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(57) **ABSTRACT**

In a planet roller speed changer, a plurality of shaft portions of a carrier is disposed such that, when the carrier is displaced in a direction that intersects with the axial direction of an output shaft, the outer periphery of at least one of the shaft portions that are displaced with a displacement of the carrier contacts the stationary ring-side portion of the inner periphery of is corresponding planet roller without contacting the input shaft-side portion of the inner periphery of the corresponding planet roller.
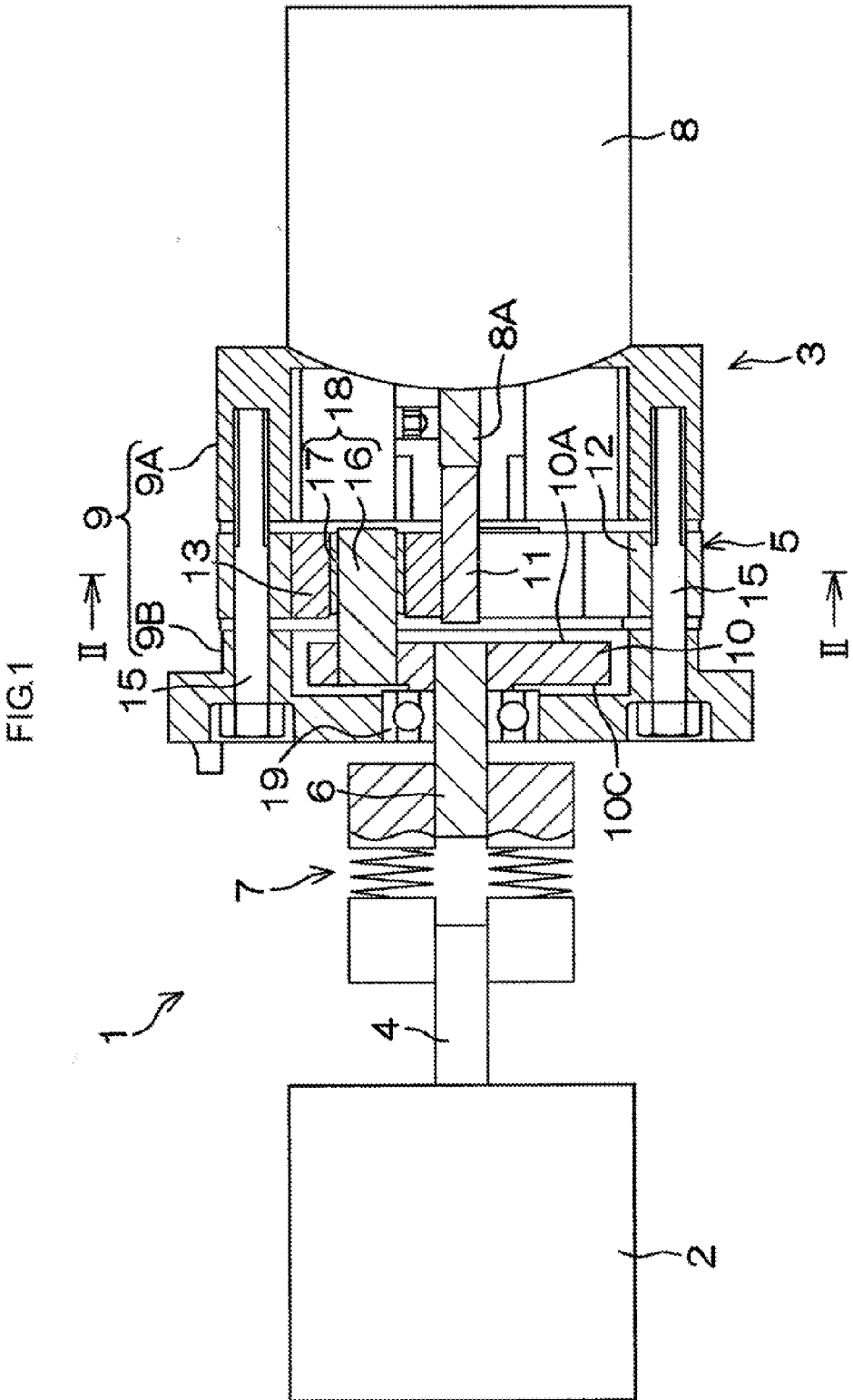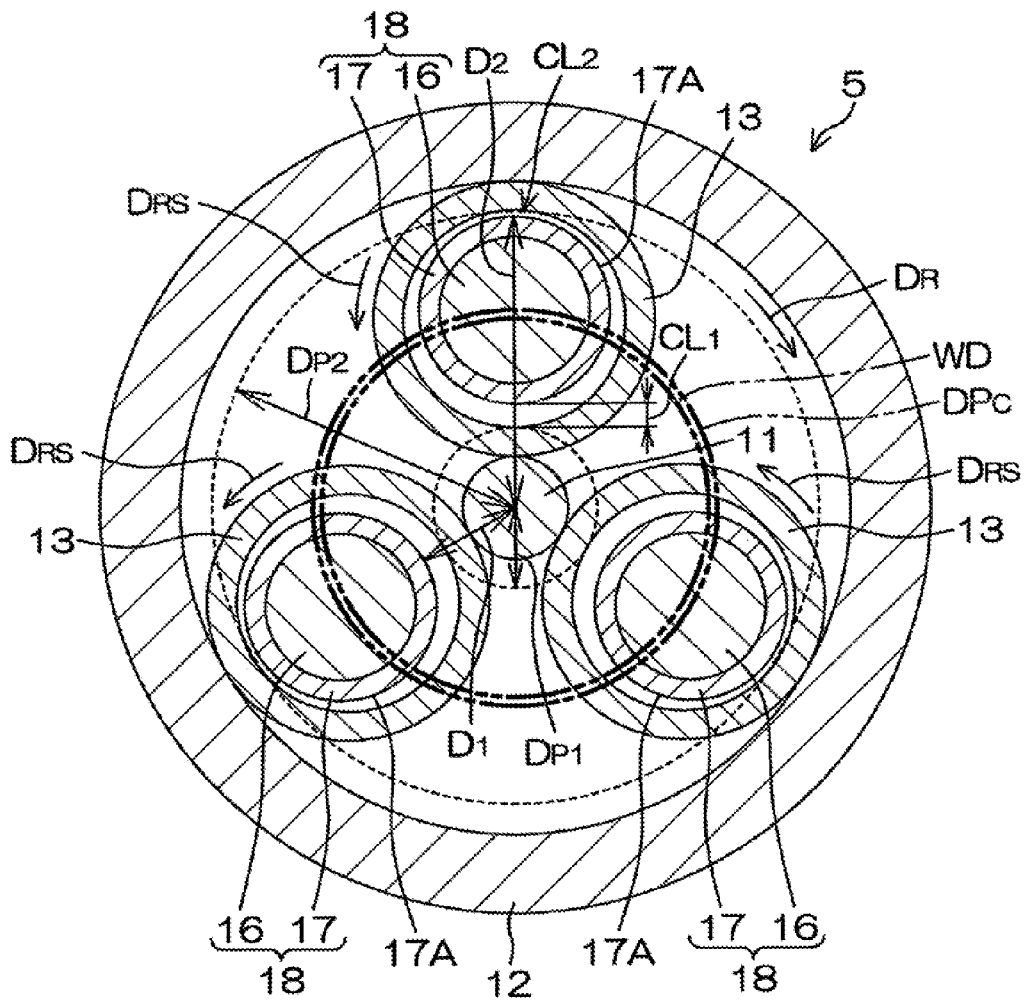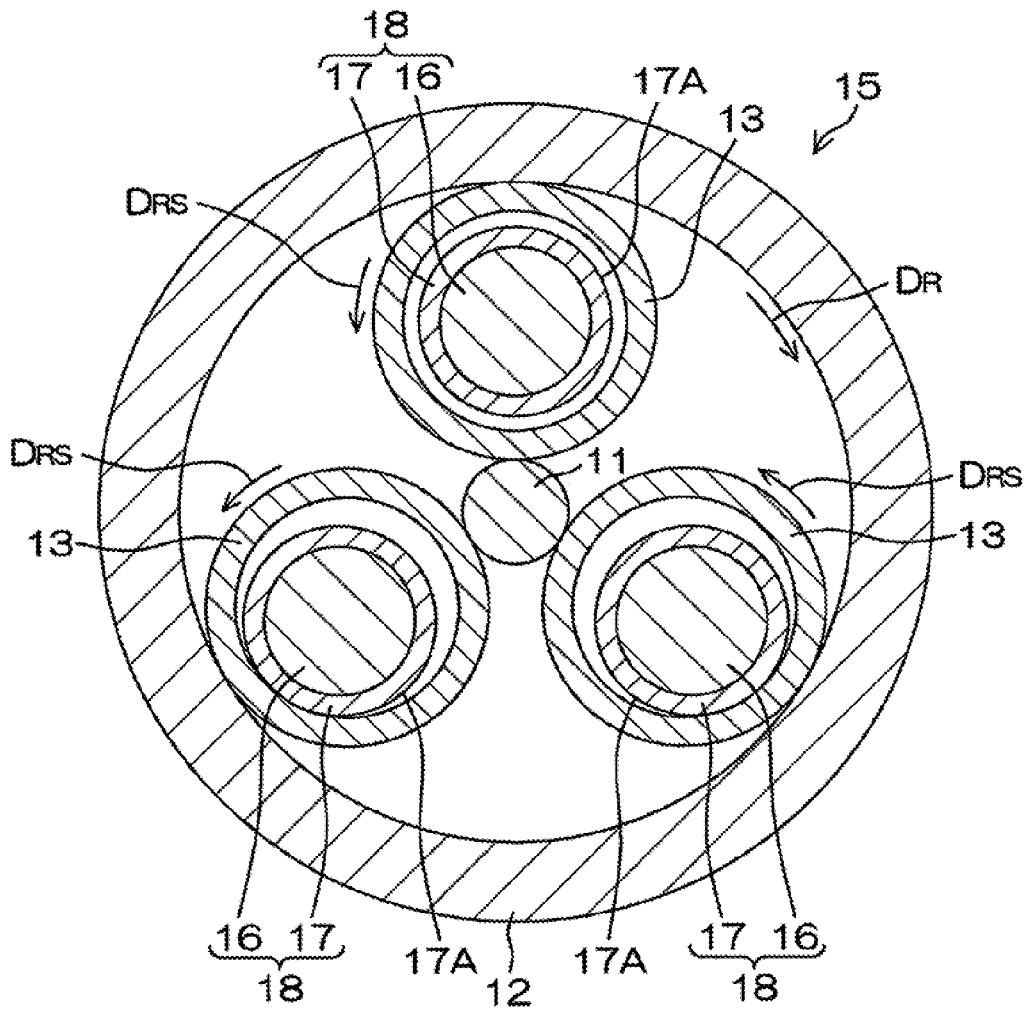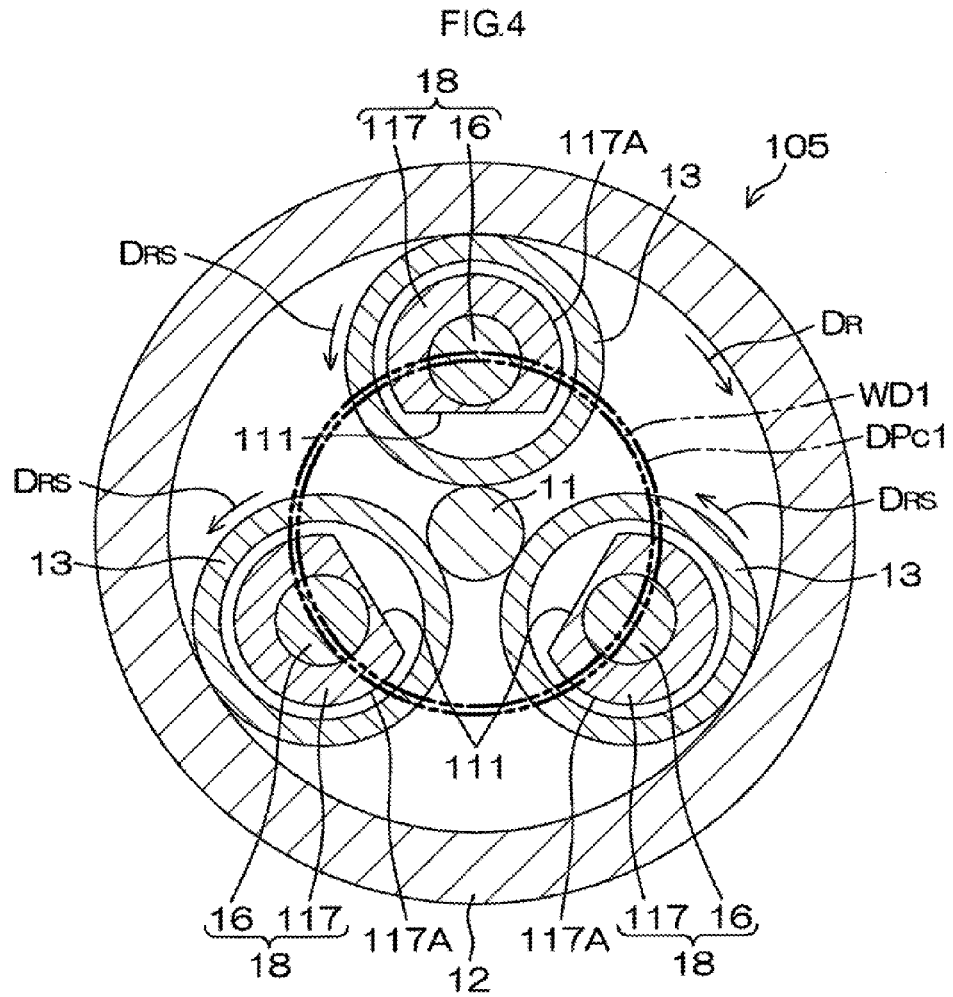
FIG.1

