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Torque transfer joint and electric motor with worm reduction gear

Abstract

A torque transmission joint includes a first elastic body having a plurality of first elastic pieces pinched in a circumferential direction between respective first convex portions and a coupling, and a second elastic body having a plurality of second elastic pieces pinched in the circumferential direction between respective second convex portions and the coupling.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application is a National Stage of International Application No. PCT/JP2020/044945 filed Dec. 2, 2020, claiming priority based on Japanese Patent Application No. 2019-219337, filed Dec. 4, 2019, the contents of all of which are incorporated herein by reference in their entirety.

TECHNICAL FIELD

(2) The present invention relates to a torque transmission joint incorporated into various mechanical devices and used to transmit torque between a pair of rotating members, and a worm reducer-attached electric motor including the torque transmission joint.

BACKGROUND ART

(3) A power steering device is widely used because the power steering device can reduce force required for a driver to operate a steering wheel. There are two types of power steering devices: an electric power steering device which uses an electric motor as an auxiliary power source, and a hydraulic power steering device which uses hydraulic pressure as an auxiliary power source. Of these, the electric power steering device has advantages of being smaller and lighter than the hydraulic power steering device, being easy to control an amount of the auxiliary power, having less power loss of an engine, and the like, and thus the electric power steering device is used more frequently.

(4) In the electric power steering device, the auxiliary power of the electric motor is applied to a rotation shaft for steering which rotates based on an operation of the steering wheel via a reducer. As a reducer, a worm reducer is widely used because a large reduction ratio and the like can be obtained.

(5) However, since there is an unavoidable backlash in a meshing portion between a worm wheel and a worm which compose the worm reducer, there is a problem that it is easy to generate a rattling noise when a rotation direction of the worm wheel changes.

(6) In JP-A-2004-306898 (Patent Document 1), a structure is disclosed in which an urging member including a spring between a bearing placed on a tip side of a worm, which one of a pair of bearings for rotatably supporting the worm with respect to a housing, and the housing, and a tip portion of the worm is urged toward a worm wheel. According to such a structure, backlash of a meshing portion can be suppressed, and the generation of rattling noise at the meshing portion between the worm wheel and the worm can be suppressed.

PRIOR ART DOCUMENT

Patent Document

(7) Patent Document 1: JP-A-2004-306898

SUMMARY OF INVENTION

Technical Problem

(8) In the structure described in JP-A-2004-306898, by spline-engaging a spline shaft portion provided at a tip portion of an output shaft of an electric motor and a spline hole provided at a base end portion of the worm, the output shaft and the worm are connected to allow torque transmission. When the spline shaft portion and the spline hole are spline-engaged without any circumferential clearance (without backlash), no abnormal noise is generated at a connection portion (spline engagement portion) between the output shaft and the worm. However, in the structure described in JP-A-2004-306898, since it is necessary for the worm to be oscillated and displaced in order to urge the tip portion of the worm toward the worm wheel by the urging member, backlash at the spline engagement portion cannot be completely eliminated. Therefore, there is room for improvement in order to suppress the generation of abnormal noise.

(9) The present invention is made in view of the circumstances described above, and an object thereof is to realize a structure of a torque transmission joint which can smoothly transmit torque between a pair of rotating members and prevent generation of abnormal noise between the pair of rotating members even when central axes of the pair of rotating members do not match each other.

Solution to Problem

(10) A torque transmission joint of the present invention includes: a first rotating member having first convex portions protruding toward axial one side at a plurality of locations in a circumferential direction on an axial one side surface; a second rotating member having second convex portions protruding toward axial other side at a plurality of locations in the circumferential direction on an axial other side surface; a coupling having first recess portions which are opened at least on the axial other side surface and with which the first convex portions are respectively engaged to allow relative displacement in the circumferential direction at a plurality of locations in the circumferential direction and second recess portions which are opened at least on the axial one side surface and with which the second convex portions are respectively engaged to allow relative displacement in the circumferential direction at a plurality of locations in the circumferential direction which deviate from the first recess portions in the circumferential direction; a first elastic body having a plurality of first elastic pieces pinched in the circumferential direction between the respective first convex portions and the coupling; and a second elastic body having a plurality of second elastic pieces pinched in the circumferential direction between the respective second convex portions and the coupling.

