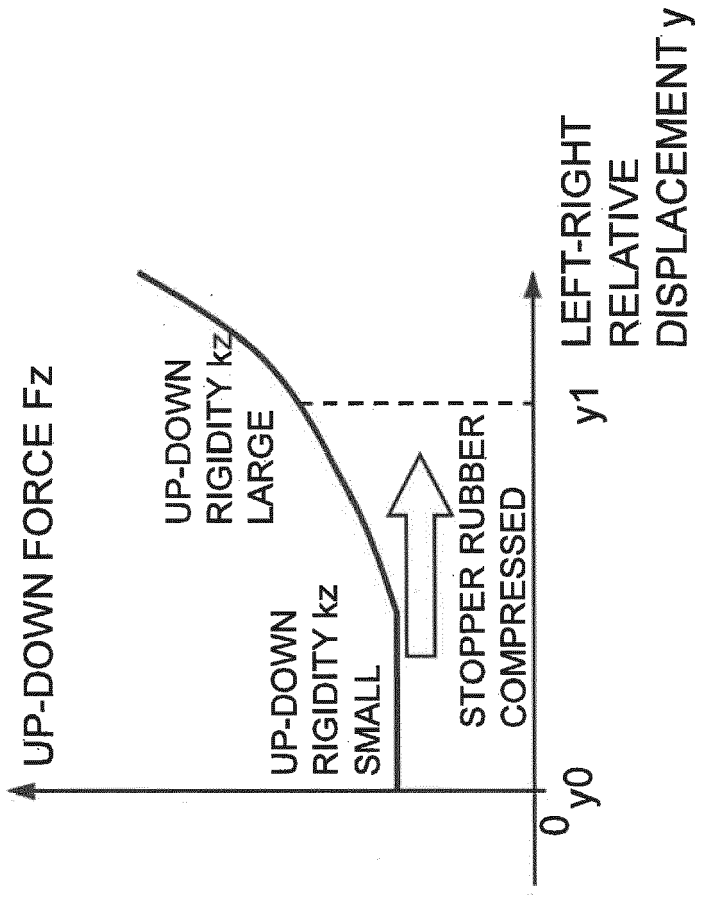



FIG. 4

FIG. 5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UP-DOWN RIGIDITY kz LARGE
UP-DOWN RIGIDITY kz SMALL
STOPPER RUBBER COMPRESSED
0
y0
y1
LEFT-RIGHT RELATIVE DISPLACEMENT y

