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(54) **POWER TRANSMISSION SHAFT**

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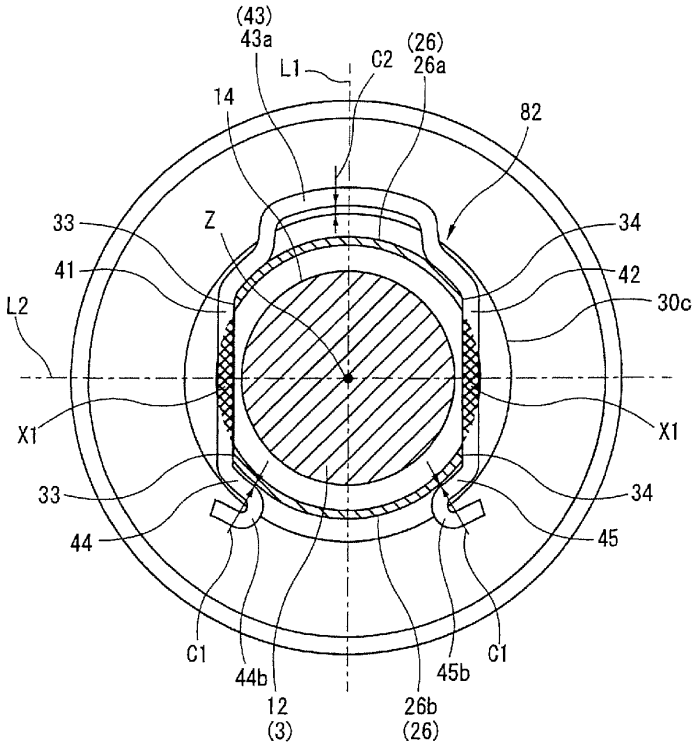
F16D 1/08	(2006.01)
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F16B 21/18	(2006.01)
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(57) **ABSTRACT**

A power transmission shaft is interposed between a first shaft section and a second shaft section. The power transmission shaft comprises: a cylindrical section rotated integrally with a shaft section and formed cylindrically; a through hole disposed in the cylindrical section and penetrated radially with respect to a rotational axial line, each of a pair of vehicle side rotational shaft sections having an engagement groove disposed on an outer peripheral side of the pair of vehicle side rotational shaft sections and extended in a direction around the rotational axial line and the engagement groove being exposed from the through hole; and a retaining ring (circlip) disposed to enclose at least a portion of the outer peripheral side of the cylindrical section, a portion of the retaining ring being inserted into the through hole from the outer peripheral side of the cylindrical section and being engaged with the engagement groove.