FIG.2
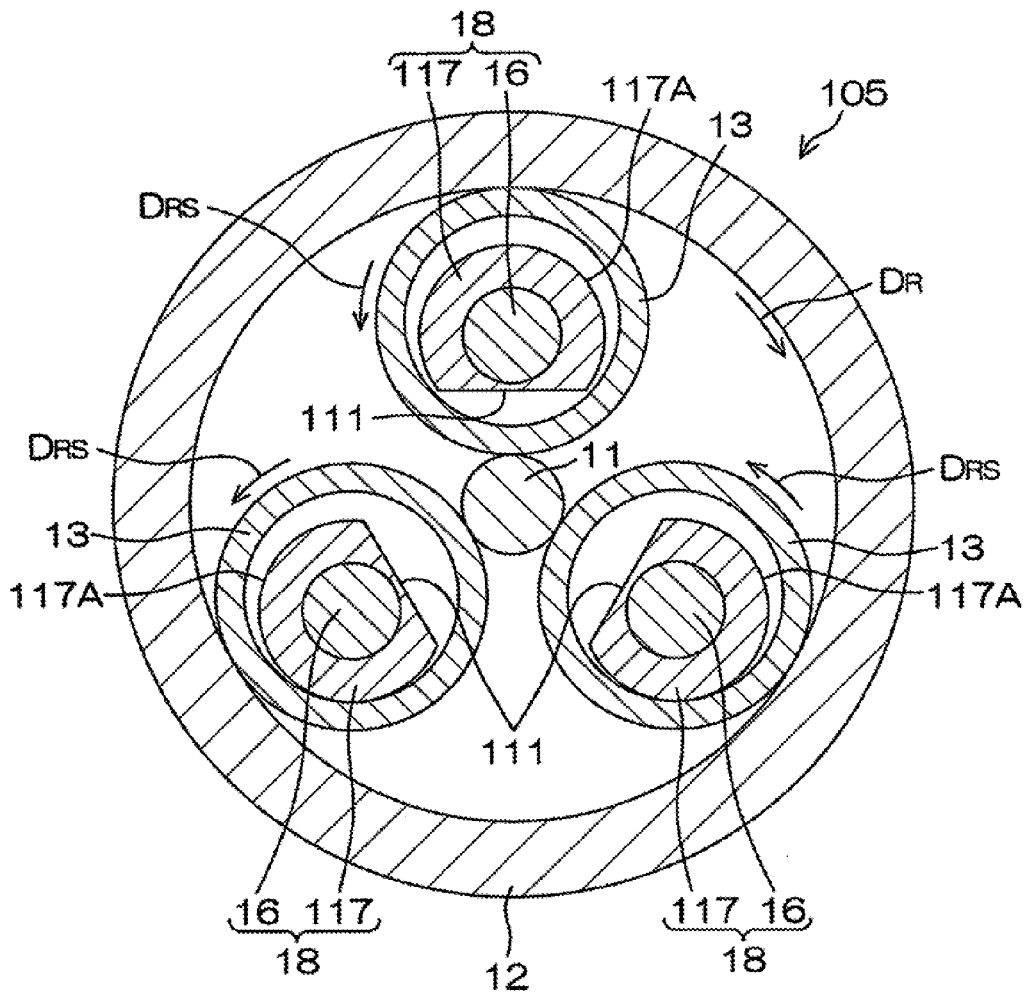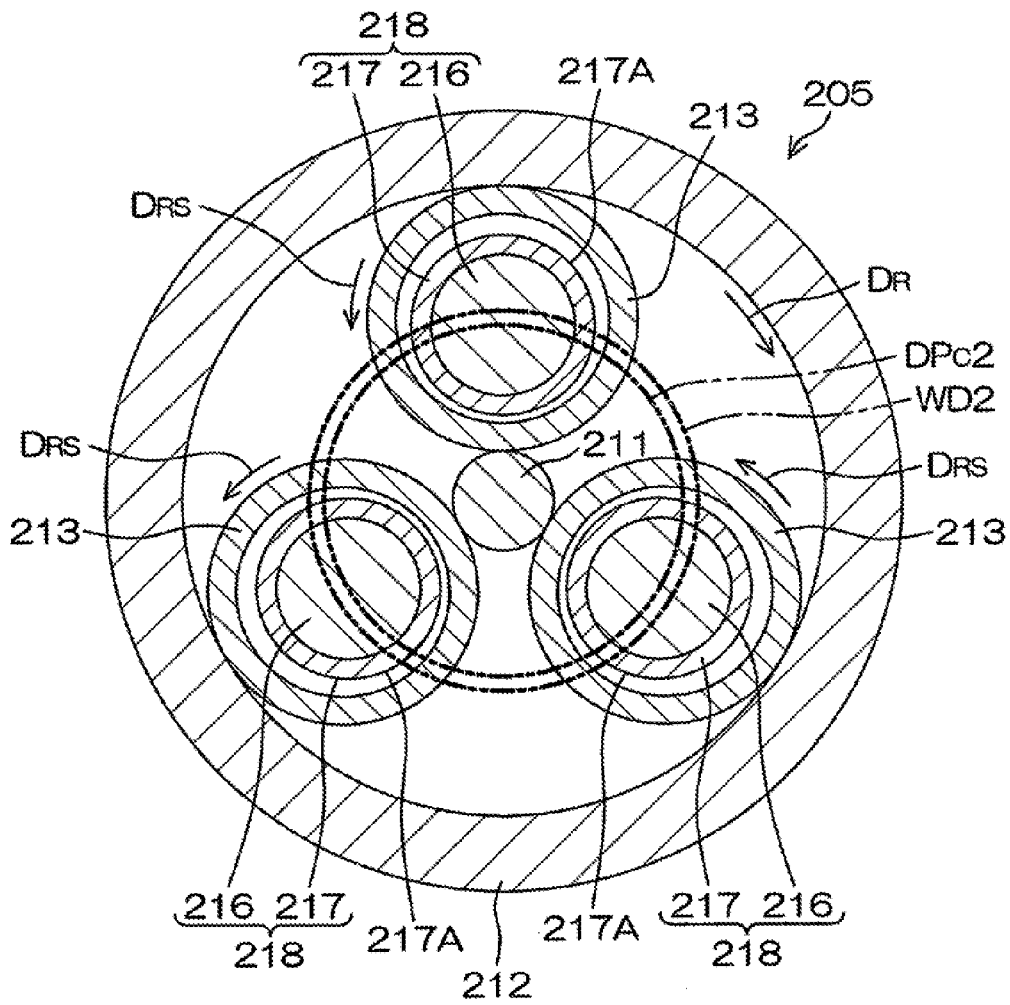