(11) The coupling may include, a boss portion having a cylindrical or columnar shape, a plurality of arm portions protruding outward in a radial direction from a plurality of circumferential locations on an outer peripheral surface of the boss portion, a plurality of first side plate portions which protrude outward in the radial direction from a plurality of circumferential locations on an outer peripheral surface of an axial one side end of the boss portion and connect axial one side ends of a pair of the arm portions adjacent in the circumferential direction in the circumferential direction, and a plurality of second side plate portions which protrude outward in the radial direction from a plurality of circumferential locations deviating from the first side plate portions in the circumferential direction of an outer peripheral surface of an axial other side end of the boss portion and connect axial other side ends of a pair of the arm portions adjacent in the circumferential direction in the circumferential direction.

(12) In this case, each of the first recess portions is defined by an outer peripheral surface of the boss portion, an axial other side surface of each of the first side plate portions, and circumferential side surfaces of a pair of the arm portions facing each other with axial one side ends connected to each of the first side plate portions, and each of the second recess portions is defined by the outer peripheral surface of the boss portion, an axial one side surface of each of the second side plate portions, and circumferential side surfaces of a pair of the arm portions facing each other with axial other side ends connected to each of the second side plate portions.

(13) The coupling may have a first support portion for supporting the first elastic body on an axial other side surface of each of the second side plate portions and have a second support portion for supporting the second elastic body on an axial one side surface of each of the first side plate portions.

(14) The first elastic body may further include a plurality of first inner diameter side connection pieces and a plurality of first outer diameter side connection pieces which are arranged alternately in the circumferential direction, and first locking pieces. In this case, the first inner diameter side connection piece connects radial inner ends of a pair of the first elastic pieces adjacent in the circumferential direction, and the first outer diameter side connection piece connects radial outer ends of a pair of the first elastic pieces adjacent in the circumferential direction, and the first locking piece connects radial outer connection portions of a pair of the first elastic pieces with the radial inner ends connected by the first inner diameter side connection piece. The first elastic body is supported by the coupling by fitting a first supported portion formed of a pair of the first elastic pieces adjacent in the circumferential direction, the first inner diameter side connection piece, and the first locking piece onto the first support portion. The second elastic body may further include a plurality of second inner diameter side connection pieces and a plurality of second outer diameter

side connection pieces which are arranged alternately in the circumferential direction, and second locking pieces. In this case, the second inner diameter side connection piece connects radial inner ends of a pair of the second elastic pieces adjacent in the circumferential direction, and the second outer diameter side connection piece connects radial outer ends of a pair of the second elastic pieces adjacent in the circumferential direction, and the second locking piece connects radial outer ends of a pair of the second elastic pieces with the radial inner ends connected by the second inner diameter side connection piece. The second elastic body is supported by the coupling by fitting a second supported portion formed of a pair of the second elastic pieces adjacent in the circumferential direction, the second inner diameter side connection piece, and the second locking piece onto the second support portion.
(15) The coupling may have a first locking groove extending circumferentially on a radial outer surface of the first support portion to lock the first locking piece, and have a second locking groove extending circumferentially on a radial outer surface of the second support portion to lock the second locking piece.
(16) The first recess portion may have a larger circumferential width dimension between axial other side portions of inner surfaces facing each other in the circumferential direction than a circumferential width dimension between axial one side portions, and the second recess portion may have a larger circumferential width dimension between axial one side portions of inner surfaces facing each other in the circumferential direction than a circumferential width dimension between axial other side portions.
(17) In a state where the first elastic piece is elastically crushed in the circumferential direction and a circumferential inner surface of the first recess portion abuts on a circumferential outer surface of the first convex portion, and the second elastic piece is elastically crushed in the circumferential direction and a circumferential inner surface of the second recess portion abuts on a circumferential outer surface of the second convex portion, it is preferable that an axial other side portion of a portion abutting on a circumferential outer surface of the first convex portion of a circumferential inner surface of the first recess portion and an axial one side portion of a portion abutting on a circumferential outer surface of the second convex portion of a circumferential inner surface of the second recess portion overlap in the circumferential direction.
(18) The first elastic body may have a plurality of first protrusions protruding toward the axial other side on an axial other side surface, and the second elastic body may have a plurality of second protrusions protruding toward the axial one side on an axial one side surface.
(19) When the coupling is not tilted with respect to the axial direction, the plurality of first protrusions are not brought into contact with an axial one side surface of the first rotating member and the plurality of second protrusions are not brought into contact with an axial other side surface of the second rotating member.
(20) When the coupling is tilted with respect to the axial direction, the plurality of first protrusions are brought into contact with the axial one side surface of the first rotating member and the plurality of second protrusions are brought into contact with the axial other side surface of the second rotating member.
(21) It is preferable that the first elastic body and the second elastic body have the same shape and dimensions, and be made of the same material.
(22) A worm reducer-attached electric motor of the present invention includes, a worm wheel having a wheel tooth on an outer peripheral surface, a worm having a worm tooth which meshes with the wheel tooth on an outer peripheral surface, an electric motor which has an output shaft, and a torque transmission joint which connects the output shaft and the worm so as to allow torque transmission.
(23) In particular, in the worm reducer-attached electric motor of the present invention, the torque transmission joint is composed of the torque transmission joint of the present invention, the first rotating member is composed of the worm or is supported and fixed to the worm, and the second