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FIG.1

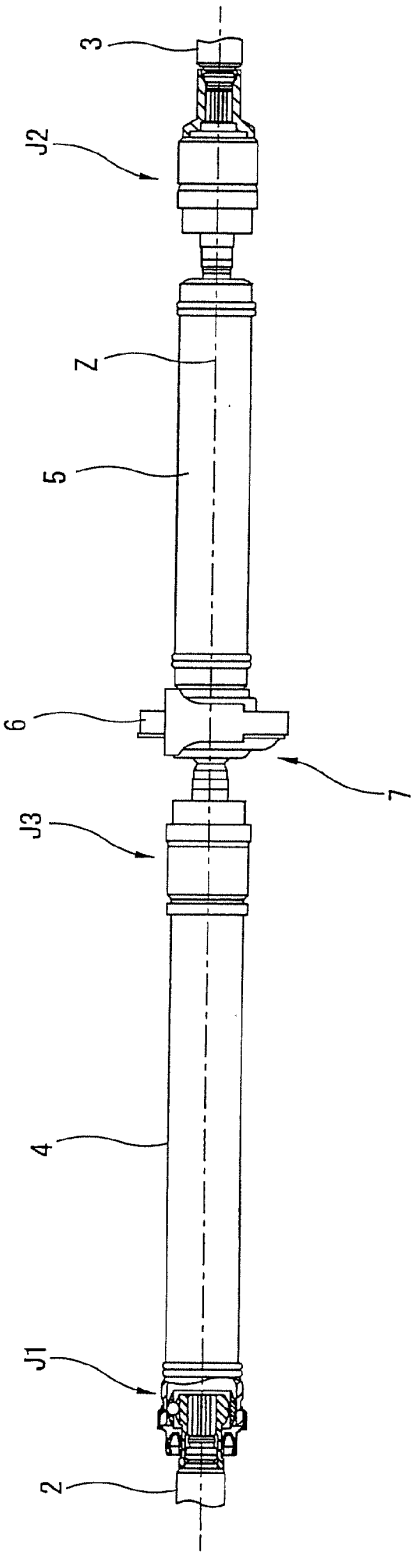


FIG.2

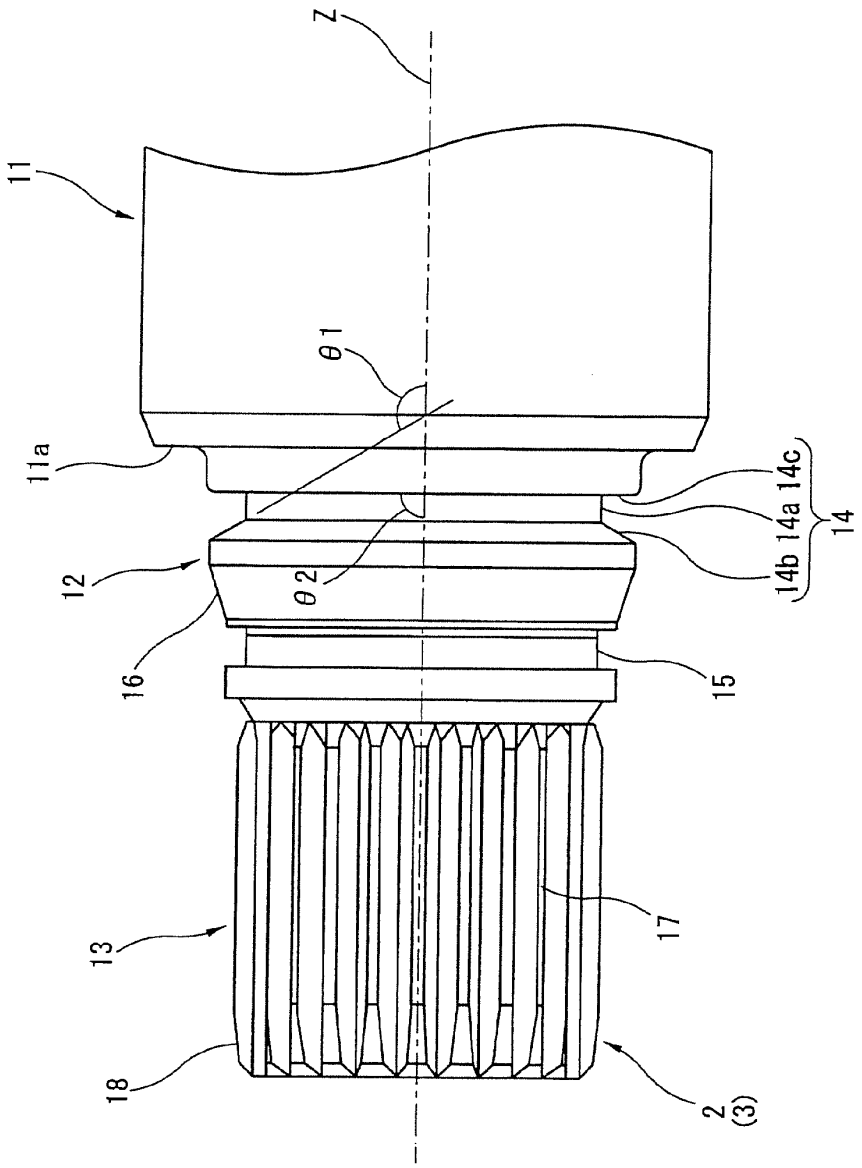


FIG.3

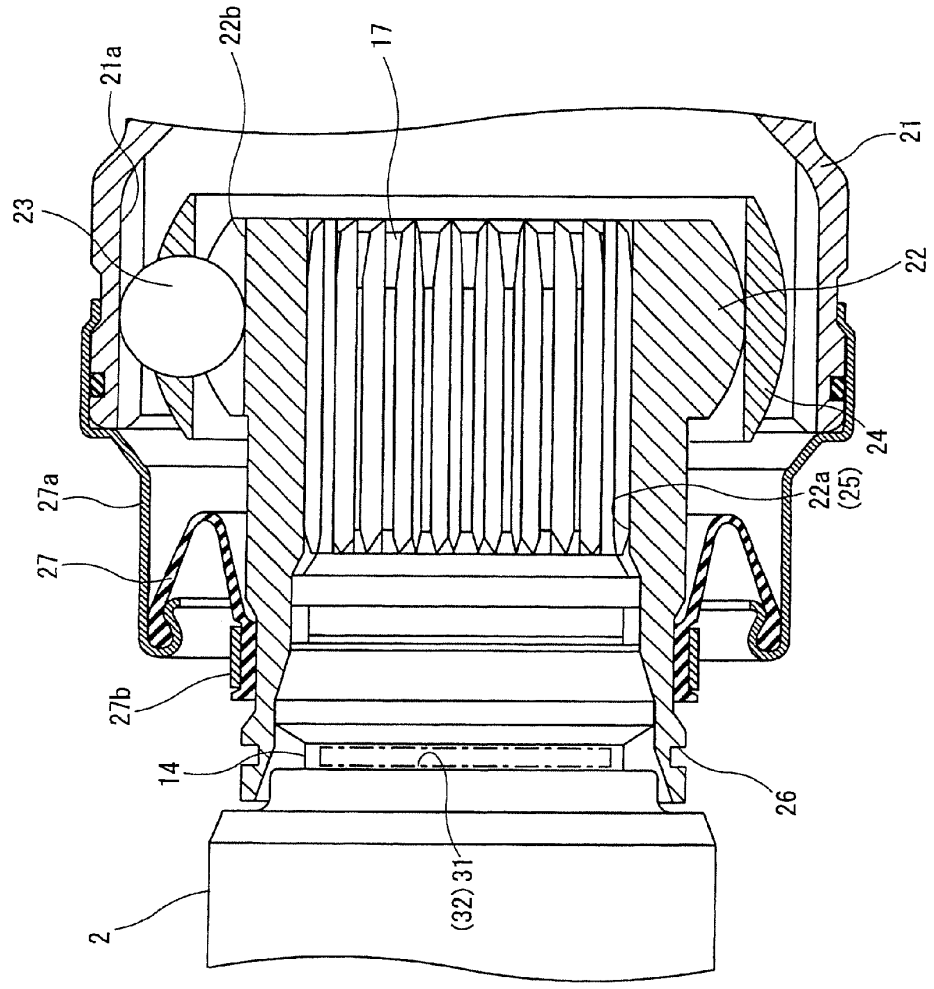


FIG.4

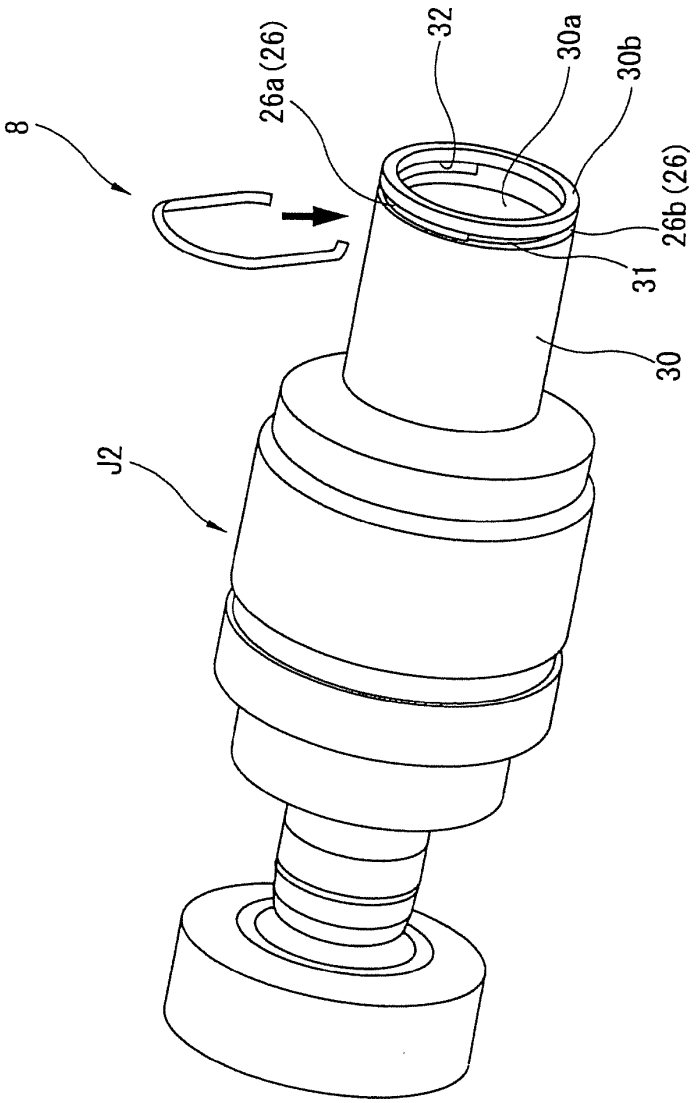


FIG.5

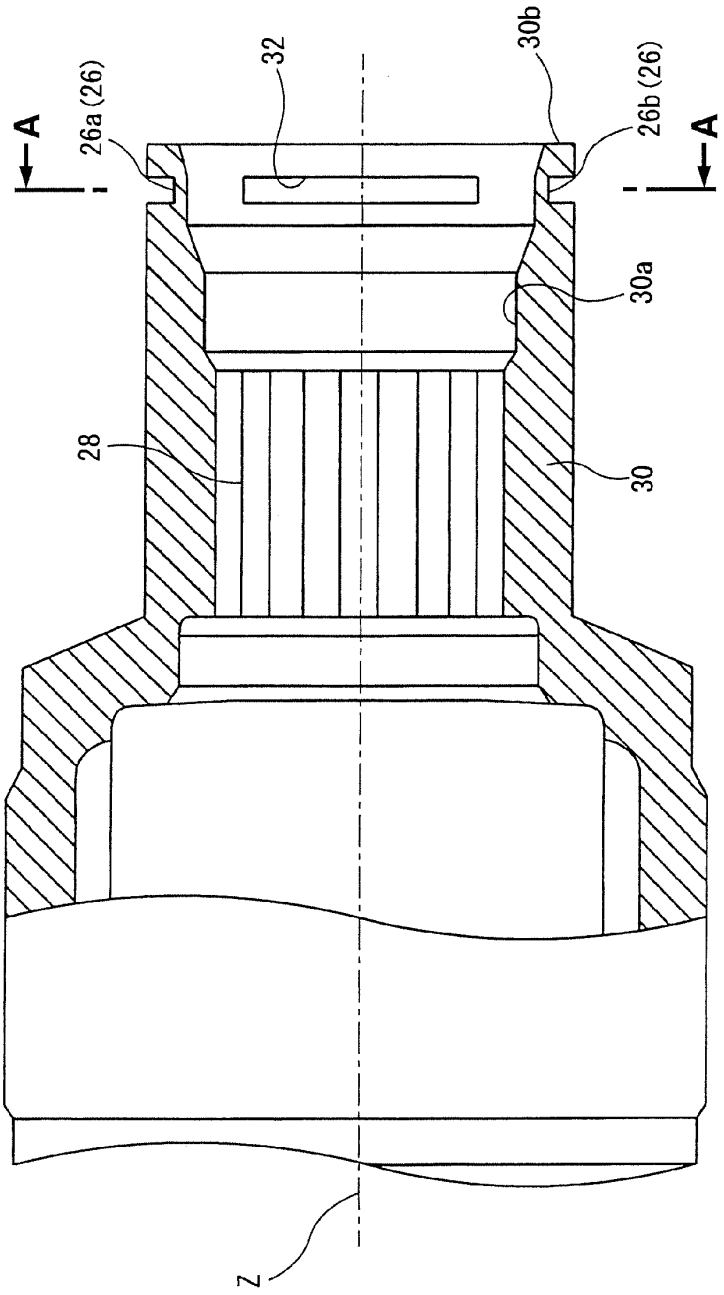


FIG.6

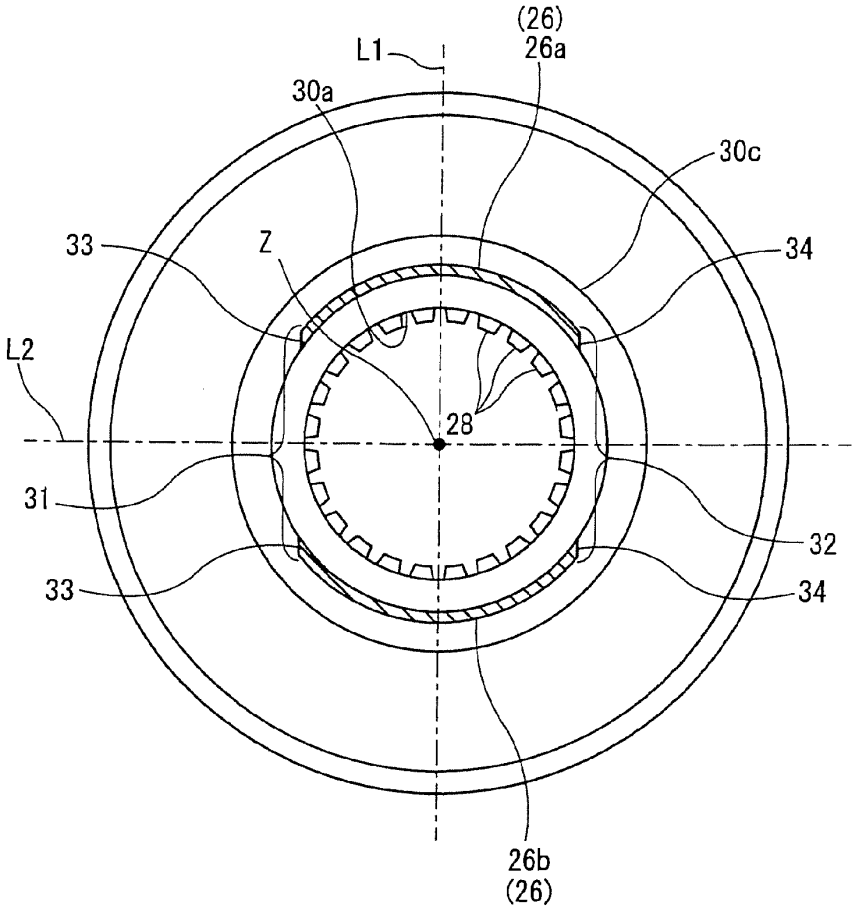


FIG.7

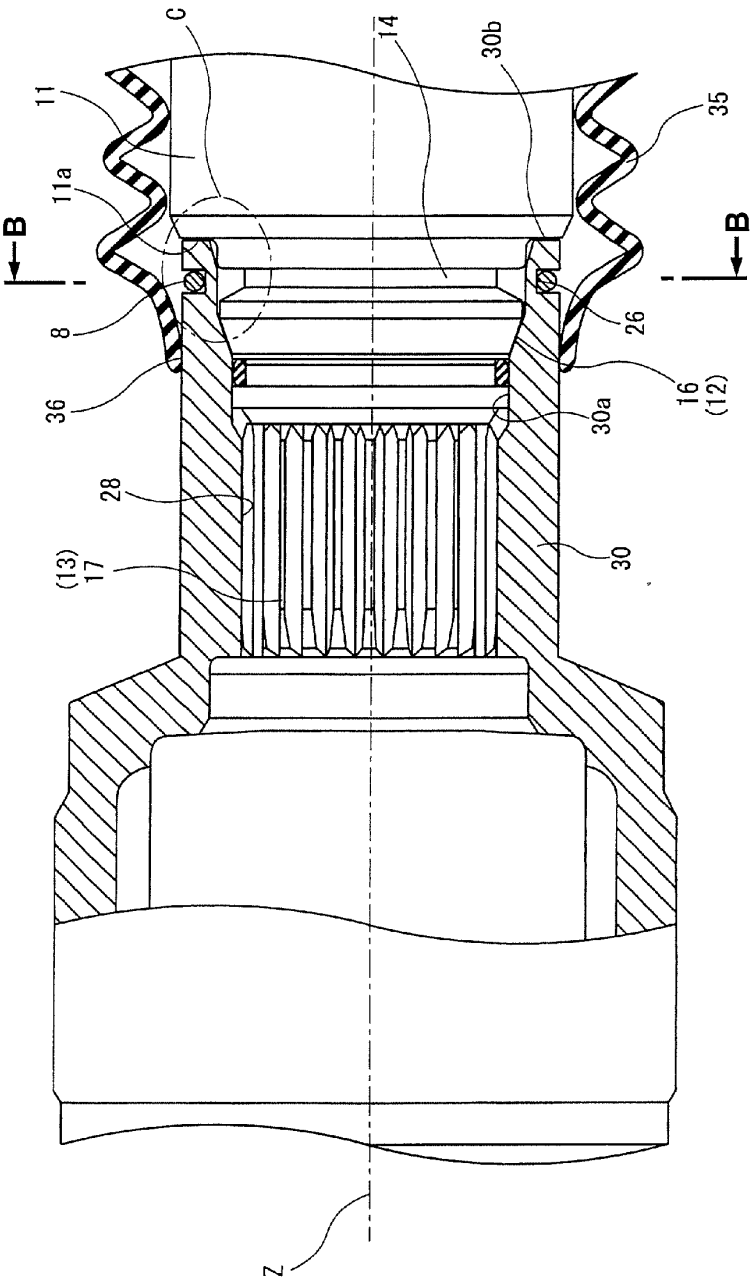


FIG.8

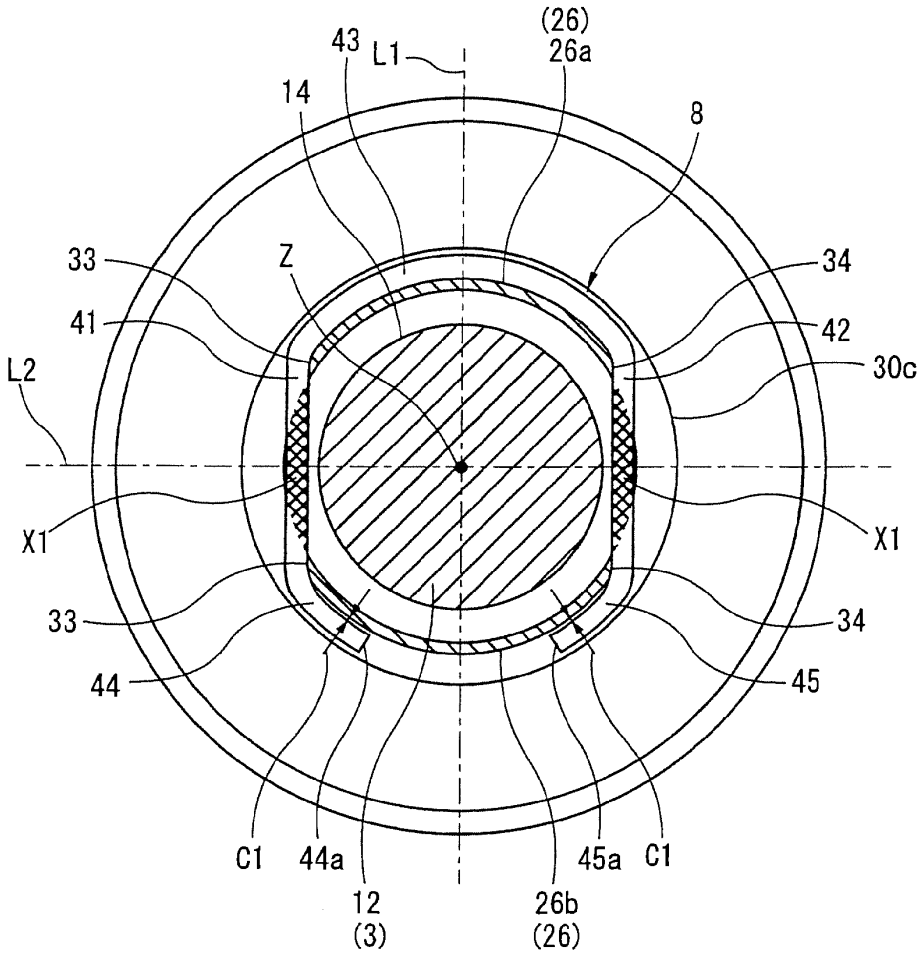

43
L1
(26)
26a
14
8
33
Z
34
41
42
L2
30c
X1
X1
33
34
44
45
C1
44a
12
(3)
26b
(26)
45a
C1

FIG.9

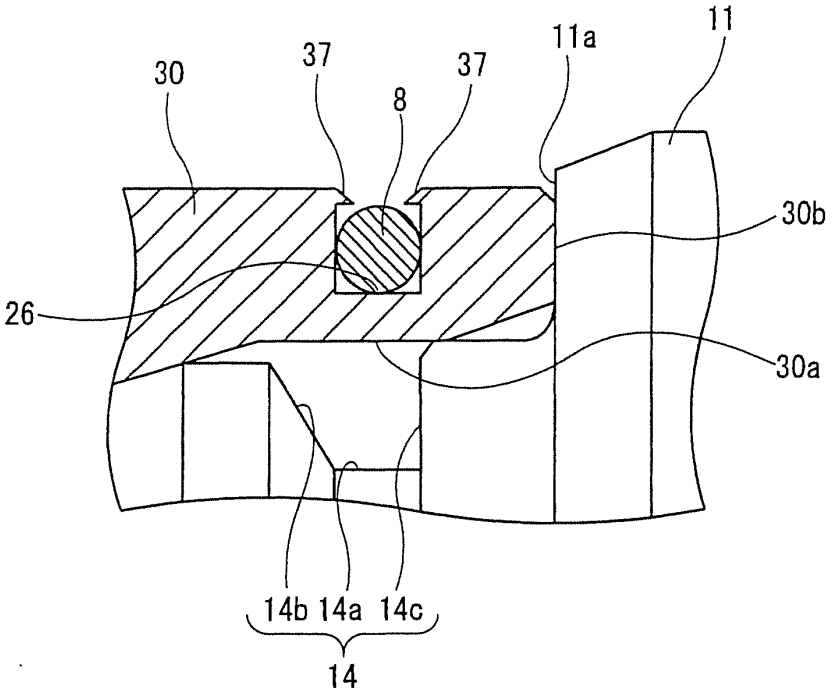


FIG.10(b)

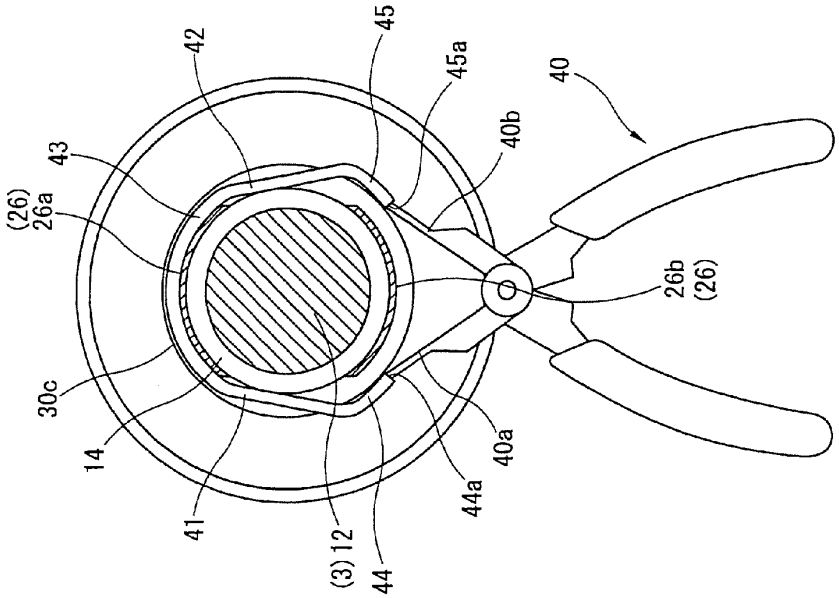


FIG.10(a)

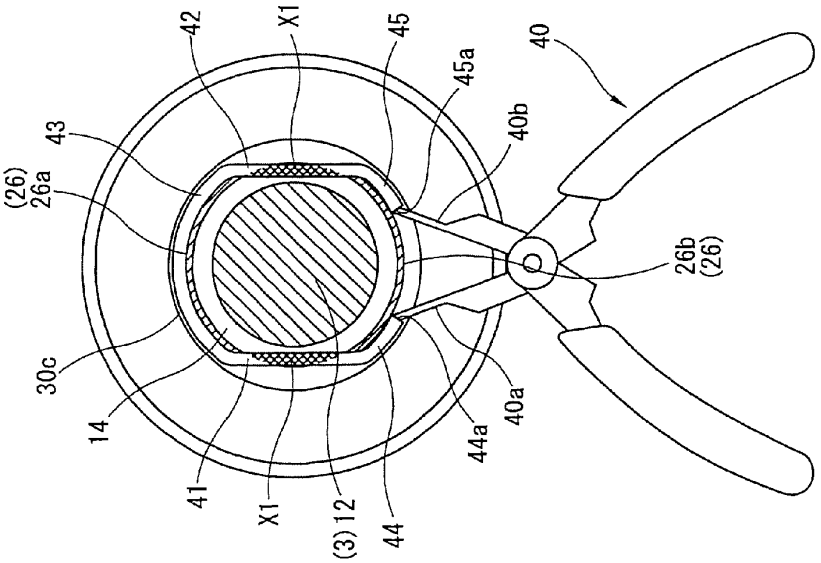


FIG.11(b)