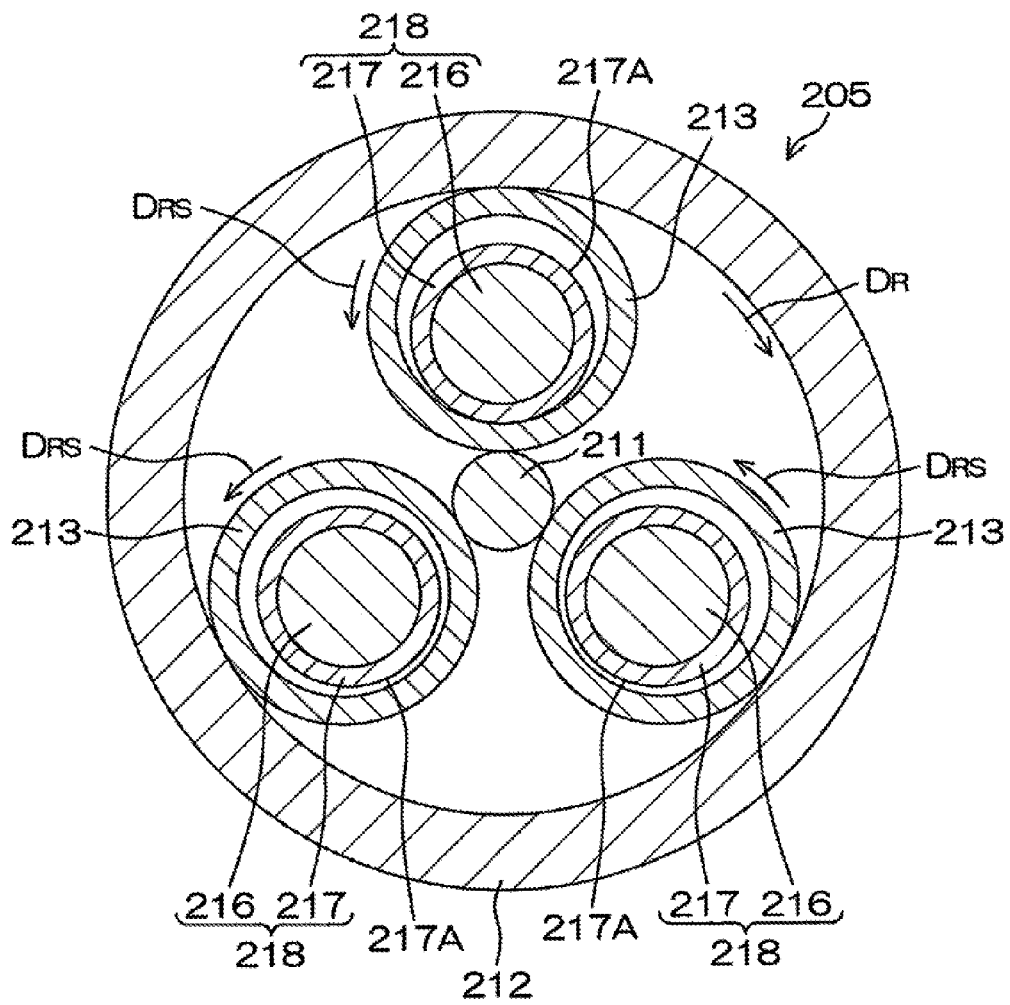
FIG.3