rotating member is composed of the output shaft or is supported and fixed to the output shaft.
Advantageous Effects of Invention
(24) According to the torque transmission joint of the present invention, even when central axes of a pair of rotating members do not match each other, torque can be smoothly transmitted between the pair of rotating members, and abnormal noise can be prevented from being generated between the pair of rotating members.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) FIG. **1** is a partially cut side view illustrating an example of an electric power steering device including a worm reducer-attached electric motor of an example according to an embodiment of the present invention.
(2) FIG. **2** is a cross-sectional view taken along the line A-A of FIG. **1**.
(3) FIG. **3**A is an end view illustrating a torque transmission joint of an example according to the embodiment of the present invention, FIG. **3**B is a side view seen from the left side of FIG. **3**A, and FIG. **3**C is a cross-sectional view taken along the line B-B of FIG. **3**A.
(4) FIG. **4** is a cross-sectional view taken along the line C-C of FIG. **3**B.
(5) FIG. **5** is a cross-sectional view taken along the line D-D of FIG. **3**C.
(6) FIG. **6** is a cross-sectional view taken along the line E-E of FIG. **3**C.
(7) FIG. **7** is a cross-sectional view taken along the line F-F of FIG. **3**C.
(8) FIG. **8** is a perspective view illustrating the torque transmission joint of the example according to the embodiment of the present invention, in which a part of the torque transmission joint is disassembled and a second rotating member is supported and fixed to a worm.
(9) FIG. **9** is an exploded perspective view of the torque transmission joint of the example according to the embodiment of the present invention.
(10) FIG. **10**A is an end view illustrating a first rotating member, FIG. **10**B is a side view seen from the left side of FIG. **10**A, and FIG. **10**C is a cross-sectional view taken along the line G-G of FIG. **10**A.
(11) FIG. **11**A is an end view illustrating the second rotating member, FIG. **11**B is a side view seen from the right side of FIG. **11**A, and FIG. **11**C is a cross-sectional view taken along the line H-H of FIG. **11**A.
(12) FIG. **12**A is an end view illustrating a coupling, FIG. **12**B is a side view seen from the right side of FIG. **12**A, and FIG. **12**C is a cross-sectional view taken along the line I-I of FIG. **12**A.
(13) FIG. **13** is an enlarged view of the J portion of FIG. **12**B.
(14) FIG. **14**A is a side view of an elastic body, FIG. **14**B is an end view seen from the right side of FIG. **14**A, and FIG. **14**C is an end view seen from the left side of FIG. **14**A.
(15) FIG. **15** is a view corresponding to FIG. **13**, illustrating a modification example of the example of the embodiment.
(16) FIG. **16** is a partially cut side view illustrating a pinion assist type electric power steering device in which the worm reducer-attached electric motor of the present invention can be incorporated.
(17) FIG. **17** is a partially cut side view illustrating a double pinion type electric power steering device in which the worm reducer-attached electric motor of the present invention can be incorporated.
DESCRIPTION OF EMBODIMENT
Example of Embodiment
(18) FIGS. **1** to **14**C illustrate an example according to an embodiment of the present invention. This example is an example in which a worm reducer-attached electric motor of the present

invention is applied to a column assist type electric power steering device. In an electric power steering device **1**, rotation of a steering wheel **2** is transmitted to an input shaft **4** of a steering gear unit **3**. That is, the steering wheel **2** is supported and fixed to a rear end of a steering shaft **5**, and a front end of the steering shaft **5** is connected to a rear end of an intermediate shaft **7** via a universal joint **6***a*. A front end of the intermediate shaft **7** is connected to the input shaft **4** via another universal joint **6***b*. Rotation of the input shaft **4** is converted into a linear motion in an axial direction of a rack shaft (not illustrated) arranged in a width direction of a vehicle body in the steering gear unit **3**. When a pair of tie rods **8** connected to ends of the rack shaft on both sides in the axial direction are pushed and pulled along with the linear motion of the rack shaft, a steered vehicle wheel is given a steering angle. The steering shaft **5** is rotatably supported inside a steering column **9** supported by the vehicle body.