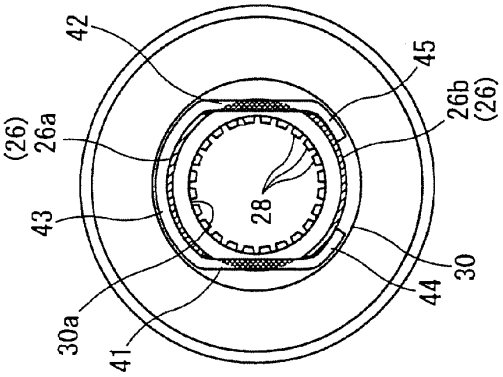


FIG.11(a)

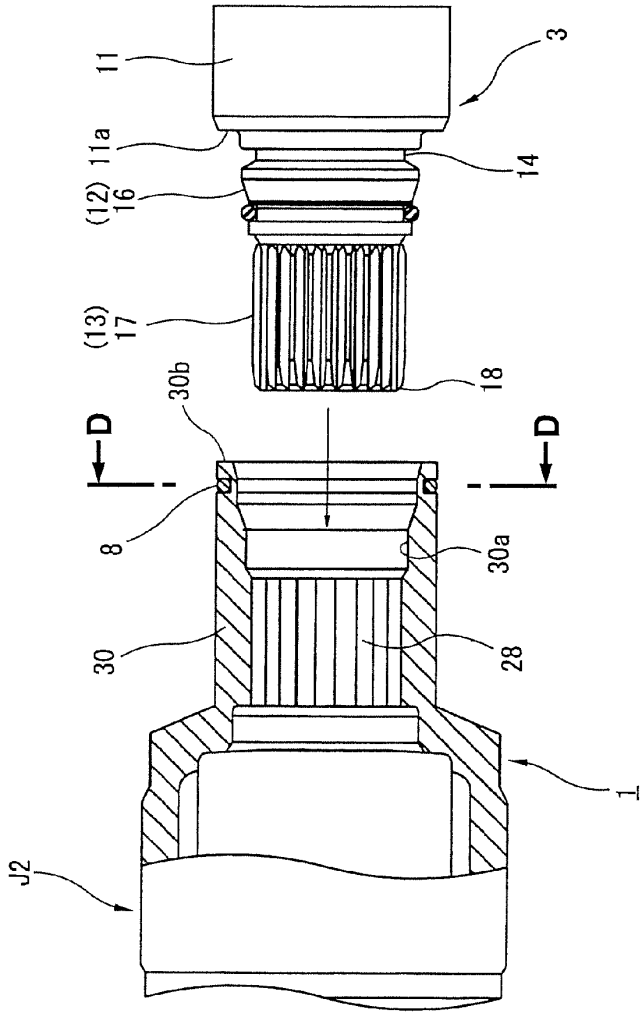


FIG.12(b)

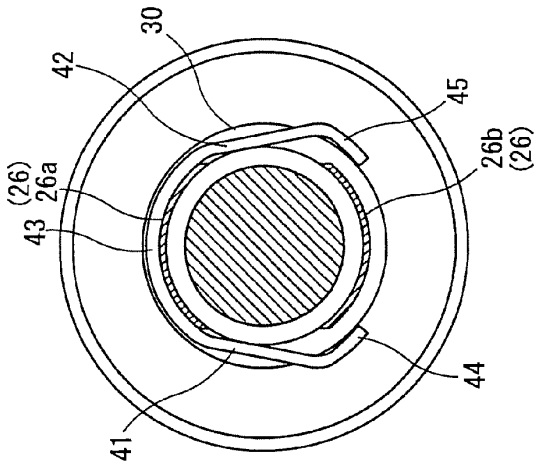


FIG.12(a)

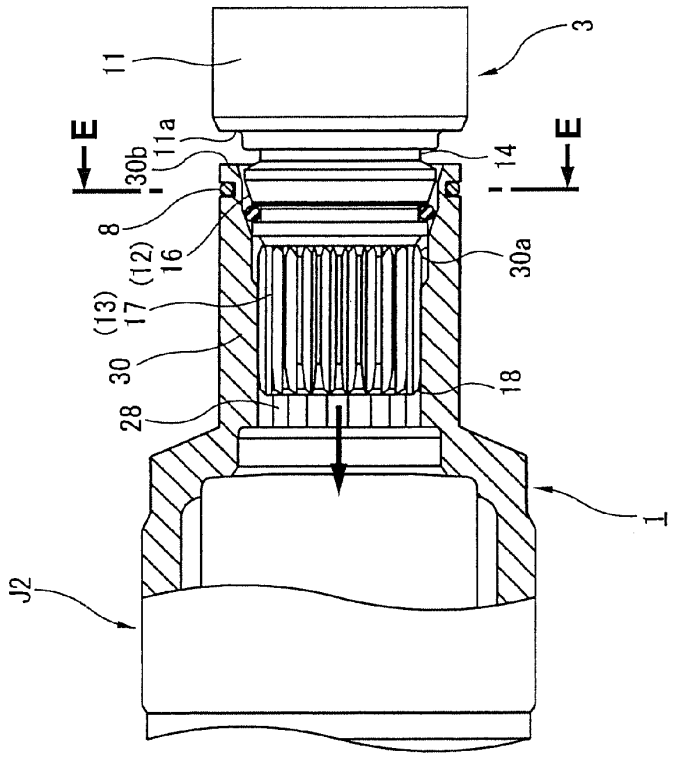


FIG.13(b)

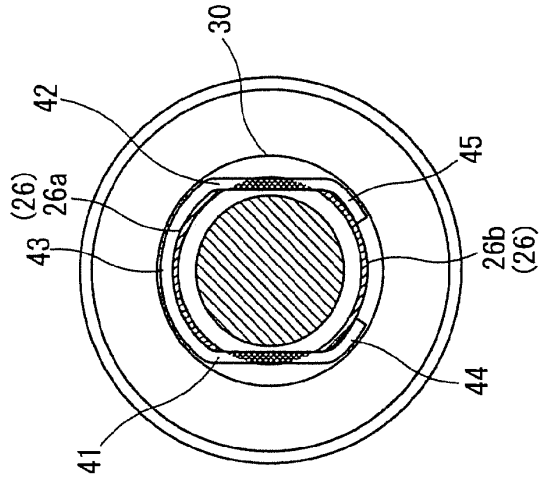


FIG.13(a)

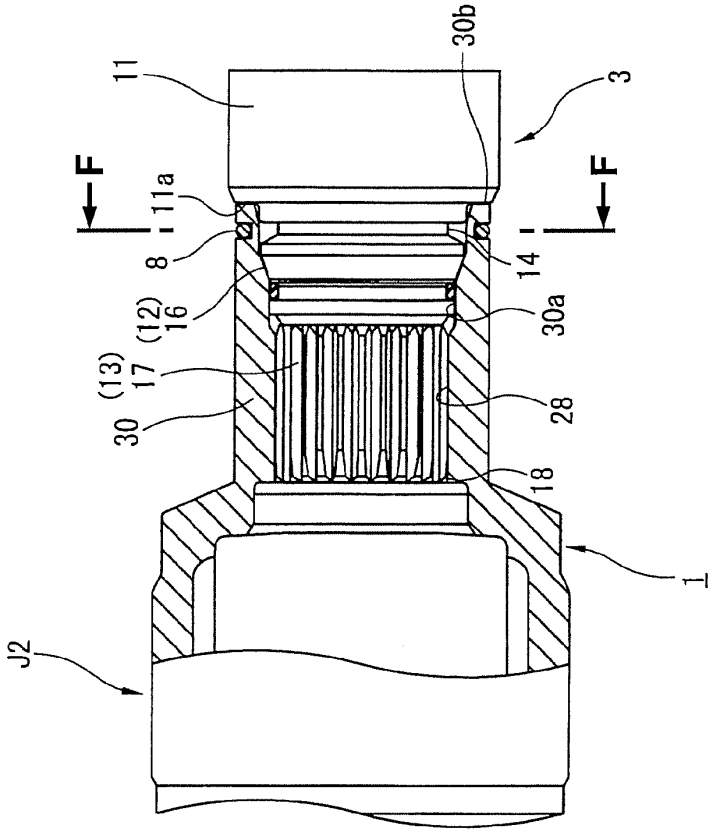


FIG.14

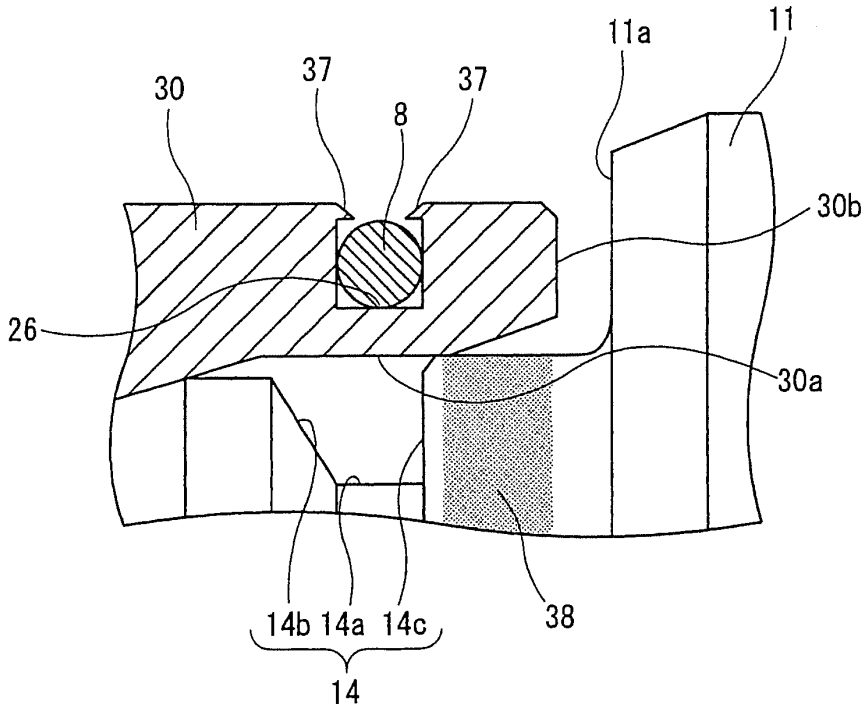


FIG.15

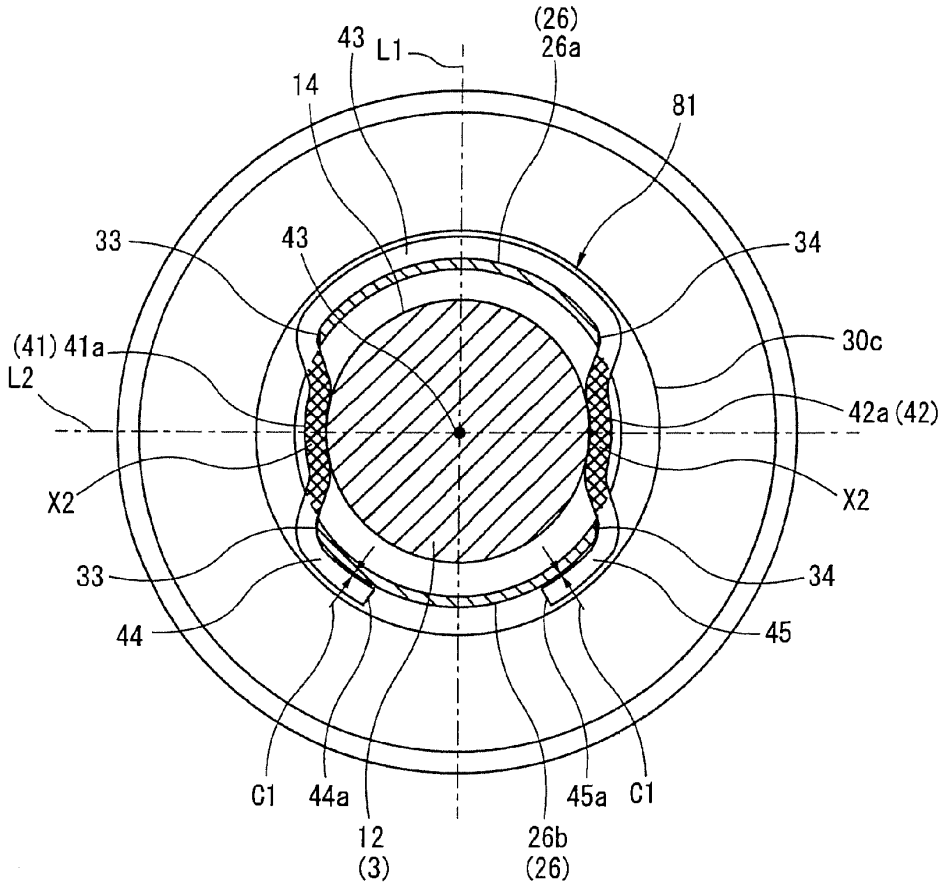

43
L1
(26)
26a
14
81
33
43
34
(41) 41a
30c
L2
42a (42)
X2
X2
33
34
44
45
C1
44a
45a
C1
12
(3)
26b
(26)

FIG.16

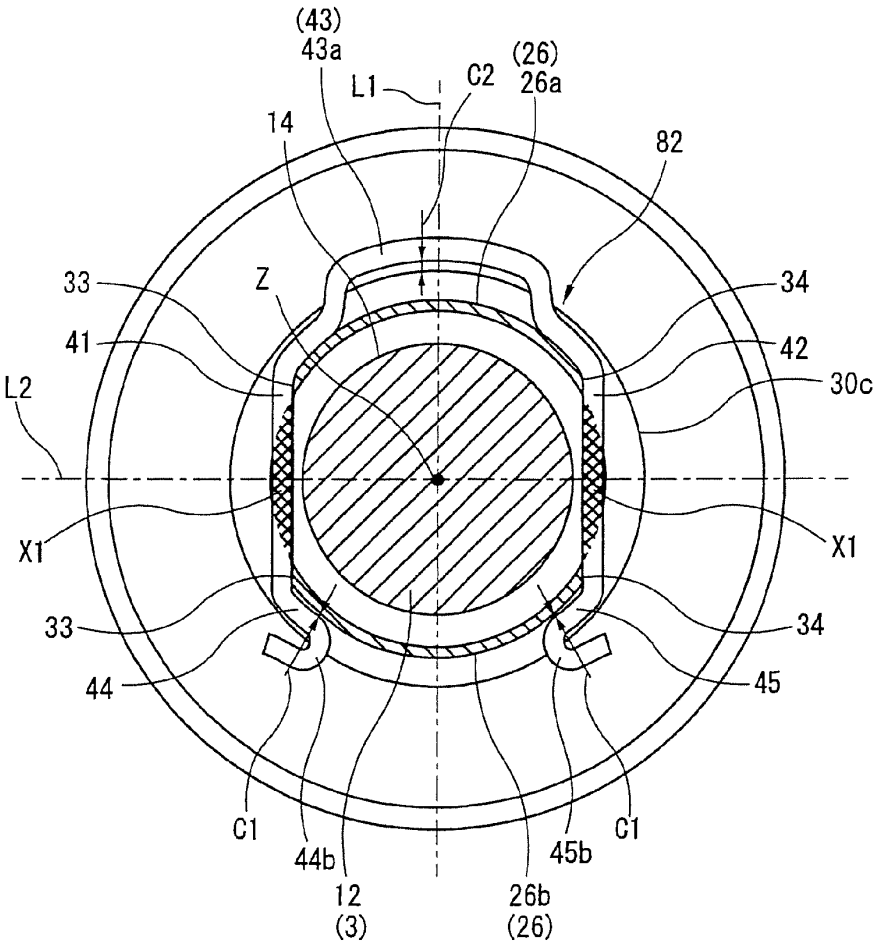

(43)
43a
L1
C2
(26)
26a
14
82
33
Z
34
41
42
L2
30c
X1
X1
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34
44
45
C1
44b
12
(3)
26b
(26)
45b
C1