FIG.4
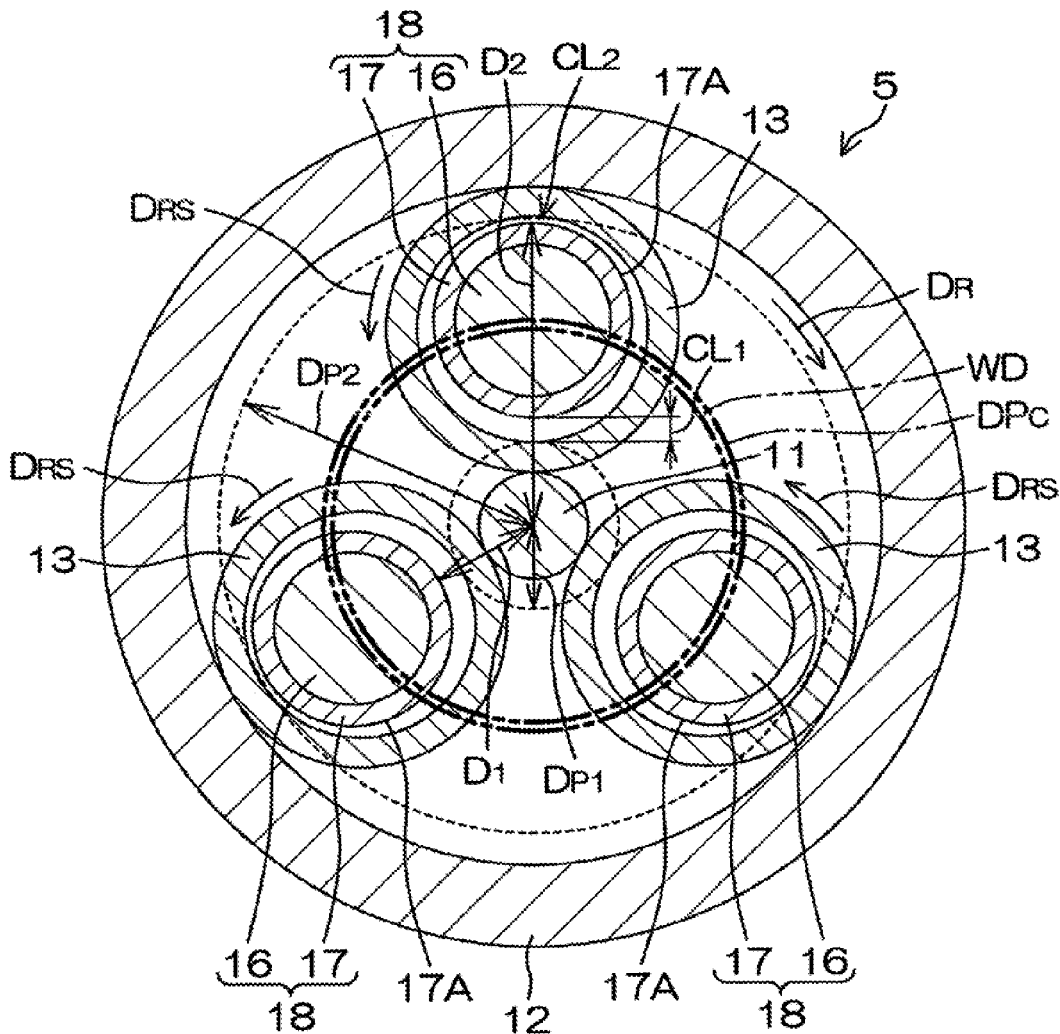
FIG.5

FIG.6

FIG.7

PLANET ROLLER SPEED CHANGER

INCORPORATION BY REFERENCE

[0001] The disclosure of Japanese Patent Application No. 2013-257098 filed on Dec. 12, 2013, including the specification, drawings and abstract, is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention
[0003] The invention relates to a planet roller speed changer.
[0004] 2. Description of the Related Art
[0005] As described in Japanese Patent Application Publication No. 2003-161351 (JP 2003-161351 A), there is a conventional planet roller speed changer (traction drive) in which each of cylindrical planet rollers is rotatably supported in a loosely fitted state by a pin that passes through the inner periphery of the planet roller and that protrudes from a carrier. A cylindrical bushing is fixedly fitted onto the outer periphery of each pin. Because each planet roller is in the loosely fitted state, there is a clearance between the inner periphery of the planet roller and the outer periphery of a corresponding one of the bushings.
[0006] For example, the planet roller speed changer is mounted transversely in an apparatus such as an image forming apparatus (i.e., mounted in a state where an input shaft and an output shaft of the planet roller speed changer extend along the horizontal direction) in some cases. In such a mounted state, the carrier may be displaced downward from a prescribed position under its own weight. As a result, there sometimes occurs a state where the center of rotation of the carrier and the center of revolutions of the planet rollers supported in the loosely fitted state by the pins of the carrier do not coincide with each other, that is, a state Where the center of rotation of the carrier is misaligned with the center of revolutions of the planet rollers.
[0007] In this case, if the outer peripheral face of the bushing contacts the input shaft side-portion of the inner periphery of the planet roller due to the misalignment of the center of rotation of the carrier with the center of revolutions of the planet rollers, the revolution of the pin may be promoted. Due to a change in the relative position between the planet roller and the pin caused by the misalignment of the center of rotation of the carrier with the center of revolutions of the planet rollers, rotation of the carrier is advanced or delayed when the output shaft is rotating. When the outer peripheral face of the bushing contacts the input shaft side-portion of the inner periphery of the planet roller, the rotation of the carrier is advanced or delayed significantly. As a result, large rotational fluctuations may occur in the planet roller speed changer.

SUMMARY OF THE INVENTION

[0008] One object of the invention is to provide a planet roller speed changer with a high degree of rotation accuracy, in which rotational fluctuations due to misalignment of the center of rotation of a carrier with the center of revolutions of planet rollers are restricted even if the misalignment occurs.
[0009] An aspect of the invention relates to a planet roller speed changer including: an input shaft; a stationary ring disposed around the input shaft so as to be concentric with the input shaft; as plurality of cylindrical planet rollers that are in rolling contact with both the input shaft and the stationary ring; an output shaft; and a carrier having a plurality of shaft portions each of which is disposed in a corresponding one of the planet rollers, passes through the corresponding one of the planet rollers, and supports the corresponding one of the planet rollers in a loosely fitted state such that the corresponding one of the rollers is rotatable, the carrier being fixed to the output shaft so as to be rotatable together with the output shaft. The shaft portions of the carrier are disposed such that, when the carrier is displaced in a direction that intersects with the axial direction of the output shaft, the outer periphery of at least one of the shaft portions that are displaced with a displacement of the carrier contacts the stationary ring-side portion of an inner periphery of the corresponding planet roller without contacting the input shaft-side portion of the inner periphery of the corresponding planet roller.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The foregoing and further features and advantages of the invention will become apparent from the following description of example embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:
[0011] FIG. 1 is a view illustrating the schematic configuration of a power transmitting device of an image forming apparatus in which a planet roller speed changer according to a first embodiment of the invention is mounted;
[0012] FIG. 2 is a cross-sectional view taken along the line II-II in FIG. 1;
[0013] FIG. 3 is a cross-sectional view illustrating a state where the center of rotation of a carrier is misaligned with the center of revolutions of planet rollers in the planet roller speed changer according to the first embodiment of the invention;
[0014] FIG. 4 is a cross-sectional view illustrating the configuration of a planet roller speed changer according to a second embodiment of the invention;
[0015] FIG. 5 is a cross-sectional view illustrating a state where the center of rotation of the carrier is misaligned with the center of revolutions of the planet rollers in the planet roller speed changer according to the second embodiment of the invention;
[0016] FIG. 6 is a cross-sectional view illustrating the configuration of a planet roller speed changer according to a comparative example; and
[0017] FIG. 7 is a cross-sectional view illustrating a state where the center of rotation of a carrier is misaligned with the center of revolutions of planet rollers in the planet roller speed changer according to the comparative example.