FIG. 6

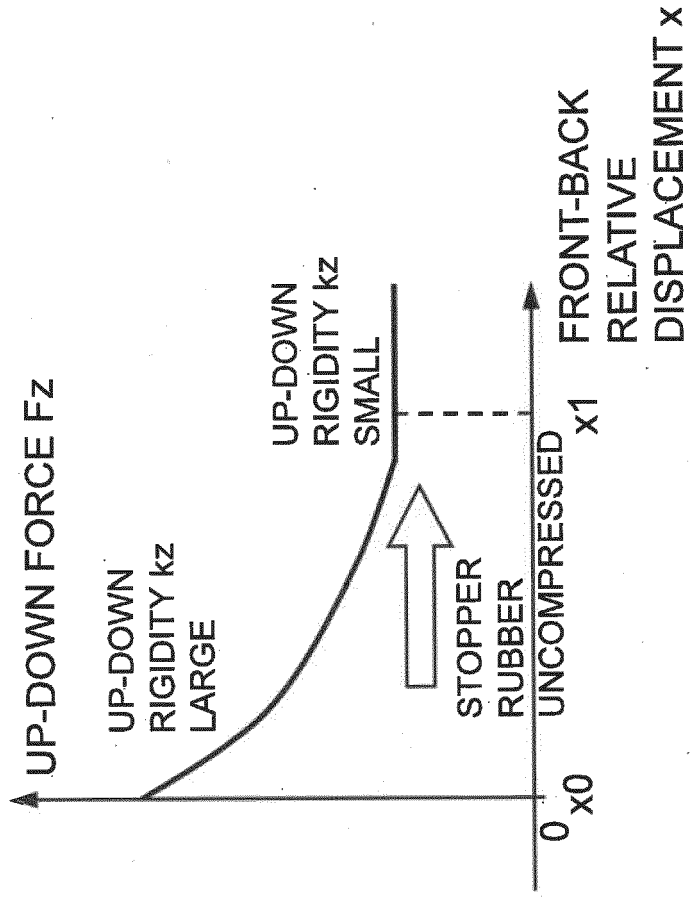
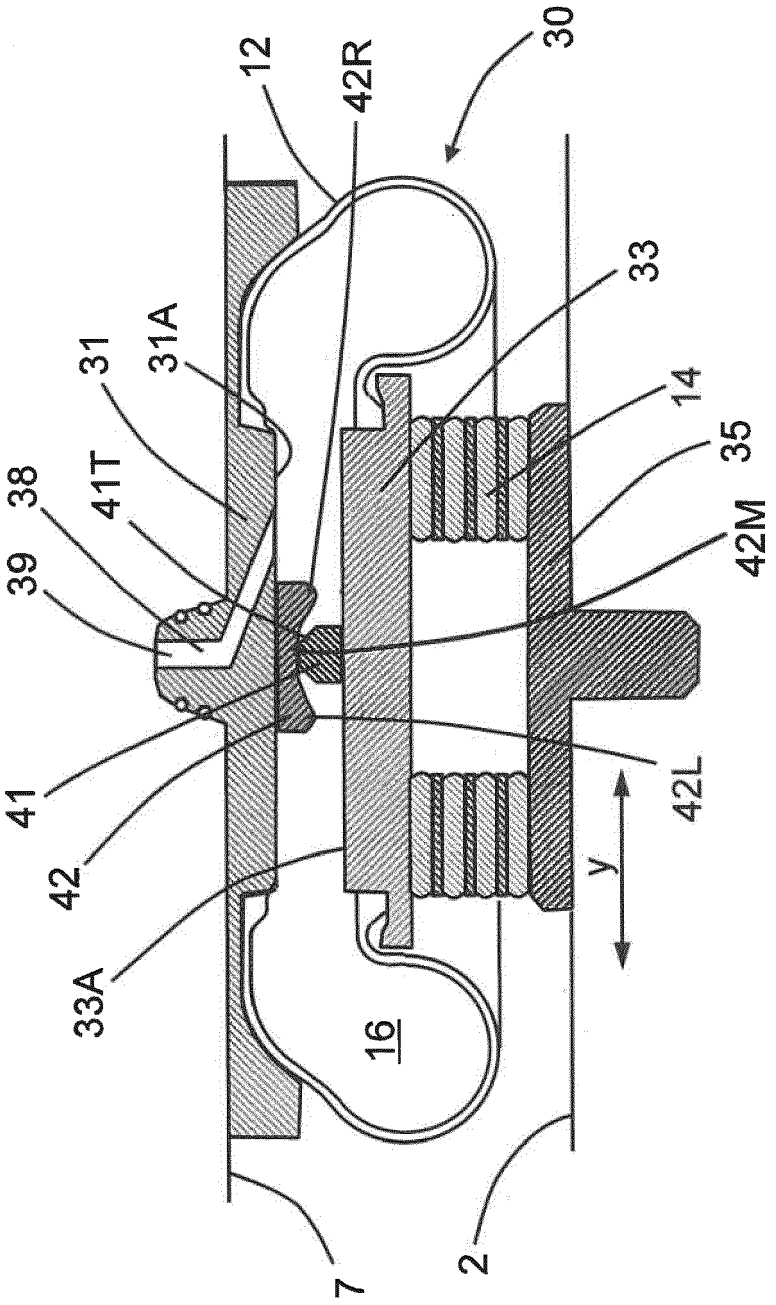

UP-DOWN FORCE Fz
UP-DOWN RIGIDITY kz LARGE
UP-DOWN RIGIDITY kz SMALL
STOPPER RUBBER
UNCOMPRESSED
FRONT-BACK RELATIVE DISPLACEMENT x
x1
0
x0