FIG.17

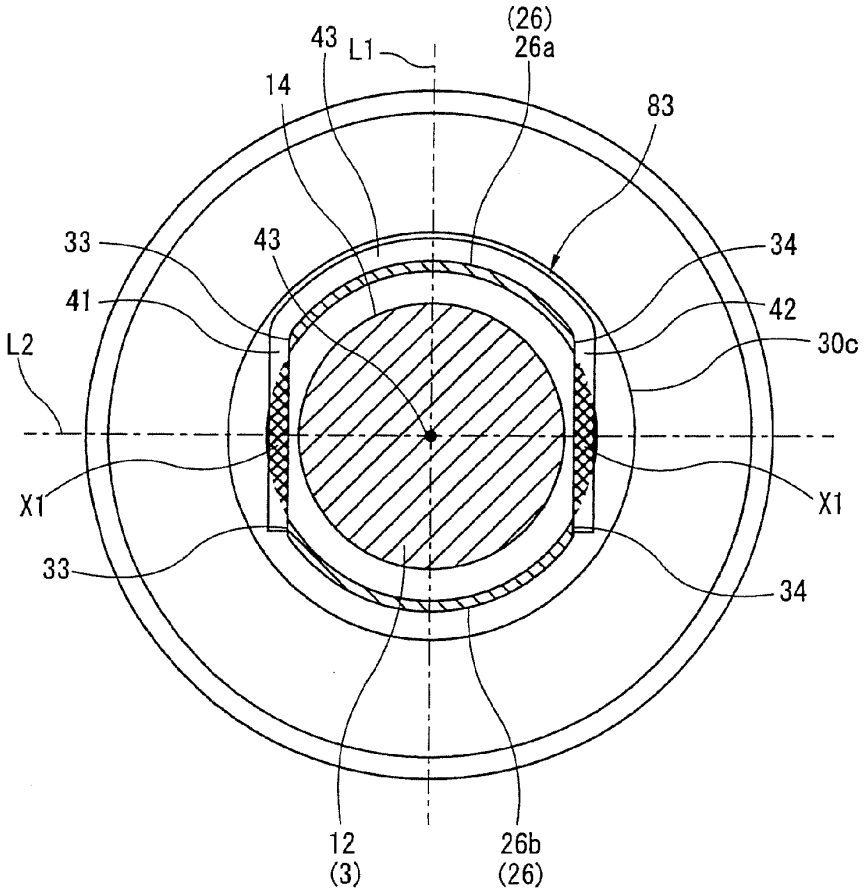
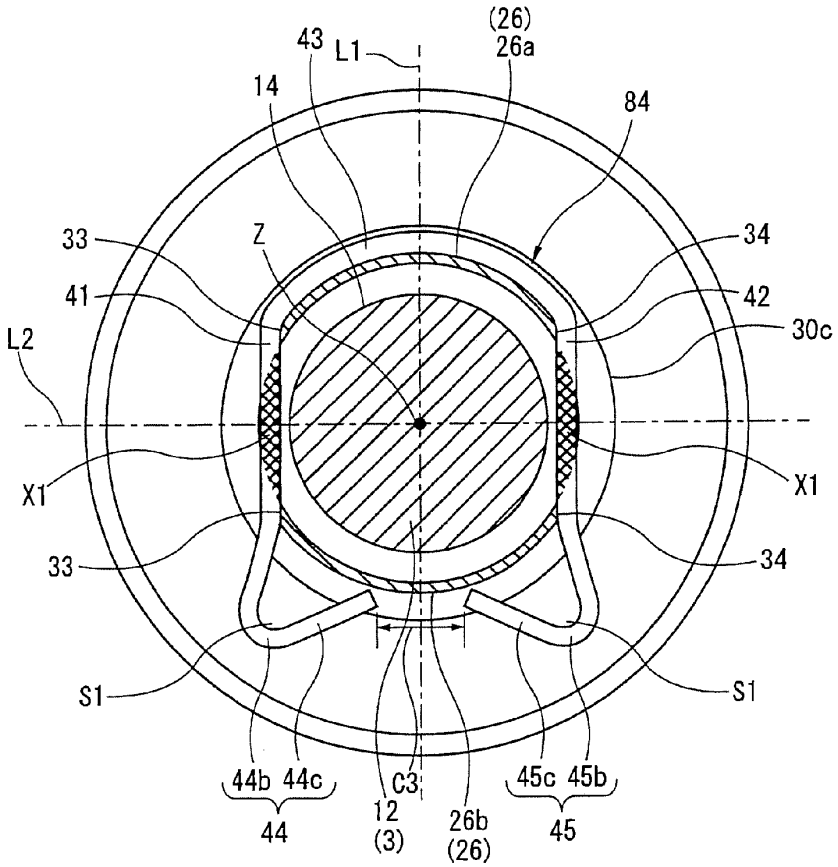
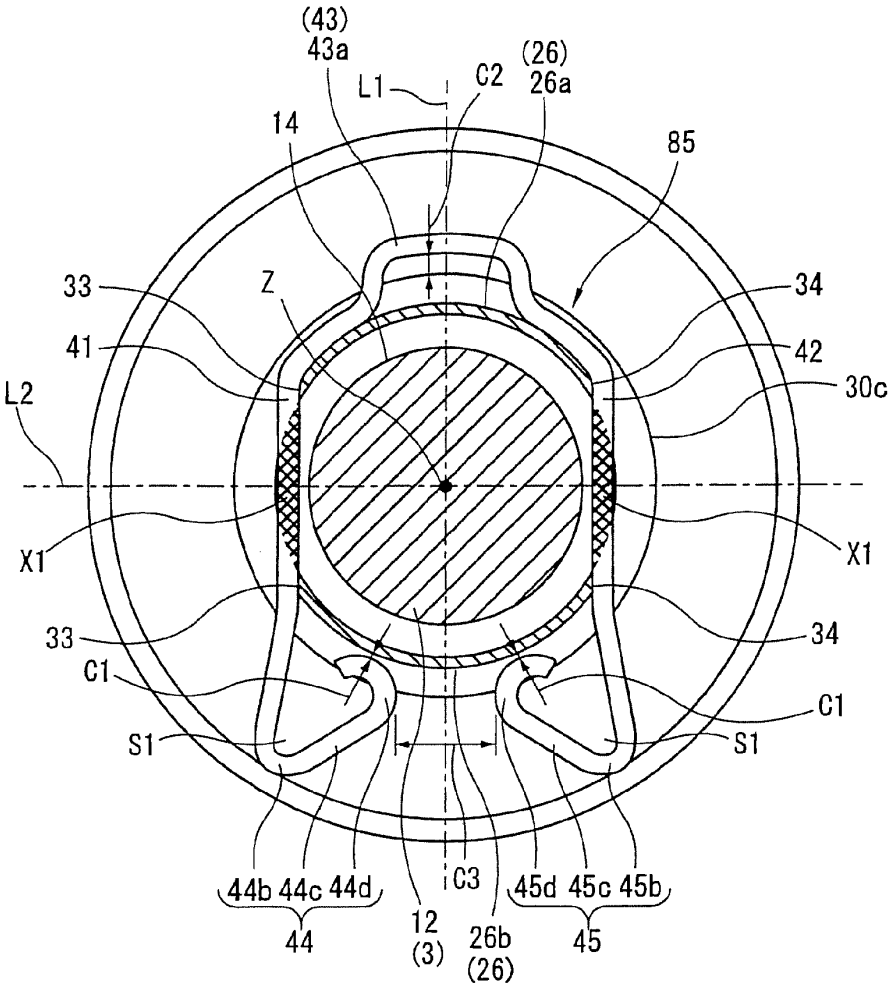


FIG.18



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FIG.19


(43)
43a
L1
C2
(26)
26a
14
85
33
Z
34
41
42
L2
30c
X1
X1
33
34
C1
C1
S1
S1
44b 44c 44d
44
12
(3)
C3
26b
(26)
45d 45c 45b
45

POWER TRANSMISSION SHAFT

BACKGROUND OF THE INVENTION

(1) Field of the Invention

[0001] The present invention relates to a power transmission shaft such as a propeller shaft applicable to, for example, an automotive vehicle for transmitting a driving force of a driving source to driving wheels of the vehicle.

(2) Description of Related Art

[0002] For example, a Japanese Patent Application Laid Open Publication No. 2013-194895 published on Sep. 30, 2013 discloses a previously proposed propeller shaft.

[0003] That is, the previously proposed propeller shaft has an axial direction one end side via a constant velocity (universal) joint linked to a first shaft at a driving source side and axial direction other end side linked to a driving wheel side via another constant velocity (universal) joint. Then, at this time, the first shaft and the second shaft are linked to the respective constant velocity (universal) joints by an engagement stop of a circlip (retaining ring) fitted onto an outer peripheral side of the first and second shafts into an annular engagement (stop) groove cut out formed on an inner peripheral side of the first and the second shafts.

SUMMARY OF THE INVENTION

[0004] However, since, in the previously proposed propeller shaft, the circlip (retaining ring) is engageably stopped into the engagement stop groove located at the inner peripheral side of each constant velocity (universal) joint (an inner wheel member), a visual recognition of the engagement stop state of the circlip (retaining ring) cannot externally be recognized. Thus, there is a possibility that an appropriate attachment of the propeller shaft (the power transmission shaft) cannot be carried out. It is an object of the present invention to provide a power transmission shaft (propeller shaft) which can recognize the engagement stop state of the circlip (retaining ring) from an external.

[0005] According to one aspect of the present invention, there is provided a power transmission shaft interposed between a first shaft section and a second shaft section, the first shaft section and the second shaft section being a pair of vehicle side rotational shaft sections, the first shaft section being disposed on a driving source side of the vehicle and the second shaft section being disposed on a driving wheel side, the power transmission shaft transmitting a rotation of the driving source to the driving wheel and comprising: a shaft section disposed between the first shaft section and the second shaft section; a cylindrical section rotated integrally with the shaft section and formed cylindrically, each of the pair of vehicle side rotational shaft sections being inserted into an inside of the cylindrical section; a through hole disposed in the cylindrical section and penetrated radially with respect to a rotational axial line of the pair of vehicle side rotational shaft sections, each of the pair of vehicle side rotational shaft sections having an engagement groove disposed on an outer peripheral side of the pair of vehicle side rotational shaft sections and extended in a direction around the rotational axial line of the pair of vehicle side rotational shaft sections and the engagement groove being exposed from the through hole in a state in which each of the pair of vehicle side rotational shaft sections is inserted into the cylindrical section; and a circlip disposed to enclose at least a portion of the outer peripheral side of the cylindrical section, a portion of the circlip being inserted into the through hole from the outer peripheral side of the cylindrical section and being engaged with the engagement groove.

[0006] According to the present invention, a drop out of the vehicle side rotational shafts is prevented in a form of a fitting of the circlip (retaining ring) onto the cylindrical section so that an engagement stop state of the vehicle side rotational shafts with the circlip (retaining ring) can be recognized from an external. Consequently, an appropriate prevention of the drop-out of the circlip can be secured.

[0007] In addition, according to the present invention, the circlip (retaining ring) can also engageably be stopped into the engagement stop groove by an insertion of the vehicle side rotational shafts in the state in which the circlip (retaining ring) is previously fitted into the cylindrical section. The engagement stop operation according to the circlip (retaining ring) can become easier and an improvement of a linkage workability (operability) between the propeller shaft (power transmission shaft) and the vehicle side rotational shafts can be achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a side view of a propeller shaft (a power transmission shaft) according to the present invention.

[0009] FIG. **2** is an essential part expanded view of an input shaft (or an output shaft) shown in FIG. **1**.

[0010] FIG. **3** is a longitudinally cross sectional view in a state in which the input shaft is inserted into an inner wheel member of a first constant velocity (universal) joint shown in FIG. **1**.

[0011] FIG. **4** is a perspective view in a proximity of a cylindrical section of a second constant velocity (universal) joint shown in FIG. **1**.

[0012] FIG. **5** is a cross sectional view in a proximity of cylindrical section of the second constant velocity (universal) joint.

[0013] FIG. **6** is a cross sectional view cut away along a line A-A in FIG. **5**.

[0014] FIG. **7** is a longitudinally cross sectional view in a state in which the output shaft is inserted into a cylindrical section of the second constant velocity (universal) joint shown in FIG. **1**.

[0015] FIG. **8** is a cross sectional view cut away along a line B-B in FIG. **7**.

[0016] FIG. **9** is an expanded view of a C section shown in FIG. **7**.

[0017] FIGS. **10**(*a*) and **10**(*b*) are views representing forms of an engagement stop state and an engagement stop release state by means of a circlip (also, called a retaining ring), respectively. (It should be noted that FIG. **10**(*b*) corresponds to the view corresponding to FIG. **8**).

[0018] FIGS. **11**(*a*) and **11**(*b*) are a side view and a cross sectional view cut away along a line D-D in FIG. **11**(*a*), each representing a state before the propeller shaft is linked to the output shaft.

[0019] FIGS. **12**(*a*) and **12**(*b*) are a side view and a cross sectional view cut away along a line E-E in FIG. **12**(*a*), each representing a midway state when the propeller shaft is linked to the output shaft.

[0020] FIGS. **13**(*a*) and **13**(*b*) are a side view and a cross sectional view cut away along a line F-F in FIG. **13**(*a*), each

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representing a state in which a linkage between the propeller shaft and the output shaft is completed.