DETAILED DESCRIPTION OF EMBODIMENTS

[0018] Hereinafter, example embodiments of the invention will be described in detail with reference to the accompanying drawings. FIG. 1 is a view illustrating the schematic configuration of a power transmitting device 1 of an image forming apparatus such as a printer, in which a planet roller speed changer 5 according to a first embodiment of the invention is mounted. FIG. 2 is a cross-sectional view taken along the line II-II in FIG. 1. The power transmitting device 1 of the image forming apparatus includes a body 2 to be driven (hereinafter, referred to as "driven body 2"), a planet roller speed changing unit 3, and a coupling 7. The driven body 2 is driven to rotated by the planet roller speed changing unit 3. The coupling 7 couples a driven body input shaft 4 of the driven body

2 and an output shaft **6** of the planet roller speed changer **5** to each other. In the power transmitting device **1**, the planet roller speed changing unit **3** is mounted transversely so that the output shaft **6** extends horizontally.

[0019] The planet roller speed changing unit **3** includes an electric motor **8**, the planet roller speed changer **5**, and a housing **9**. The housing **9** houses the electric motor **8** and the planet roller speed changer **5** together with each other. The housing **9** includes a first housing **9A** made of, for example, aluminum, and a second housing **9B** made of, for example, aluminum. The first housing **9A** houses and holds the electric motor **8**. The second housing **9B** houses and holds a part of the output shaft **6** and a carrier **10**, which will be described later.

[0020] The planet roller speed changer **5** includes an input shaft **11**, a stationary ring (sun ring) **12**, a plurality of (for example, three in the present embodiment) planet rollers **13**, the output shaft **6**, and the carrier **10**. A motor shaft **8A** of the electric motor **8** is coupled to the input shaft **11**. Note that the motor shaft **8A** may be provided as the input shaft **11**. The stationary ring **12** is fixedly disposed between the first housing **9A** and the second housing **9B** so as to be concentric with the input shaft **11**. The stationary ring **12** has an annular shape, and is made of, for example, bearing steel. The first housing **9A**, the stationary ring **12** and the second housing **9B** are fixed together with a plurality of bolts **15**.

[0021] The planet rollers **13** are housed and disposed in the stationary ring **12**. The planet rollers **13** are arranged at equal angular intervals in an annular space formed between the stationary ring **12** and the input shaft **11**. Each of the planet rollers **13** is disposed so as to be in rolling contact with both the outer peripheral face of the input shaft **11** and the inner peripheral face of the stationary ring **12** via traction oil in a pressure contact state. Each of the planet rollers **13** has a cylindrical shape (or an annular shape), and is made of, for example, bearing steel.

[0022] The carrier **10** has a disc shape. On one side face (right side face in FIG. **1**) **10A** of the carrier **10**, columnar pins **16**, of which number is the same as the number of planet rollers **13**, are projected perpendicularly to the one side face **10A**. In other words, the planet rollers **13** are disposed so as to be perpendicular to the single carrier **10**. The pins **16** may be components formed separately from the carrier **10** as illustrated in FIG. **1**, or may be formed integrally with the carrier **10**. Each pin **16** passes through a corresponding one of the planet rollers **13**, and the planet roller **13** is supported rotatably in a loosely fitted state by the pin **16**. Each of the pins **16** has a columnar shape, and is made of, for example, bearing steel.

[0023] A cylindrical bushing **17** is interposed between the planet roller **13** and the pin **16** in each set. The bushing **17** has the outer peripheral face **17A** (hereinafter, sometimes referred to as "outer periphery of as shaft portion **18**") formed of a cylindrical face. The thickness of the bushing **17** is uniform over the entire region in its circumferential direction. The bushing **17** is made of, for example, resin or ceramics, and is fixed onto the outer periphery of the pin **16** by interference fit. The pin **16** and the bushing **17** constitute the shaft portion **18**.

[0024] The output shaft **6** is fixed to the other side face (left side face in FIG. **1**) **10C** of the carrier **10**. An intermediate portion of the output shaft **6** is supported at one point by the second housing **9B** via a single rolling bearing **19**. Thus, the output shaft **6** is rotatably disposed. Rotary driving force from the electric motor **8** is applied to the input shaft **11**, whereby

each planet roller **13** rotates about its axis in a prescribed rotational direction D_{RS}, and in addition, the planet rollers **13** revolve in a prescribed revolving direction D_R. The carrier **10** rotates (about its axis) due to the revolutions of the planet rollers **13**. Rotary driving force of the carrier **10** is taken out from the planet roller speed changer **5** via the output shaft **6**. With the rotary driving force, the driven body **2** of the image forming apparatus is driven to be rotated.

[0025] As illustrated in FIG. **2**, a clearance is formed between the inner periphery of each planet roller **13** and the outer periphery of a corresponding one of the bushings **17**. The position and outer diameter of each pin **16** and the inner and outer diameters of each bushing **17** (that is, the position of the outer periphery of each shaft portion **18**) are set such that, in the case where the center of each pin **16** (the center of each shaft portion **18**), the center of the corresponding planet roller **13**, and the center of the input shaft **11** are aligned on a single straight line, a clearance CL_1 between the shaft portion **18** and the planet roller **13** on the input shaft **11** side is larger than a clearance CL_2 between the shaft portion **18** and the planet roller **13** on the stationary ring **12** side.

[0026] In this case, the clearance CL_1 is expressed by Expression (1) indicated below.

$$CL_1 = D_1 - D_{P1} \tag{1}$$

[0027] In the Expression (1), D_1 is the distance from the center of rotation of the carrier **10** to the innermost position of the outer periphery of each shaft portion **18** in the radial direction of the planet roller speed changer **5**, D_{P1} is the radius (inscribed radius) of a circle around the center of rotation of the carrier **10**, at the innermost position in the radial direction of the planet roller speed changer **5**, among positions at which each of the planet rollers **13** contacts the corresponding shaft portion **18**.