FIG. 7



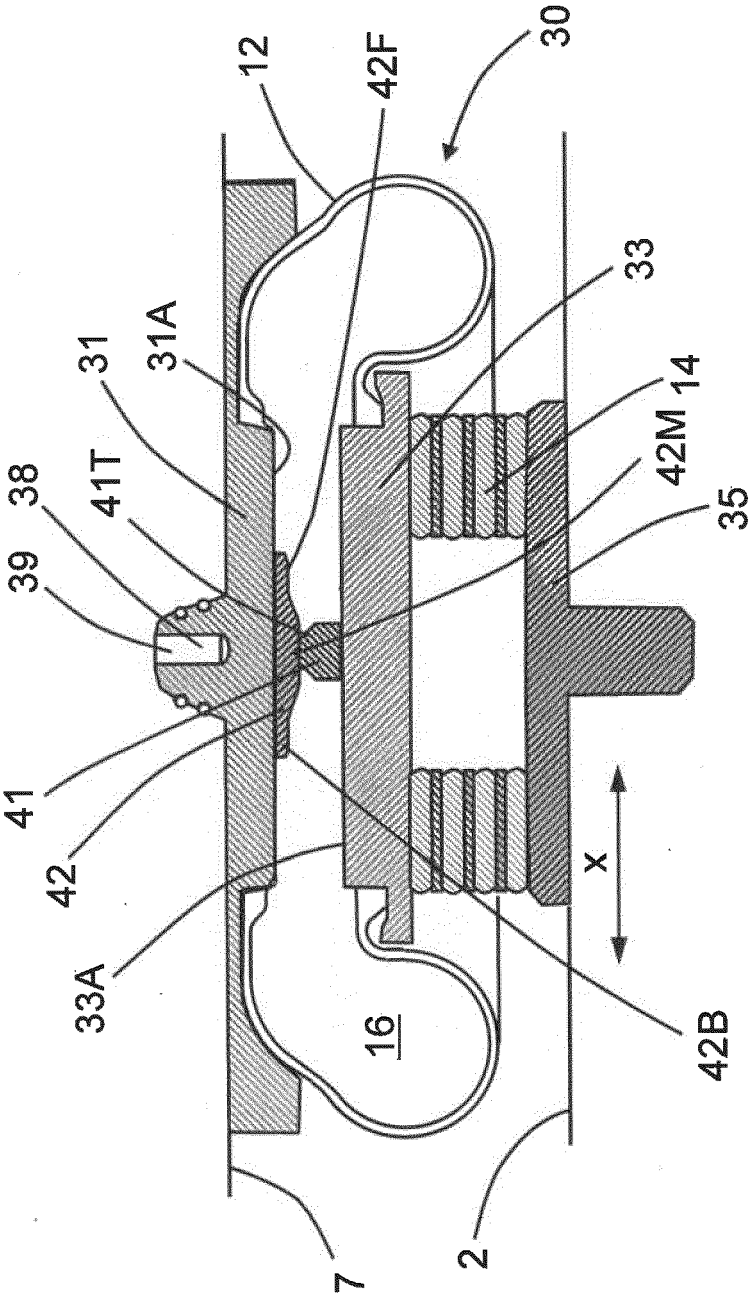
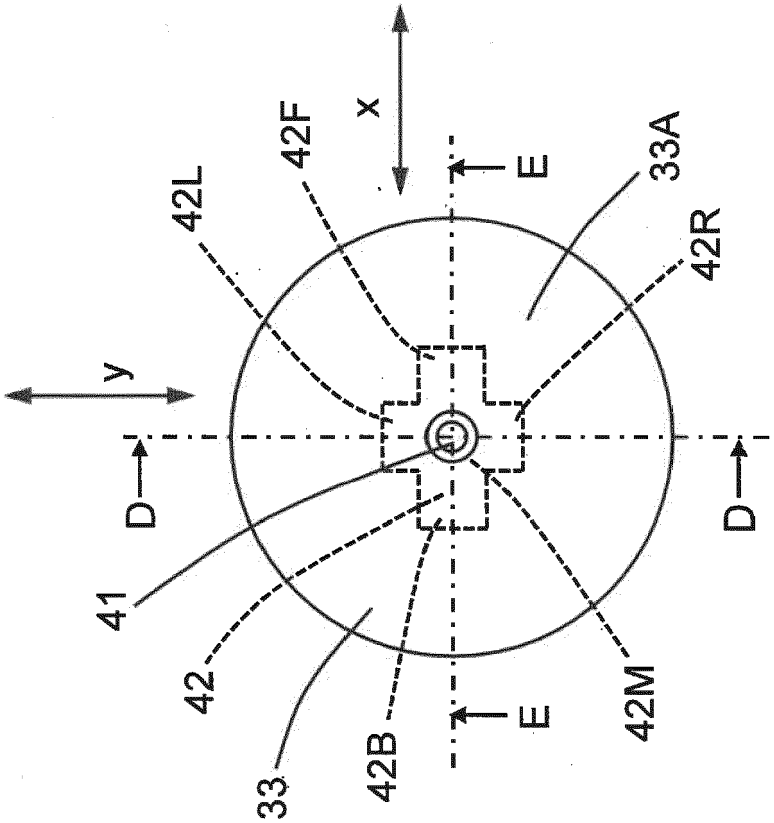



FIG. 8

FIG. 9



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# EUROPEAN SEARCH REPORT

Application Number
EP 23 20 3965

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The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 19 March 2024 | Awad, Philippe |

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