[0021] FIG. **14** is a view corresponding to FIG. **9** representing a modification of the first embodiment according to the present invention.

[0022] FIG. **15** is a view corresponding to FIG. **8** representing an engagement stop state by means of the circlip (retaining ring) in a second preferred embodiment according to the present invention.

[0023] FIG. **16** is a view corresponding to FIG. **8** representing the engagement stop state by means of the circlip (retaining ring) in a third preferred embodiment according to the present invention.

[0024] FIG. **17** is a view corresponding to FIG. **8** representing the engagement stop state by means of the circlip (retaining ring) in a fourth preferred embodiment according to the present invention.

[0025] FIG. **18** is a view corresponding to FIG. **8** and representing the engagement stop state by means of the circlip (retaining ring) in a fifth preferred embodiment according to the present invention.

[0026] FIG. **19** is a view corresponding to FIG. **8** and representing the engagement stop state by means of the circlip (retaining ring) in a sixth preferred embodiment according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0027] Hereinafter, a detailed description of a power transmission shaft (viz., a propeller shaft) has been made in order to facilitate better understanding of preferred embodiments according to the present invention on a basis of accompanied drawings. It should be noted that, in the preferred embodiments of the power transmission shaft (viz., propeller shaft), the present invention is applicable to the power transmission shaft (propeller shaft) for an automotive vehicle and this application will be exemplified, in the same way as described before for the previously proposed propeller shaft.

First Embodiment

[0028] FIGS. **1** through **13**(*b*) show a first preferred embodiment of the power transmission shaft (also called the propeller shaft) according to the present invention. FIG. **1** shows a side view of the power transmission shaft (propeller shaft) representing a whole of the propeller shaft (power transmission shaft).

[0029] It should be noted that, in the following description, for convenient purposes, a left side of FIG. **1** is explained as a front, a right side of FIG. **1** is explained as a rear, a direction along a rotation center axial line in FIG. **1** is explained as an axial (shaft) line, and a direction around a rotational center axial (shaft) line is explained as a peripheral direction.

[0030] (Structure of Power Transmission Shaft)

[0031] Power transmission shaft **1** includes: a driving shaft **4** integrally rotatably linked to an input shaft **2** interlinked to a transmission (not shown) via a first constant velocity (universal) joint J**1**; and a driven shaft **5** integrally rotatably linked to an output shaft **3** interlinked to a differential (not shown) via a second constant velocity (universal) joint J**2**. Both of shafts **4**, **5** are integrally rotatably linked to each other via a third constant velocity (universal) joint. In addition, both of shafts **4**, **5** are rotatably supported via a center bearing **7** suspended on a vehicle body (not shown).

[0032] It should be noted that driving shaft **4** and driven shaft **5** constitute a shaft section according to the present invention.

[0033] FIG. **2** shows an essential part expanded view of the input shaft or the output shaft expanding and displaying a linkage end section of the input shaft or the output shaft to the propeller shaft (power transmission shaft).

[0034] Each of input shaft **2** and output shaft **3** is mainly constituted by a large diameter section **11** interlinked to the transmission or the differential, a middle diameter section **12** in a step difference diameter shape integrally disposed on an end section of large diameter section **11**; and a small diameter section **13** integrally disposed on an end section of middle diameter section **12**.

[0035] Middle diameter section **12** includes an annular engagement stop groove (or an engagement groove) **14** into which a circlip (also called a retaining ring) **8** (refer to FIG. **4**) which serves as a retainer (or stopper) for input shaft **2** and output shaft **3** during linkages between input shaft **2** and output shaft **3** and first and second constant velocity (universal) joints **31**, **32** is engagement stopped and which is cut out formed along the peripheral direction, at large diameter **11** side thereof.

[0036] On the other hand, at the small diameter **13** side thereof, a seal groove **15** into which a seal ring (not shown) which serves to suppress an invasion of moisture (water) or so forth into an inside of each of first and second constant velocity (universal) joints **31**, **32** is cut out formed along the peripheral direction.

[0037] Engagement stop mechanism **14** includes a pair of rising surfaces including a bottom surface **14***a* and small diameter side and large diameter side rising surfaces **14***b*, **14***c* standing up at axial (directional) both end sides of bottom surface **14***a*.

[0038] Small diameter side rising surface **14***b* of both rising surfaces **14***b*, **14***c* which is opposite side to a pull-out direction (first and second constant velocity (universal) joint sides **31**, **32**) is constituted as an upward tilting inclination wall directing toward first and second constant velocity (universal) joints set in such a way that an angle θ**1** of engagement stop groove **14** side from among angles formed between the corresponding small diameter rising surface **14***b* and a rotation center axial line Z is larger than 90 degrees but smaller than 180 degrees.

[0039] Large diameter side rising surface **14***c* in the pull out direction (anti first and second constant velocity (universal) joint J**1**, J**2** sides) is constituted as a vertically standing (upright) wall which is set in such a way that an angle θ**2** formed between large diameter side rising surface **14***c* and rotational center axial (shaft) line Z is substantially at a right angle.

[0040] A downward tilting tapered section **16** directing toward seal groove **15** side namely, directing toward insertion directions of input shaft **2** and output shaft **3** is formed at anti first and second constant velocity (universal) joint sides **31**, **32** of seal groove **15**.

[0041] A male spline **17** is formed along the axial direction on a whole of an outer peripheral surface of small diameter section **13**. In addition, another tapered section **18** is formed on a tip section of this small diameter section **13** and tapered section **18** serves to guide an insertion of small diameter section **13** into cylindrical section **30** as will be described

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later so that a smooth insertion thereof into cylindrical section **30** can easily be carried out.

[0042] FIG. **3** shows a longitudinally cross sectional view in a state in which input shaft **2** is inserted into first constant velocity (universal) joint J**1**.

[0043] First constant velocity (universal) joint J**1** is mainly constituted by: an outer wheel member **21** whose one end in the axial direction is connected to driving wheel **4**; an inner wheel member **22** arranged on an inner peripheral side of outer wheel member **21** and which receives a driving torque from input shaft **2**; and a plurality of rolling bodies, viz., balls **23** rollably interposed between inner wheel member **22** and outer wheel member **21** and retained by a retainer **24** (or a retaining unit).

[0044] Outer wheel member **21** indicates a substantially cup shape which opens the other end side of outer wheel member **21** in the axial direction. Outer wheel member **21** includes a ball engagement groove **21***a*, at the inner peripheral side, as an axial direction groove which limits a relative movement of both outer wheel and inner wheel members **21**, **22** in the peripheral direction by the engagement of each ball **23** to groove **21***a*, while allowing the relative movement of both wheel members **21**, **22** in the axial direction by a rolling of each ball **23** thereon, ball engagement groove **21***a* being formed linearly along the axial direction, at an inner peripheral side.

[0045] Inner wheel member **22** exhibits a substantially cylindrical shape. An insertion hole **22***a* is penetrated in an inside axial direction of inner wheel member **22**. A female spline **25** to which male spline **17** of input shaft **2** is engaged from the axial direction is cutout formed along the axial direction, at the inner peripheral side of insertion hole **22***a*. In addition, at the outer peripheral side at which each ball **23** is rolled, a ball engagement groove **22***b* is linearly cutout formed along the axial direction which is the axial directional groove in the same way as ball engagement groove **21***a* of outer wheel member **21**.

[0046] Furthermore, an annular retaining groove **26** which serves to retain circlip (retaining ring) **8** is cutout formed along the peripheral direction, in a proximity of a front end edge of inner wheel member **22**. At a portion of retaining groove **26** in the peripheral direction, a first through hole **31** and a second through hole **32** which are a pair of through holes opposed against engagement stop groove **14** of input shaft **2** in the radial direction in a state in which input shaft **2** is inserted into insertion hole **32***a* of inner wheel member **22** to expose engagement stop groove **14** externally are disposed against each other in the radial direction.

[0047] It should be noted that, since retaining groove **26** and first and second through holes **31**, **32** are the same as those disposed on a cylindrical section **30** of second constant velocity (universal) joint J**2** as will be described later, for convenience purposes, the specific structures of these groove and through holes will be described later together with the structure of cylindrical section **30**.

[0048] A water-proof boot **27** which serves to protect first constant velocity (universal) joint J**1** from water or dust is interposed between outer wheel member **21** and inner wheel member **22** to extend on both wheel members **21**, **22**. This water-proof boot **27** has a middle section in a bent form so as to be formed elastically in the axial direction. One end side in the axial direction of this boot **27** is fixed by caulking via a mounting bracket (attachment metal fittings) **27***a* onto an outer peripheral surface at a tip side of outer wheel member **21** and the other end of this boot **27** in the axial direction is fixed to the outer peripheral surface of inner wheel member **22** in a tight binding manner via a well known boot band **27***b*.

[0049] FIG. **4** shows a perspective view of a proximity of cylindrical section **30** of second constant velocity (universal) joint J**2**, FIG. **5** shows a partially cross sectional view in a proximity of cylindrical section **30** of second constant velocity (universal) joint J**2**, and FIG. **6** shows a cross sectional view cut away along a line A-A in FIG. **5**, respectively. In addition, FIG. **7** shows a longitudinal cross sectional view in a state in which the output shaft is inserted into the cylindrical section of the second constant velocity (universal) joint, and FIG. **8** shows a longitudinal cross sectional view cut away along a line B-B in FIG. **7** and FIG. **8** shows an expanded view of a C portion depicted in FIG. **7**.

[0050] Second constant velocity (universal) joint J**2** has a rear end section at which a substantially cylindrically shaped cylindrical section **30** which serves to link second constant velocity (universal) joint J**2** to output shaft **3** and an insertion hole **30***a* penetrated in an inside axial direction of this cylindrical section **30**. A female spline **17** with which male spline **17** of output shaft **3** is engaged from the axial direction is cutout formed along the axial direction at the inner peripheral side of insertion hole **30***a*.

[0051] Furthermore, an annular retaining groove **26** which serves to retain circlip (retaining ring) **8** is cutout formed along the peripheral direction in the proximity of a rear end edge of cylindrical section **30**. At a portion of retaining groove **26** in the peripheral direction, a first through hole **31** and a second through hole **32**, namely, a pair of through holes which serve to expose engagement groove **14** externally, opposing against engagement stop groove **14** of output shaft **3** in a state in which output shaft **3** is inserted into insertion hole **30***a* of cylindrical section **30** are formed to oppose against each other in the radial direction. In other words, a portion of cylindrical section other than first and second through holes **31**, **32** from among the peripheral range in which first and second through holes **31**, **32** are disposed is constituted as retaining groove **26**.

[0052] More specifically, first and second through holes **31**, **32** are disposed so as to be spaced apart from each other in the peripheral direction and opposed against each other at a position symmetrically to rotation axial line Z by deleting a region of a portion of retaining groove **26** in the peripheral direction linearly along a vertical direction of FIG. **6**.

[0053] Furthermore, shapes and positions of first and second through holes **31**, **32** are formed to be orthogonal to rotation center axial line Z and are formed to be line symmetrical to a phantom line L**1** passing through rotation center axial line Z. The circlip (retaining ring) **8** is disposed to be line symmetrical to phantom line L**1**.

[0054] In addition, first and second through holes **31**, **32** are formed line symmetrically to a second phantom line L**2** passing through rotation center axial line Z and orthogonal to rotation center axial line Z, as typically shown in FIG. **6**. Retaining groove **26** is disposed line symmetrically to second phantom line L**2**.

[0055] In addition, as described above, on both end edges of retaining groove **26** at which first and second through holes **31**, **32** are linearly cutout formed along a vertical direction in FIG. **6**, first planar sections **33**, **33** and second

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planar sections **34**, **34** which are a pair of planar sections parallel to phantom line L**1** are formed.

[0056] It should, herein, be noted that first and second through holes **31**, **32** are coincident with (completely overlapped on) engagement stop mechanism **14** of output shaft **3** at an axial directional position at which tip end surface **30***b* of cylindrical section **30** is just brought in contact with an end surface **11***a* of large diameter section **11** of output shaft **3** which serves as a butting section.

[0057] In other words, tip surface **30***b* of cylindrical section **30** is brought in contact with end surface **11***a* of large diameter section **11** of output shaft **3** when output shaft **3** is appropriately inserted into insertion hole **30***a* and circlip (retaining ring) **8** is engagement stopped into engagement stop groove **14**. According to this contact, the confirmation such that output shaft **3** is appropriately linked to cylindrical section **30** can be made.

[0058] A water-proof boot **35** which serves to prevent an invasion of water or dust from first and second through holes **31**, **32** is mounted on cylindrical section **30** in a form of extending on and over cylindrical section **30** and output shaft **3** so as to enclose first and second through holes **31**, **32**. This water-proof boot **35** has a middle section structured in a substantially bellows shape so that water-proof boot **35** is formed to enable expansion and contraction (telescopically) in the axial direction. This water-proof boot **35** is attached and fixed to cylindrical section **30** via a boot attachment section **36** disposed at a basic end side of cylindrical section **30** which is opposite to an insertion inlet of output shaft **3**. One end side of water-proof boot **35** in the axial direction is located at the outer peripheral side of cylindrical section **30**.

[0059] Circlip (retaining ring) **8** is formed of a metal having a substantially circular shape in cross section and having a slightly smaller linear diameter than a groove depth (a radial width) of retaining groove **26** and bent in substantially letter C shape. Circlip (retaining ring) **8** includes: a first insertion section **41** and a second insertion section **42** which are straight line sections formed linearly and parallel to first and second planar sections **33**, **34** and inserted into first and second through holes **31**, **32**; a connection section **43** formed in an arc shape along the outer peripheral surface of retaining groove **26** (upper side retaining groove **26***a*) so as to envelop the outer peripheral surface of upper side retaining groove **26** located at an upper side of FIG. **8** and which connects peripheral direction one end sections (upper end sections in FIG. **8**) of first and second insertion sections **41**, **42**; and a first engagement section **44** and a second engagement section **45**; and a first engagement section **44** and a second engagement section **45** formed in arc shapes along the outer peripheral surface of a lower side retaining groove **26***b* of retaining groove **26** so as to enclose the outer peripheral surface of lower side retaining groove **26***b* (in FIG. **8**) of retaining groove **26**.

[0060] Then, a caulked sections **37** on which a caulking is carried out for a portion of opening edges of retaining groove **26** in a state in which circlip (retaining ring) **8** is fitted into retaining groove **26** is formed so that a drop out of circlip (retaining ring) **8** fitted into retaining groove **26** is suppressed.

[0061] It should be noted that, in this embodiment, caulked section **37** which is formed on the opening edge of retaining groove **26** is exemplified. However the caulked section **37** is not always disposed on retaining groove **26**. Although a specific drawing indication is omitted, caulked section **37** may be disposed on a portion of the peripheral direction of circlip (retaining ring) **8** which is a party side of retaining groove **26** so that the drop out of circlip (retaining ring) **8** from retaining groove **26** can be suppressed.