[0028] The clearance CL_2 is expressed by Expression (2) indicated below.

$$CL_2 = Dp_2 - D_2 \tag{2}$$

[0029] In the Expression (2), D_2 is the distance from the center of rotation of the carrier **10** to the outermost position of the outer periphery of the shaft portion **18** in the radial direction of the planet roller speed changer **5**, D_{P2} is the radius (circumscribed radius) of a circle around the center of rotation of the carrier **10**, at the outermost position in the radial direction of the planet roller speed changer **5**, among positions at winch each of the planet rollers **13** contacts the corresponding shaft portion **18**. In other words, the position of the outer periphery of each of the shaft portions **18** is set such that a pitch circle diameter DP_C of the carrier **10** is larger than a value WD obtained by doubling the inter-axis distance between the input shaft **11** and each planet roller **13**. Note that, in this case, the pitch circle diameter DP_C is expressed by Expression (3) indicated below, and the value WD obtained by doubling the inter-axis distance between the input shaft **11** and each planet roller **13** is expressed by Expression (4) indicated below.

$$DP_C = D_1 + D_2 \tag{3}$$

$$WD = D_S + D_P \tag{4}$$

[0030] In the Expression (4), D_P is the outer diameter of each planet roller **13**, and D_S is the outer diameter of the input shaft **11**.

[0031] Because the planet roller speed changing unit **3** is mounted transversely, the carrier **10** may be displaced down-

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ward from a prescribed position under its own weight (the carrier **10** may be displaced in a direction that intersects with the axial direction of the output shaft **6**). In particular, when the output shaft **6** is supported at its one position in the axial direction (supported in a cantilever manner) as in the present embodiment, the carrier **10** is easily displaced downward. The downward displacement of the carrier **10** may cause a state where the center of rotation of the carrier **10** and the center of revolutions of the planet rollers **13** supported by the respective shaft portions of the carrier **10** in the loosely fitted state do not coincide with each other. That is, the center of the carrier **10** is misaligned with the center of revolutions of the planet rollers **13** (the rotation axis of the input shaft **11**).

[0032] FIG. **3** is a cross-sectional view illustrating a state where the center of rotation of the carrier **10** is misaligned with the center of revolutions of the planet rollers **13** in the planet roller speed changer **5** according to the first embodiment of the invention. In the planet roller speed changer **5**, the pitch circle diameter DP_C (refer to FIG. **2**) of the carder **10** is set larger than the value WD obtained by doubling the inter-axis distance (refer to FIG. **2**) between the input shaft **11** and each planet roller **13**. As a result, the clearance between each shaft portion **18** and a corresponding one of the planet rollers **13** on the input shaft **11** side is larger than the clearance between each shaft portion **18** and a corresponding one of the planet rollers **13** on the stationary ring **12** side.

[0033] Thus, when the carrier **10** is displaced downward from the prescribed position under its own weight, the outer peripheral face **17**A of the bushing **17** of at least one of the shaft portions **18** (the two shaft portions **18** located on the lower side, in FIG. **3**) contacts the stationary ring **12**-side portion of the inner periphery of the corresponding planet roller **13** instead of contacting the input shaft **11**-side portion of the inner periphery of the corresponding planet roller **13**. At this time, frictional force is generated between the outer peripheral face **17**A of the bushing **17** and the inner peripheral face of the planet roller **13** that is rotating about its axis. In this case, because the revolving direction D_R of the shaft portions **18** and the rotational direction D_{RS} of each planet roller **13** are opposite to each other, the generated frictional force acts so as to extrude the shaft portion **18** toward the rotational direction of the carrier **10**. As a result, aligning of the shaft portion **18** is promoted.

[0034] Due to a change in the relative position between the planet roller **13** and the pin **16** caused by the misalignment of the center of rotation of the carrier **10** with the center of revolutions of the planet rollers **13**, the rotation of the carrier **10** is advanced or delayed when the output shaft **6** is rotating. In this case, the outer peripheral face **17**A of the bushing **17** contacts the input shaft-**11** side portion of the inner periphery of the corresponding planet roller **13**, whereby aligning of the shaft portion **18** is promoted. Thus, advancement and delay of the rotation of the carrier **10** are restricted, and as a result, rotational fluctuations generated in the planet roller speed changer **5** are reduced. Thus, even in a case where misalignment of the center of rotation of the carrier **10** with the center of revolutions of the planet rollers **13** occurs, the rotational fluctuations caused by the misalignment are restricted. As a result, the planet roller speed changer **5** with a high degree of rotation accuracy is provided.

[0035] FIG. **4** is a cross-sectional view illustrating the configuration of a planet roller speed changer **105** according to a second embodiment of the invention. FIG. **5** is a cross-sectional view illustrating a state where the center of rotation of the carrier **10** is misaligned with the center of revolutions of the planet rollers **13** in the planet roller speed changer **105** according to the second embodiment of the invention. Note that, the same configurations of the planet roller speed changer **105** according to the second embodiment as those in the planet roller speed changer **5** according to the first embodiment will be denoted by the same reference symbols as those in the first embodiment, and description thereon will be omitted.

[0036] In the planet roller speed changer **105**, a pitch circle diameter DP_C1 of the carrier **10** is set substantially equal to a value WD1 obtained by doubling the inter-axis distance between the input shaft **11** and each planet roller **13**. In this case, the clearance between the shaft portion **18** and the planet roller **13** on the input shaft **11** side is substantially equal to the clearance between the shaft portion **18** and the planet roller **13** on the stationary ring **12** side. In the second embodiment, each shaft portion **18** includes a bushing **117** in place of the bushing **17**. The bushing **117** has a generally cylindrical shape. The bushing **117** has an outer peripheral face **117**A having a cylindrical face. Each of the outer peripheral faces **117**A has a cut portion **111** formed of a flat face, and the radius of the bushing **117** at the cut portion **111** is shorter than the radius of the bushing **117** at the other portion than the cut portion **111**. The cut portion **111** is located at a part of the bushing **117** in the circumference direction of the input shaft **11**, and extends over the entire region in the axial direction of the bushing **117**.

[0037] In the present embodiment, when the carrier **10** is displaced downward under its own weight and thus the center of rotation of the carrier **10** is misaligned with the center of revolutions of the planet rollers **13**, the two shaft portions **18** located on the lower side in FIG. **5** contact the stationary ring **12**-side portions of the inner peripheries of the corresponding planet rollers **13** before the one shaft portion **18** located on the upper side in FIG. **5** contacts the input shaft-**11** side portion of the inner periphery of the corresponding planet roller **13**. In this case, as in the first embodiment, frictional force generated between the outer peripheral face **117**A of the bushing **117** and the inner peripheral face of the planet roller **13** that is rotating about its axis acts so as to extrude the shaft portion **18** toward the rotational direction of the carrier **10**. As a result, aligning of the shaft portion **18** is promoted. Thus, advancement and delay of the rotation of the carrier **10** are restricted, and as a result, rotational fluctuations generated in the planet roller speed changer **5** are reduced.

[0038] Next, a planet roller speed changer **205** in a comparative example that is compared with the first and second embodiments of the invention will be described with reference to FIG. **6** and FIG. **7**. FIG. **6** is a cross-sectional view illustrating the configuration of the planet roller speed changer **205**. FIG. **7** is a cross-sectional view illustrating the state where the center of rotation of a carrier (not illustrated) is misaligned with the center of revolutions of planet rollers **213** in the planet roller speed changer **205**.

[0039] The planet roller speed changer **205** includes an input shaft **211**, a stationary ring **212**, a plurality of planet rollers **213**, an output shaft (not illustrated), and the carrier (not illustrated). The stationary ring **212** is disposed so as to be concentric with the input shaft **211**. Each of the planet rollers **213** is disposed so as to be in rolling contact with both the outer peripheral face of the input shaft **211** and the inner peripheral face of the stationary ring **212**. The carrier is fixed to the output shaft. The carrier has a plurality of pins **216**. One

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planet roller **213** is disposed around one pin **216**. A bushing **217** is fixedly fitted onto the outer periphery of each pin **215**. Each pin **216** passes through a corresponding one of the planet rollers **213**, and the planet roller **213** is supported rotatably in a loosely fitted state by the pin **216**.

[0040] In the planet roller speed changer **205**, the position and outer diameter of each pin **216** and the inner and outer diameters of each bushing **217** are set such that a pitch circle diameter DP_C2 of the carrier is smaller than a value WD2 obtained by doubling the inter-axis distance between the input shaft **211** and each of the planet rollers **213**. In this case, a clearance between the shaft portion **218** and the planet roller **213** on the input shaft **211** side is set smaller than a clearance between the shaft portion **218** and the planet roller **213** on the stationary ring **212** side.

[0041] Thus, when the carrier (not illustrated) is displaced downward from a prescribed position under its own weight, the outer peripheral face **217A** of the bushing **217** of at least one of the three shaft portions **218** of the carrier (the shaft portion **18** located on the upper side, in FIG. **7**) contacts the input shaft **211**-side portion of the inner periphery of the corresponding planet roller **213**. At this time, frictional force is generated between the outer peripheral face **217A** of the bushing **217** and the inner peripheral face of the planet roller **213** that is rotating about its axis. In this case, because the revolving direction D_R of the shaft portions **18** and the rotational direction D_{RS} of each planet roller **213** are opposite to each other, the generated frictional force acts so as to extrude the shaft portion **218** in the revolving direction D_R. As a result, the revolution of the pin **216** is promoted. Due to a change in the relative position between the planet roller **213** and the shaft portion **218** caused by the misalignment of the center of rotation of the carrier with the center of revolutions of the planet rollers **213**, rotation of the carrier is advanced or delayed. When the outer peripheral face **217A** of the bushing **217** contacts the input shaft **211** side-portion of the inner periphery of the planet roller **213**, the rotation of the carrier is advanced or delayed significantly. As a result, large rotational fluctuations may occur in the planet roller speed changer **205**.

[0042] While the two example embodiments of the invention are described above, the invention may be implemented in other embodiments. In the first embodiment, bearings such as rolling bearings or plain bearings may be used in place of the bushings **17**. In the embodiments described above, the planet rollers **13** may be directly supported by pins without interposing the bushings or the like between the pins **16** and the planet rollers **13**. In this case, each shaft portion **18** is formed only of the pin **16**.

[0043] In the second embodiment, when each shaft portion **18** is formed only of the pin **16**, a cut portion such as a flat face may be formed on the outer peripheral face of each pin **16**. In the embodiments described above, each of the planet roller speed changers **5**, **105** is mounted in the image forming appa-

ratus. However, the invention may be applied to planet roller speed changers applied to other kinds of apparatuses.

[0044] Further, a variety of design changes may be made within the scope of the invention defined in the appended claims.

What is claimed is:

1. A planet roller speed changer comprising:
an input shaft;
a stationary ring disposed around the input shaft so as to be concentric with the input shaft;
a plurality of cylindrical planet rollers that are in rolling contact with both the input shaft and the stationary ring;
an output shaft: and
a carrier having a plurality of shaft portions each of which is disposed in a corresponding one of the planet rollers, passes through the corresponding one of the planet rollers, and supports the corresponding one of the planet rollers in a loosely fitted state such that the corresponding one of the rollers is rotatable, the carrier being fixed to the output shaft so as to be rotatable together with the output shaft, wherein
the shaft portions of the carrier are disposed such that, when the carrier is displaced in a direction that intersects with an axial direction of the output shaft, an outer periphery of at least one of the shaft portions that are displaced with a displacement of the carrier contacts the stationary ring-side portion of an inner periphery of the corresponding planet roller without contacting the input shaft-side portion of the inner periphery of the corresponding planet roller.

2. The planet roller speed changer according to claim **1**, wherein:
each of the shaft portions has an outer peripheral face formed of a cylindrical face; and
a pitch circle diameter of the carrier, the pitch circle diameter being defined by the shaft portions, is set larger than a value obtained by doubling an inter-axis distance between the input shaft and each of the planet rollers.

3. The planet roller speed changer according to claim **1**, wherein:
each of the shaft portions has a generally cylindrical shape; and
a cut portion is formed at the input shaft-side portion of an outer peripheral face of each of the shaft portions, a radius of the shaft portion at the cut portion is shorter than a radius of the shaft portion at the other portion than the cut portion.

4. The planet roller speed changer according to claim **3**, wherein:
each of the shaft portions includes a pin, and a cylindrical bushing fixedly fitted onto the pin; and
the cut portion is formed on an outer peripheral face of the bushing.

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