[0062] First and second insertion sections **41**, **42** are brought in contact with respective first and second planar sections **33**, **34** of upper side retaining groove **26***a* and lower side retaining groove **26***b* and inserted into first and second through holes **31**, **32** in a form of extending on and over both planar sections **33**, **34**. Portions X**1**, X**1** of first and second insertion sections **41**, **42** denoted by shading in FIG. **8** are engageably stopped to side walls (rising surfaces **14***b*, **14***c*) of engagement stop groove **14** of cylindrical section **30** by exposing first and second insertion sections **41**, **42** to the inner peripheral side of cylindrical section **30** via these respective through holes **31**, **32**.

[0063] First and second engagement sections **44**, **45** are housed and retained within retaining groove **26** so as not to be protruded (not projected) from outer peripheral surface **30***c* of cylindrical section **30** while a slight gap C**1** against lower side retaining groove **26***b* is provided, in a state in which circlip (retaining ring) **8** is appropriately mounted.

[0064] FIGS. **10**(*a*) and **10**(*b*) show corresponding drawings of FIG. **8** representing an engagement stop state and an engagement stop release state by means of a jig **40**, respectively.

[0065] Jig engagement surfaces **44***a*, **45***a* which serve as jig engagement sections to engage a substantially pliers shaped jig **40** which serves to perform an engagement stop and a release of the engagement stop of circlip **8** (retaining ring) fitted into retaining groove **26** (refer to FIG. **8**) are formed on tips of first and second engagement sections **44**, **45** (refer to FIG. **8**). This jig engagement surfaces **44***a*, **45***a* are surfaces substantially orthogonal to an extension direction of first and second engagement sections **44**, **45** and are structured in a letter of a Japanese character of ハ as viewed from a front side of FIGS. **10**(*a*) and **10**(*b*) in a fitted state of these first and second engagement sections **44**, **45** to retaining groove **26**.

[0066] As viewed from such a structure as described above, in order to release the linkage between cylindrical section **30** and output shaft **3**, as shown in FIG. **10**(*a*), tip sections **40***a*, **40***b* of bifurcated jig **40** are brought in contact with jig engagement surfaces **44***a*, **45***a*, tip sections **40***a*, **40***b* are opened toward the outside so that first and second engagement sections **44**, **45** are widened toward the outside and, thus, the engagement states of first and second insertion sections **41**, **42** are released. Consequently, output shaft **3** can be pulled out from cylindrical section **30**.

[0067] (A linkage method between propeller shaft (power transmission shaft) and the output shaft) Hereinafter, a linkage method between the propeller shaft (power transmission shaft) and the output shaft will be described below on a basis of FIGS. **11**(*a*) through **13**(*b*). It should be noted that FIGS. **11**(*a*) and **11**(*b*) show a state before the linkage, FIGS. **12**(*a*) and **12**(*b*) show a state in which the linkage is being carried out, and FIGS. **13**(*a*) and **13**(*b*) show a state in which the linkage is completed, respectively. FIGS. **11**(*a*), **12**(*a*), and **13**(*a*) show views viewed from side directions of the propeller shaft (power transmission shaft) and the output shaft. FIGS. **11**(*b*), **12**(*b*), and **13**(*b*) show cross sectional views cut away along line D-D of the corresponding FIGS. **11**(*a*), **12**(*a*), and **13**(*a*), respectively.

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[0068] First, as shown in FIGS. **11**(*a*) and **11**(*b*), circlip (retaining ring) **8** is fitted into retaining groove **26** of cylindrical section **30** of second constant velocity (universal) joint J**2** from an upward direction. Thereafter, output shaft **3** is inserted along the axial direction into insertion hole **30***a* of cylindrical section **30** into which circlip (retaining ring) **8** is fitted.

[0069] Then, this output shaft **3** is inserted into insertion hole **30***a* of cylindrical section **30** in a form of widening (elastically deforming in an expanding open direction) first and second insertion sections **41**, **42** exposed to the inner peripheral side (within insertion hole **30***a*) of cylindrical section **30** through first and second through holes **31**, **32**. Then, when first and second insertion sections **41**, **42** run over a maximum diameter section of tapered section **16** and tip surface **30***b* of cylindrical section **30** is brought in contact with end surface **11***a* of large diameter section **11** of output shaft **3**, as shown in FIGS. **13**(*a*) and **13**(*b*), restored first and second insertion sections **41**, **42** are engageably inserted into engagement stop groove **14** and the linkage between propeller shaft **1** and output shaft **3** is completed.

[0070] It should, herein, be noted that, as described before, in this embodiment, on a state in which circlip (retaining ring) **8** is engageably inserted into engagement stop groove **14** at a time point at which end surface **11***a* of large diameter section **11** of output shaft **3** is brought in contact with tip surface **30***b* of cylindrical section **30** and the insertion of output shaft **3** is incomplete, as shown in FIG. **12**(*b*), first and second insertion sections **41**, **42** run on tapered section **16** and are protruded (projected) toward the outside of retaining groove **26**.

[0071] That is, it becomes possible to visually recognize the engagement stop state of circlip (retaining is ring) **8** from the outside of propeller shaft (power transmission shaft) **1** depending upon whether tip surface **30***b* of cylindrical section **30** is brought in contact with end surface **11***a* of output shaft **3** and whether first and second engagement sections **44**, **45** are protruded from the outside (outer peripheral surface **30***c* of cylindrical section **30**) of engagement stop groove **14**.

Actions an Effects of the First Embodiment

[0072] As described hereinabove, propeller shaft (power transmission shaft) **1** in the first embodiment, includes: the shaft section interposed (intervened) between input shaft **2** and output shaft **3** (which is the pair of vehicle side rotational shafts); cylindrical section **30** disposed so as to enable an integral (integration) rotation with the shaft section, the pair of vehicle side rotational shafts being inserted into the inner peripheral side of cylindrical section **30**; through holes **31**, **32** penetrated in a peripheral directional range of a portion of cylindrical section **30** and opposed against engagement groove **14** in the radial direction disposed on the outer peripheral side of vehicle side rotational shafts in a state in which the vehicle side rotational shafts are inserted into the inner peripheral side of cylindrical section **30**; and circlip (retaining ring) **8** fitted into cylindrical section **30** from the outer peripheral side, a portion of the circlip (retaining ring) in the peripheral direction enclosing the outer peripheral side of cylindrical section **30** and another portion of the circlip (retaining ring) in the peripheral direction being exposed to the inner peripheral side of the circlip (retaining ring) via through holes **31**, **32**, the circlip (retaining ring) **8** being enageably insertable into engagement stop groove **14**.

[0073] That is, by an insertion of the vehicle side rotational shafts into cylindrical section **30** in a state in which circlip (retaining ring) **8** is fitted into cylindrical section **30**, a portion of circlip (retaining ring) **8** in the peripheral direction exposed to the inner peripheral side of cylindrical section **30** via through holes **31**, **32** is enabled to be engageably inserted into engagement stop groove **14**.

[0074] In this way, the drop out of the vehicle side rotational shafts in a form of fitting circlip (retaining ring) **8** externally into cylindrical section **30** (from an external) is prevented. Thus, it becomes possible to visually recognize the engagement stop state of vehicle side rotational shafts by means of circlip (retaining ring) **8** from an external. Therefore, a facilitation of an engagement stop operation according to circlip (retaining ring) **8** is achieved and a security of an appropriate drop-out prevention with circlip (retaining ring) **8** is achieved.

[0075] Furthermore, in this embodiment, it becomes possible to engageably stop circlip (retaining ring) **8** into engagement stop groove **14** by an insertion of vehicle side rotational shafts in a state in which circlip (retaining ring) **8** is previously fitted into cylindrical section **30**. Thus, an engagement operation according to circlip (retaining ring) **8** can be facilitated and a linkage operability between propeller shaft (power transmission shaft) **1** and the vehicle side rotational shafts can be improved.

[0076] In addition, cylindrical section **30** includes retaining groove **26** retaining circlip (retaining ring) **8** at a portion of a peripheral directional range in which through holes **31**, **32** are disposed other than through holes **31**, **32**. In this way, by a retaining of circlip (retaining ring) **8** into retaining groove **26**, a positional shift of circlip (retaining ring) **8** in the axial direction accompanied with the insertion of vehicle side rotational shafts can be suppressed and a quantity of a protrusion of circlip (retaining ring) **8** from outer peripheral surface **30***c* of cylindrical section **30** can be suppressed.

[0077] In addition, retaining groove **26** is annularly formed. Since retaining groove **26** is annularly formed, an advantage such that an overlap allowance between retaining groove **26** and circlip (retaining ring) **8** can largely be secured. In addition, in a case where retaining groove **26** is formed through a machining, the machining can easily be carried out.

[0078] In addition, through holes **31**, **32** are constituted by first and second through holes **31**, **32** spaced apart from each other in the peripheral direction of cylindrical section **30**. In this way, the through holes are constituted as the pair of through holes **31**, **32**. An engagement stop force of circlip (retaining ring) **8** can be increased as compared with those constituted as a single through hole. A favorable drop-out prevention of vehicle side rotational shafts can be achieved.

[0079] In addition, first and second through holes **31**, **32** are arranged at symmetrical positions to rotational center axial line Z of cylindrical section **30**. Thus, a balance of circlip (retaining ring) **8** at the time of an expansion diameter becomes favorable and an improvement of the linkage operability between propeller shaft (power transmission shaft) **1** and vehicle side rotational shafts can be achieved.

[0080] Furthermore, shapes and positions of first and second through holes **31**, **32** are orthogonal to rotational center axial line Z of cylindrical section **30** and these holes

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31, **32** are formed line symmetrically to phantom line L**1** passing through rotational center axial line Z. In the structure described above, it becomes possible to engageably stop and fix propeller shaft (power transmission shaft) **1** in spite of the fact that the insertion direction of circlip (retaining ring) **8**. Thus, a further improvement of the linkage operability between power transmission shaft (propeller shaft) **1** and vehicle side rotational shafts can be achieved.

[0081] In addition, first and second through holes **31**, **32** are formed by a deletion of a portion of cylindrical section **30** and first and second planer surface sections **33**, **34** which are the pair of planer sections are formed at both end sections of rotational center axial line Z in the peripheral direction from among the deleted cross sections. These first and second planar sections **33**, **34** are disposed in parallel to phantom line L**1**. Thus, the overlap allowance of circlip (retaining ring) **8** can largely be secured.

[0082] In addition, circlip (retaining ring) **8** includes first and second insertion sections **41**, **42** as a straight line section by forming linearly a portion of circlip (retaining ring) **8** which is brought in contact with first and second planar sections **33**, **34**. Thus, since first and second planar sections **33** **34** and first and second insertion sections **41** **42** which are straight line sections can be brought in contact with each other, there is such a merit that the lap allowance of circlip (retaining ring) **8** can largely be secured.

[0083] In addition, cylindrical section **30** is provided with retaining groove **26** retaining circlip (retaining ring) **8** at the portion of the peripheral directional range in which first and second through holes **31**, **32** are disposed other than first and second through holes **31**, **32**, the phantom line passing through rotational center axial line Z and orthogonal to rotational center axial line Z is the second phantom line L**2**. At this time, first and second through holes **31**, **32** are formed line symmetrically to second phantom line L**2** and retaining groove **26** is formed line symmetrically to second phantom line L**2**. In this way, since first and second through holes **31**, **32** and retaining groove **26** are formed vertically and horizontally symmetrically, an improvement of a degree of freedom in the insertion direction of circlip (retaining ring) **8** is achieved and the improvement of the linkage operability between propeller shaft (power transmission shaft) **1** and vehicle side rotational shafts is achieved.

[0084] In addition, through holes **31**, **32** are constituted by first through hole **31** and second through hole **32** spaced apart from each other in the peripheral direction of cylindrical section **30**. Circlip (retaining ring) **8** includes: first insertion section **41** inserted into first through hole **31**; second insertion section **42** inserted into second through hole **32**; connection section **43** which connects the peripheral directional end section of first insertion section **41** and the peripheral directional end section of second insertion section **43**; first engagement section **44** extended on the peripheral directional other end section **41**; and a second engagement section **45** extended at the peripheral directional other end side of second insertion section **42**. In this way, since first and second engagement sections **44**, **45** which are engaged with retaining groove **26** are provided, the drop-out of circlip (retaining ring) **8** can be suppressed.

[0085] Moreover, first and second engagement sections **44**, **45** are formed not to be protruded from outer peripheral surface **30***a* of cylindrical section **30**. Thus, it becomes possible to detect an attachment failure of circlip (retaining ring) **8** depending on whether circlip (retaining ring) **8** protrudes from outer peripheral surface **30***c* of cylindrical section **30**. Consequently, an improvement of a yield of a linkage failure of circlip (retaining ring) **8** between propeller shaft **1** and circlip (retaining ring) **8** can be achieved.

[0086] Furthermore, first and second engagement sections **44**, **45** are provided with jig engagement surfaces **44***a*, **45***a* to which jig **40** which serves to remove circlip (retaining ring) **8** is engaged. In this way, since jig engagement surfaces **44***a*, **45***a* are provided, the improvement in operability of a removal operation of circlip (retaining ring) **8** can be achieved.

[0087] In addition, first and second engagement sections **44**, **45** are formed to have a gap C**1** against cylindrical section **30** in the radial direction of rotational center axial line Z. In this way, since gap C**1** is provided between first and second engagement sections **44**, **45** and cylindrical section **30**, the attachment failure of circlip (retaining ring) **8** regardless of manufacturing errors of circlip (retaining ring) **8** and cylindrical section **30** can be suppressed.

[0088] In addition, engagement stop groove **14** includes small diameter side rising surface **14***b* and large diameter side rising surface **14***c* which are the pair of rising surfaces disposed on both sides of rotational center axial line Z in the axial direction. Small diameter side rising surface **14***b* which is the opposite side to the pull-out direction of vehicle side rotational shafts from among both rising surfaces **14***b*, **14***c* is formed in such a way that an angle θ**1** of engagement stop groove **14** side from among angles formed between small diameter side rising surface **14***b* and rotational center axial line Z is larger than 90 degrees but smaller than 180 degrees. Thus, it becomes possible to form small diameter side rising surface **14***b* in an upward tilting shape directing toward first and second constant velocity (universal) joints J**1**, J**2** and, consequently, small diameter side rising surface **14***b* which is the tilting wall reduces a pull-out load of vehicle side rotational shafts. Then, the improvement in a break-up operability of propeller shaft (power transmission shaft) **1** can be achieved.

[0089] Furthermore, large diameter side rising surface **14***c* in the pull-out direction of vehicle side rotational shafts of these both rising surfaces **14***b*, **14***c* is set in such a way that an angle **0** **2** formed between large diameter side rising surface **14***c* and rotational center axial line Z is substantially (at) a right angle. Thus, it becomes possible to suppress an inconvenience such that circlip (retaining ring) **8** easily run on (over) large diameter side rising surface **14***c* which is the standing-up wall. Consequently, the engagement force between engagement stop groove **14** and circlip (retaining ring) **8** in the insertion direction of vehicle side rotational shafts can sufficiently be exhibited.

[0090] In addition, vehicle side rotational shafts include tapered section **16** at the tip side of cylindrical section **30**. Thus, the insertion of vehicle side rotational shafts into insertion hole **30***a* of cylindrical section **30** is guided along tapered section **16**. Consequently, an insertion ability of vehicle side rotational shafts can be improved.

[0091] Moreover, vehicle side rotational shafts include the butting section (end surface **11***a* of large diameter section) against which the end section (tip surface **30***b*) of cylindrical section **30** in the state in which vehicle side rotational shafts are appropriately inserted. Thus, it becomes possible to confirm the insertion completion of vehicle side rotational shafts from the butting of vehicle side rotational shafts

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against tip surface **30***b* of cylindrical section **30**. Consequently, the insertion confirmation can easily and accurately be made.

[0092] It should be noted that, in this embodiment, as confirmation means for confirming the insertion completion of vehicle side rotational shafts is not limited to the contact between cylindrical section **30** and end surface **11***a* of large diameter section **11**. As shown in FIG. **14**, for example, a colored section **38** which colors an opening edge section of engagement stop groove **14** of vehicle side rotational shafts at the large diameter side is continuously formed on the opening edge section in the peripheral direction. Then, when colored section **38** is enclosed and hidden by the tip section of cylindrical section **30**, circlip (retaining ring) **8** is engageably inserted into engagement stop groove **14**. The confirmation of the insertion completion of vehicle side rotational shafts may be carried out according to a presence or absence of the exposure of colored section **38**.

[0093] In other words, vehicle side rotational shafts include colored section **38** enclosed and hidden by cylindrical section **30** in the state in which vehicle side rotational shafts are appropriately inserted into cylindrical section **30**. In this way, according to enclosure and hide of colored section **38**, the insertion completion of vehicle side rotational shafts may be confirmed. This method can also easily and accurately perform the insertion confirmation of vehicle side rotational shafts.

[0094] In addition, cylindrical section **30** includes boot attachment section **36** which serves to attach water-proof boot **35** at the opposite side to the insertion direction of vehicle side rotational shafts into through holes **31**, **32** at the outer peripheral side of cylindrical section **30**. Thus, first and second through holes **31**, **32** are enclosed by water-proof boot **35** so that the invasion of water moisture or so forth from first and second through holes **31**, **32** can be suppressed.

[0095] In addition, cylindrical section **30** or circlip (retaining ring) **8** includes caulked sections **37**, **37** which caulk a portion of cylindrical section **30** or circlip (retaining ring) **8** in the peripheral direction in the state in which circlip (retaining ring) **8** is fitted into cylindrical section **30**. In this way, the drop out of circlip (retaining ring) **8** can be suppressed according to the fastening structure by means of caulked sections **37**, **37**.

Second Embodiment

[0096] FIG. **15** shows a second preferred embodiment of the propeller shaft (power transmission shaft) according to the present invention. In the second embodiment, the shape of circlip (retaining ring) **8** in the case of the first embodiment is modified. It should be noted that the basic structure of the second embodiment is the same as the first embodiment except the modification of circlip (retaining ring) **8**. Hence, for the same structure as the first embodiment, the same reference numerals are provided and their explanations will be omitted (the same as those described below).

[0097] That is to say, circlip (retaining ring) **81** in this embodiment is structured in such a way that first and second projection sections **41***a*, **42***a* are formed as projection sections in which portions of respective insertion sections **41**, **42** are projected in the outsides of the radial directions on first and second insertion sections **41**, **42** which are formed linearly in the first embodiment.

[0098] In other words, circlip (retaining ring) **81** in this embodiment includes first and second projection sections **41***a*, **42***a* as projection sections in which portions of respective insertion sections **41**, **42** are projected radially in the outward direction of rotational center axial line Z.

[0099] As described above, in the second embodiment, circlip (retaining ring) **81** is structured in such a way that portions of first and second insertion sections **41**, **42** projected toward the outside of radial direction along side walls (rising surfaces **14***b*, **14***c*) of engagement stop groove **14** so that the overlap allowance (areas of portions X**2**, X**2** denoted by net (shading) in FIG. **15**) can further be increased.

Third Embodiment

[0100] FIG. **16** shows a third preferred embodiment of the propeller shaft (power transmission shaft) according to the present invention.

[0101] In this embodiment, the shape of circlip (retaining ring) **8** described in the first embodiment is modified.

[0102] Circlip (retaining ring) **82** in this embodiment includes a projection section **43***a* formed in such a way that a portion of connection section **43** is offset toward a more radially outer side of cylindrical section **30** than an outer peripheral surface **30***c* of cylindrical section **30**. In addition, a predetermined gap C**2** is formed radially between projection section **43***a* and cylindrical section **30** in an appropriate mounting state of circlip (retaining ring) **82**.

[0103] In addition, in circlip (retaining ring) **82** in this embodiment, first and second engagement sections **44**, **45** are bent in folded shapes toward the outside (radially outside). At the same time, portions of bending sections which are brought in contact with cylindrical section **30** (retaining groove) **26** during the external fitting of circlip (retaining ring) **82** into retaining groove **26** from the external are formed in arc shapes as first and second arc sections **44***b*, **45***b*. Specifically, basic end sides of first and second engagement sections **44**, **45** are bent toward the inside along the inner peripheral surface of retaining groove **26** and tip end sides thereof are bent toward the outside via bending sections (first and second arc shaped sections **44***b*, **45***b*) in the fold shapes.

[0104] As described above, in this embodiment, first and second engagement sections **44**, **45** have portions which are brought in contact with cylindrical section **30** (first and second arc shaped sections **44***b*, **45***b*) are bent in the arc shapes during the external fitting of circlip (retaining ring) **82** into retaining groove **26** from the external. Thus, during the external fitting of circlip (retaining ring) **82** into retaining groove **26** from the external, it becomes possible to suppress such an inconvenience that first and second engagement sections **44**, **45** are caught in hole edges of first and second through holes **31**, **32** and am attachment workability (operability) of circlip (retaining ring) **82** can be improved.

[0105] In addition, in this embodiment, connection section **43** includes projection section **43***a* formed in such a way that the portion of connection section **43** is offset toward the radial outside of cylindrical section **30** and is projected toward more outer side than outer peripheral surface **30***c* of cylindrical section **30**.

[0106] Thus, in a case where circlip (retaining ring) **82** is removed, a predetermined tool having a tip side formed to be relatively flat such as a slotted screwdriver (not shown) is inserted within gap C**2** and connection section **43** (projection section **43***a*) is lifted up toward an upper side of FIG.

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16 via the tool. Consequently, a removal operation of circlip (retaining ring) **82** can become easier.

Fourth Embodiment

[0107] FIG. **17** shows a fourth preferred embodiment of the propeller shaft (the power transmission shaft) according to the present invention. In this embodiment, the shape of circlip (retaining ring) **8** described in the first embodiment is modified.

[0108] That is, circlip (retaining ring) **83** in this embodiment has no first and second engagement sections **44**, **45** (eliminated) from circlip (retaining ring) **8** in the first embodiment. Circlip (retaining ring) **83** includes: first insertion section **41** inserted into first through hole **31**; second insertion section **42** inserted into second through hole **32**; and connection section **43** which connects a peripheral directional one end section of first insertion section **41** and the peripheral directional one end section of second insertion section **42**.

[0109] In this way, first and second engagement sections **44**, **45** for drop-out prevention purposes are not installed in circlip (retaining ring) **83**. Thus, during the external fitting of circlip (retaining ring) **83** onto retaining groove **26** from the external, there is no possibility that first and second engagement sections **44**, **45** are caught in the hole edges or so forth of first and second through holes **31**, **32** and the attachment workability of circlip (retaining ring) **83** can be improved.

Fifth Embodiment

[0110] FIG. **18** shows a fifth preferred embodiment of the propeller shaft (power transmission shaft) according to the present invention. In this embodiment, the shape of circlip (retaining ring) **8** described in the first embodiment is modified.

[0111] That is, in circlip (retaining ring) **84** in this embodiment, forms of first and second engagement sections **44**, **45** of the first embodiment are modified. First and second engagement sections **44**, **45** are bent in the folded shapes toward the inside (inner side in the radial direction) and the bending sections are formed as arc shaped first and second arc shaped sections **44***b*, **45***b*.

[0112] In addition, more basic end sides of first and second engagement sections **44**, **45** than first and second arc shaped sections **44***b*, **45***b* are formed to spread progressively toward the outside in a form of a Japanese letter of ハ as viewed from the front side and to be bent toward the inner side in the folded shapes so that more tip sides of first and second engagement sections **44**, **45** than first and second arc shaped sections **44***b*, **45***b* indicates the Japanese letter of ハ as viewed from the front side. As a whole, first and second engagement sections **44**, **45** are structured to be substantially in a letter V shape.

[0113] Predetermined spaces S**1**, S**1** are formed between the inner sides of first and second arc shaped sections **44***b*, **45***b* and cylindrical section **30**. That is, by stretching predetermined spaces S**1**, S**1** toward the outside with pliers type of jig (not shown) fitted (engaged) into predetermined spaces **51**, **51**, engagement states of first and second insertion sections **41**, **42** are released so that output shaft **3** can be pulled out from cylindrical section **30**.

[0114] In addition, since more tip sides of first and second engagement sections **44**, **45** than first and second arc shaped sections **44***b*, **45***b* are formed in the Japanese letter of ハ as viewed from the front side of FIG. **18**, first and second inclination sections **44***c*, **45***c* in which portions of first and second engagement sections **30** (retaining groove **26**) during the external fitting of circlip (retaining ring) **84** into retaining groove **26** from the external are downward inclination shapes toward the outside so as to constitute first and second inclination sections **44***c*, **45***c*. Then, an interval C**3** (distance) of both inclination sections **44***c*, **45***c* is so constructed to be narrower than the interval between first and second engagement sections **44**, **45** in the first embodiment.

[0115] As described above, since, in this embodiment, portions of first and second engagement sections **44**, **45** which are brought in contact with cylindrical section **30** (retaining groove **26**) are constituted by first and second inclination sections **44***c*, **45***c* downwardly inclined shapes toward the outside during the external fitting of circlip (retaining groove) **84** into retaining groove **26** from the external. From the relationship of first and second engagement sections **44**, **45** to upper side retaining groove **26***a* which is downwardly inclined shape oriented toward the outside, first and second engagement sections **44**, **45** become easily spread along the downward inclination so that the attachment workability of circlip (retaining ring) **84** can be improved.

[0116] In addition, since interval C**3** between first and second inclination sections **44***c*, **45***c* is formed relatively narrowly, when output shaft **3** is inserted into cylindrical section **30** in a state in which circlip (retaining groove **26**) is fitted into retaining groove **26** as described above, an effective suppression of such an inconvenience as the drop out of circlip (retaining ring) **84** from retaining groove **26** can be achieved.

Sixth Embodiment

[0117] FIG. **19** shows a sixth preferred embodiment of the propeller shaft (the power transmission shaft) according to the present invention. In this embodiment, the shape of circlip (retaining ring) **83** described in the third embodiment is modified.

[0118] That is, circlip (retaining ring) **85** in this embodiment is formed in such a way that first and second engagement sections **44**, **45** of circlip (retaining ring) **85** in this embodiment is formed in such a way that first and second engagement sections **44**, **45** of circlip (retaining ring) **82** in this embodiment are bent in a letter of V shape toward the inside in the same way as first and second engagement sections **44**, **45** of circlip (retaining ring) **84** related to the fifth embodiment. In addition, tip sections of first and second inclination sections **44***c*, **45***c* opposed against lower side retaining groove **26***b* are formed as third and fourth arc shaped sections **44***d*, **45***d* which are bent toward the inside thereof in the arc shape.

[0119] Thus, in this embodiment, since third and fourth arc shaped sections **44***d*, **45***d* are installed in addition to the action and effect achieved in the third and fifth embodiments, when circlip (retaining ring) **85** is removed via projection section **43***a*, first and second engagement sections **44**, **45** easily spread along the upward inclination from the relationship of third and fourth arc shaped sections **44***d*, **45***d* to lower side retaining groove **26***b*. Consequently, a removal operability of circlip (retaining ring) **85** can be improved.

[0120] The present invention is not limited to the structures and forms exemplified in the respective embodiments. In a case of forms which can achieve the actions and effects

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according to the present invention, free modifications can be made according to specifications of application items, cost, or so forth.

[0121] Especially, in the embodiments described above, output shaft **3** is inserted into insertion hole **30***a* of cylindrical section **30** in the state in which the circlip (retaining ring) (**8**, **81**, **82**, **83**, **84**, and **85**) is previously fitted into retaining groove **26** of cylindrical section **30** of second constant velocity (universal) joint J**2**. However, the linkage of both of the output shaft and the cylindrical section is not limited to this form.

[0122] In other words, after output shaft **3** is inserted into insertion hole **30***a* of cylindrical section **30** without previous external fitting of circlip (retaining ring) **8**, **81**, **82**, **83**, **84**, or **85** into retaining groove **26** from the external, circlip (retaining ring) **8**, **81**, **82**, **83**, **84**, or **85** may engageably be stopped into engagement stop groove **14** of output shaft **3** with circlip (retaining ring) **8**, **81**, **82**, **83**, **84**, or **85** externally fitted into retaining groove **26** from the external.

[0123] In addition, in the respective embodiments, as the linkage structure of propeller shaft (power transmission shaft) **1**, the linkage between second constant velocity (universal) joint J**2** and output shaft **3** is exemplified. As described before, the present invention is applicable to the same as the linkage of first constant velocity (universal) joint J**1** and input shaft **2**.

[0124] Furthermore, the respective embodiments exemplify the present invention applicable to the constant velocity (universal) joint of the propeller shaft (the power transmission shaft). However, the present invention may be applied to another joint, for example, a rubber coupling, a Cardan joint, or so forth in addition to the constant velocity (universal) joint.

[0125] As the propeller shaft (power transmission shaft) based on the above-described embodiments, the following forms may be considered.

[0126] That is, the propeller shaft (power transmission shaft) includes, as a first form, a shaft section intervened between a first shaft of a driving source side and a second shaft of a driving wheel side which are a pair of vehicle side rotational shafts; a cylindrical section disposed integrally rotatable with the shaft section and into an inner peripheral side of which the vehicle side rotational shafts are inserted; a through hole penetrated in a peripheral direction range of a portion of the cylindrical section and opposed against an engagement stop groove in a radial direction, the engagement stop groove being disposed on the outer peripheral side of the vehicle side rotational shafts in a state in which the vehicle side rotational shafts are inserted into inner peripheral side of the cylindrical section; and a circlip (retaining ring) fitted into the cylindrical section from the outer peripheral side thereof, a portion of the circlip in a peripheral direction enclosing the outer peripheral side of the cylindrical section, and another portion of the circlip in the peripheral direction being exposed to the inner peripheral side of the cylindrical section via the through hole to be engageably inserted (stopped) into the engagement stop groove.

[0127] In a preferred embodiment of the propeller shaft (power transmission shaft), the cylindrical section includes a retaining groove retaining the circlip (retaining ring) at a portion of the cylindrical section in the peripheral direction range in which the through holes are disposed other than the through holes.

[0128] Furthermore, in another preferred embodiment, the retaining groove is formed annually, in any of forms of the propeller shaft (power transmission shaft).

[0129] In another preferred embodiment, in any of forms of the propeller shaft (power transmission shaft), the through holes are constituted by first and second through holes spaced apart from each other in the peripheral direction of the cylindrical section.

[0130] In another preferred embodiment, the first and second through holes are arranged at positions symmetrically to the rotational center axial line of the cylindrical section.

[0131] In another preferred embodiment, the shapes and positions of the first and second through holes are orthogonal to the rotation center axial line of the cylindrical section and are formed to be line symmetrical to a phantom line passing through the rotational center axial line, and the circlip (retaining ring) is disposed line symmetrically to the phantom line.

[0132] In a still another preferred embodiment, in any of the forms of the propeller shaft (power transmission shaft) the first and second through holes are formed by a deletion of a portion of the cylindrical section, a pair of plane sections are formed at both end section of the deleted cross section in the peripheral direction of the rotation center axial line, and the pair of plane sections are disposed in parallel to the phantom line.

[0133] In a further preferred embodiment, in any of the forms of the propeller shaft (power transmission shaft), the circlip (retaining ring) includes a straight line section which is formed in a straight line shape from a portion of the circlip (retaining ring) which is brought in contact with the pair of planar sections.

[0134] In a further another preferred embodiment, in any of the forms of the propeller shaft (power transmission shaft), the circlip (retaining ring) includes the projection sections which project a portion of the circlip (retaining ring) passing through the rotational center axial line and intersecting a second phantom line orthogonal to the rotational center axial line toward a radial directional outside of the rotational center axial line.

[0135] In a further another preferred embodiment, in any of the forms of the propeller shaft (the power transmission shaft), the cylindrical section includes the retaining groove which retains the circlip (retaining ring) at a portion of the peripheral direction range in which the through holes are disposed other than the through holes. When a phantom line passing through the rotational center axial line and orthogonal to the rotational center axial line is a second phantom line, the first and second through holes are formed line symmetrically to the second phantom line and the retaining groove is formed line symmetrically to the second phantom line.

[0136] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), the through hole is constituted by the first and second through holes spaced from each other in the peripheral direction of the cylindrical section and the circlip (retaining ring) includes: a first insertion section inserted into the first through hole; a second insertion section inserted into the second through hole; a connection section which connects the peripheral directional one end section of the first insertion section and the peripheral directional one end section of the second insertion section; the first engagement section

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extended at the other end side of the first insertion section; and a second engagement section extended at the peripheral directional other end side of the second insertion section.

[0137] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), the first and second engagement sections are formed not to be protruded from the outer peripheral surface of the cylindrical section in an appropriately mounted state.

[0138] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), the first and second engagement sections include jig engagement sections which engage a jig which serves to remove the circlip (retaining ring).

[0139] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), the gap is provided between the first and second engagement sections and the cylindrical section in the radial direction of the rotation center axial line.

[0140] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), portions of the first and second engagement sections which are brought in contact with the cylindrical section during the fitting of the circlip (retaining ring) onto the retaining groove are bent in the arc shapes.

[0141] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), the engagement stop groove includes a bottom surface and the pair of rising surfaces disposed at the axial directional both sides of the bottom surface and, concerning one of the pair of rising surfaces which is the opposite side to the pull-out direction of the vehicle side rotational shafts, from among angles formed between the corresponding one of the pair of rising surfaces and the rotation center axial line, one of the angles at the engagement stop groove side is larger than 90 degrees but is smaller than 180 degrees.

[0142] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), concerning one of the pair of rising surfaces in the pull-out direction of the vehicle side rotational shafts, the angle formed between the corresponding one of the pair of rising surfaces and the rotation center axial line is set at substantially a right angle.

[0143] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), the vehicle side rotational shafts have a tapered section at tip end sides of the cylindrical section.

[0144] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), the vehicle side rotational shafts include a butting section against which the end section of the cylindrical section is butted in a state in which the vehicle side rotational shafts are appropriately inserted.

[0145] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), the vehicle side rotational shafts include the colored section hidden by the cylindrical section in a state in which the vehicle side rotational shafts are appropriately inserted into the cylindrical section.

[0146] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), the cylindrical section includes the boot attachment section which serves as the attachment of the water-proof boot at a portion of the outer peripheral side of the cylindrical section which is an opposite side to the insertion inlet of the vehicle side rotational shafts.

[0147] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), either the cylindrical section or the circlip (retaining ring) includes a caulking section which caulks a peripheral directional section of the cylindrical section or the circlip (retaining ring) in a state in which the circlip is fitted into the cylindrical section.

[0148] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), the though hole is constituted by the first through hole and the second through hole which are spaced apart from each other in the peripheral direction of the cylindrical section and the circlip includes the first insertion section inserted into the first through hole and the second insertion section inserted into the first through hole, and the connection section which connects the peripheral direction end section of the first insertion section and the peripheral direction end section of the second insertion section.

[0149] In a further another preferred embodiment, in any one of the forms of the propeller shaft (power transmission shaft), the connection section is formed in such a way that a portion of the connection section is offset toward the outside in the radial direction of the cylindrical section and is projected exceeding the outer peripheral surface of the cylindrical section.

[0150] In addition, as a linkage method of the propeller shaft (power transmission shaft) based on the above-described embodiments, the following form described below may be considered.

[0151] That is, a linkage method of the propeller shaft (power transmission shaft), the propeller shaft (power transmission shaft) includes: a shaft section a shaft section intervened between a first shaft of a driving source side and a second shaft of a driving wheel side which are a pair of vehicle side rotational shafts; a cylindrical section disposed integrally rotatable with the shaft section and into an inner peripheral side of which the vehicle side rotational shafts are inserted; a through hole penetrated in a peripheral direction range of a portion of the cylindrical section and opposed against an engagement stop groove in a radial direction, the engagement stop groove being disposed on an outer peripheral side of the vehicle side rotational shafts on a state in which the vehicle side rotational shafts are inserted into an inner peripheral side of the cylindrical section; and a circlip (retaining ring) fitted into the cylindrical section from the outer peripheral side thereof, a portion of the circlip in a peripheral direction enclosing the outer peripheral side of the cylindrical section, and another portion of the circlip in the peripheral direction being exposed to the inner peripheral side of the cylindrical section via the through hole to be engageably inserted into the engagement stop groove, the portion of the circlip (retaining ring) in the peripheral direction exposed to the inner peripheral side of the cylindrical section via the through hole is engageably inserted into the engagement stop groove by inserting the vehicle side rotational shafts into the cylindrical section in the state in which the circlip (retaining ring) is fitted onto the cylindrical section.

[0152] This application is based on a prior Japanese Patent Application No. 2016-129514 filed in Japan on Jun. 30, 2016. The entire contents of this Japanese Patent Application No. 2016-129514 are hereby incorporated by reference.

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Although the invention has been described above by reference to certain embodiments of the invention, the invention is not limited to the embodiment described above. Modifications and variations of the embodiments described above will occur to those skilled in the art in light of the above teachings.

[0153] The scope of the invention is defined with reference to the following claims.

What is claimed is:

1. A power transmission shaft interposed between a first shaft section and a second shaft section, the first shaft section and the second shaft section being a pair of vehicle side rotational shaft sections, the first shaft section being disposed on a driving source side of the vehicle and the second shaft section being disposed on a driving wheel side, the power transmission shaft transmitting a rotation of the driving source to the driving wheel and comprising:

a shaft section disposed between the first shaft section and the second shaft section;

a cylindrical section rotated integrally with the shaft section and formed cylindrically, each of the pair of vehicle side rotational shaft sections being inserted into an inside of the cylindrical section;

a through hole disposed in the cylindrical section and penetrated radially with respect to a rotational axial line of the pair of vehicle side rotational shaft sections, each of the pair of vehicle side rotational shaft sections having an engagement groove disposed on an outer peripheral side of the pair of vehicle side rotational shaft sections and extended in a direction around the rotational axial line of the pair of vehicle side rotational shaft sections and the engagement groove being exposed from the through hole in a state in which each of the pair of vehicle side rotational shaft sections is inserted into the cylindrical section; and

a circlip disposed to enclose at least a portion of the outer peripheral side of the cylindrical section, a portion of the circlip being inserted into the through hole from the outer peripheral side of the cylindrical section and being engaged with the engagement groove.

2. The power transmission shaft as claimed in claim **1**, wherein the cylindrical section includes a retaining groove disposed on a portion of the outer peripheral side of the cylindrical section other than the portion of the cylindrical section at which the through hole is disposed, in the direction around the rotational axial line.

3. The power transmission shaft as claimed in claim **2**, wherein the retaining groove is an annular groove.

4. The power transmission shaft as claimed in claim **1**, wherein the through hole includes a first through hole and a second through hole, the first through hole and the second through hole being spaced apart from each other by a predetermined distance in the direction around the rotational axial line.

5. The power transmission shaft as claimed in claim **4**, wherein the first through hole and the second through hole are disposed at symmetrical positions to the rotational axial line.

6. The power transmission shaft as claimed in claim **5**, wherein shapes and positions of the first through hole and the second through hole are orthogonal to the rotational axial line, are disposed symmetrically to a phantom line passing through the rotational axial line, and the circlip is disposed line symmetrically to the phantom line.

7. The power transmission shaft as claimed in claim **6**, wherein each of the first through hole and the second through hole is formed by an elimination of a portion of the cylindrical section, a pair of planer sections are formed at both end sections of an eliminated cross section of the cylindrical section in the direction around the rotational axial line.

8. The power transmission shaft as claimed in claim **7**, wherein the circlip includes a straight line section, a position of the straight line section at which the retaining groove is brought in contact with the pair of planer sections are formed in a straight line.

9. The power transmission shaft as claimed in claim **8**, wherein the retaining groove includes a projection section formed to project toward an outside in a radial direction of the rotational axial line at a portion of the circlip passing through the rotational axial line and intersecting a second phantom line orthogonal to the rotational axial line.

10. The power transmission shaft as claimed in claim **5**, wherein the cylindrical section includes a retaining groove disposed on an outer peripheral side of the cylindrical section and disposed at a portion of the cylindrical section other than portions of the cylindrical section at which the pair of through holes are disposed in the direction around the rotational axial line, when a phantom line passing through the rotational axial line and orthogonal to the rotational axial line is a second phantom line, the first through hole and the second through hole being formed line symmetrically to the phantom line and the second phantom line and the retaining groove being formed line symmetrically to the phantom line and the second phantom line.

11. The power transmission shaft as claimed in claim **1**, wherein the through hole includes a first through hole and a second through hole, both of the first and second through holes being spaced apart from each other by a predetermined distance in a direction around the rotational axial line, the retaining ring includes: a first inserting section inserted into the first through hole; a second inserting section inserted into the second through hole; a connection section connecting one end side of the first inserting section to one end side of the second through hole; a first engagement section disposed on the other end side of the first inserting section and extended in an opposite side of the first inserting section in the direction around the rotational axial line; and a second engagement section disposed on the other end side of the second inserting section and extended in an opposite side to the second inserting section.

12. The power transmission shaft as claimed in claim **11**, wherein the first engagement section and the second engagement section are formed not to be protruded from the outer peripheral surface of the cylindrical section in a state in which the circlip is normally attached.

13. The power transmission shaft as claimed in claim **11**, wherein the first engagement section and the second engagement section include a jig purpose engagement section to which a jig to remove the retaining ring is engaged.

14. The power transmission shaft as claimed in claim **11**, wherein the first engagement section and the second engagement section include a gap against the cylindrical section in the radial direction of the rotational axial line.

15. The power transmission shaft as claimed in claim **1**, wherein the engagement groove of the pair of the vehicle side rotational shaft sections includes: a bottom surface; and a pair of rising surfaces disposed on both sides of the bottom

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surface in the direction of the rotational axial line, one of the pair of rising surfaces which is an opposite side to a direction in which a corresponding one of the vehicle side rotational shaft sections is pulled out from the cylindrical section being formed in such a way that one of angles formed between a corresponding one of the pair of rising surfaces which is the opposite side to the direction in which the corresponding one of the vehicle side rotational shaft sections is pulled out from the cylindrical section and the rotational axial line which is the engagement groove side is larger than 90 degrees but smaller than 180 degrees.

16. The power transmission shaft as claimed in claim **15**, wherein one of the pair of rising surfaces which is at the side of the direction in which a corresponding one of the vehicle side rotational shaft sections is pulled out is formed in such a way that an angle formed between a corresponding one of the pair of rising surfaces which is at the side of the direction in which a corresponding one of the vehicle side rotational shaft sections is pulled out and the corresponding one of the vehicle side rotational shaft sections is a substantially right angle.

17. The power transmission shaft as claimed in claim **1**, wherein the vehicle side rotational shaft sections include a tapered section formed at a tip side of an insertion side of the cylindrical section in such a way that a diameter of one of the vehicle side rotational shaft sections becomes smaller as a corresponding one of the vehicle side rotational shaft sections goes toward a tip side.

18. The power transmission shaft as claimed in claim **1**, wherein each of the vehicle side rotational shaft sections includes a butting section against which an end section of the cylindrical section is butted.

19. The power transmission shaft as claimed in claim **1**, wherein the vehicle side rotational shaft sections include a colored section colored on outer peripheral side of the vehicle side rotational shaft sections and which is enclosed by the cylindrical section in a state in which the vehicle side rotational shaft section is normally inserted into the cylindrical section.

20. The power transmission shaft as claimed in claim **1**, wherein the cylindrical section includes a boot attachment section disposed at an opposite side to an insertion inlet into which the vehicle side rotational shaft sections are inserted with respect to the through hole at the outer peripheral side of the cylindrical section.

21. The power transmission shaft as claimed in claim **1**, wherein either the retaining ring or the cylindrical section includes a caulking section fixed by caulking in a state in which the retaining ring is attached to the cylindrical section.

22. The power transmission shaft as claimed in claim **21**, wherein the through hole includes a first through hole and a second through hole disposed to be spaced apart from each other by a predetermined distance in a direction around the rotational axial line and the circlip includes a first insertion section inserted into the first through hole; a second insertion section inserted into the second through hole; and a connection section connecting one end side of the first insertion section and one end side of the second insertion section.

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