(19) The electric power steering device **1** includes a worm reducer-attached electric motor **10**. The electric power steering device **1** of this example is configured so that the force required for a driver to operate the steering wheel **2** can be reduced by applying the power of the worm reducer-attached electric motor **10** to the steering shaft **5**. The worm reducer-attached electric motor **10** includes an electric motor **11**, a worm reducer **12**, and a torque transmission joint **13**.

(20) The electric motor **11** has an output shaft **14**. The electric motor **11** rotationally drives the output shaft **14** in both directions based on energization.

(21) The worm reducer **12** includes a housing **15**, a worm wheel **16**, and a worm **17**.

(22) The housing **15** includes a wheel accommodation portion **18** and a worm accommodation portion **19** having a central axis at a position twisted with respect to a central axis of the wheel accommodation portion **18** and having an axial intermediate portion opened in the wheel accommodation portion **18**.

(23) The wheel accommodation portion **18** is supported and fixed to a front end of the steering column **9** so that a central axis of the wheel accommodation portion **18** and a central axis of the steering column **9** are coaxial with each other.

(24) The worm accommodation portion **19** is formed in a cylindrical shape and has opening portions at both ends in the axial direction. The opening portion on axial one side (right side in FIG. **2**) of the worm accommodation portion **19** is closed by the electric motor **11** coupled and fixed to the housing **15**. The opening portion on axial other side (left side in FIG. **2**) of the worm accommodation portion **19** is closed by a lid body **20**.

(25) Regarding the worm accommodation portion **19**, the worm **17** rotatably supported inside the worm accommodation portion **19**, and the torque transmission joint **13** connecting the worm **17** and the output shaft **14** of the electric motor **11**, the axial one side is a base end side of the worm **17** and refers to the right side of FIG. **2**, FIG. **3**B, FIG. **3**C, FIG. **8**, FIG. **9**, FIG. **10**B, FIG. **10**C, FIG. **11**B, FIG. **11**C, FIG. **12**B, and FIG. **12**C, and the axial other side is a tip side of the worm **17** and refers to the left side of FIG. **2**, FIG. **3**B, FIG. **3**C, FIG. **8**, FIG. **9**, FIG. **10**B, FIG. **10**C, FIG. **11**B, FIG. **11**C, FIG. **12**B, and FIG. **12**C.

(26) The worm accommodation portion **19** has a cylindrical surface portion **21** having a cylindrical surface shape on an inner peripheral surface of an axial one side portion. In addition, the worm accommodation portion **19** has a step portion **22** which faces the axial one side and is provided at an axial other side end of the cylindrical surface portion **21**. Further, the worm accommodation portion **19** has a guide holding portion **23** which has a cylindrical surface shape and is provided on an inner peripheral surface of an axial other side portion.

(27) The worm wheel **16** has a wheel tooth **24** which is a helical gear on an outer peripheral surface, and is rotatably supported inside the wheel accommodation portion **18**. In this example, the worm wheel **16** is supported and fixed so as to rotate integrally with the steering shaft **5** around the front end of the steering shaft **5** rotatably supported inside the wheel accommodation portion **18**. The worm wheel **16** of this example is formed by coupling and fixing an outer wheel element **26** which is made of synthetic resin and has a wheel tooth **24** on an outer peripheral surface, around an

inner wheel element **25** which is made of metal and has a circular plate shape.
(28) The worm **17** has a screw-shaped worm tooth **27** which meshes with the wheel tooth **24** of the worm wheel **16** on an outer peripheral surface of the intermediate portion in the axial direction, and is rotatably supported inside the worm accommodation portion **19**.
(29) That is, the worm **17** is provided with a fitting cylinder portion **28** at a portion located further on the axial one side than the worm tooth **27**. The fitting cylinder portion **28** is rotatably supported by a ball bearing **29** with respect to the cylindrical surface portion **21** of the worm accommodation portion **19**. An outer ring of the ball bearing **29** is fitted in the cylindrical surface portion **21** in a state where the displacement in the axial direction is prevented. An inner ring of the ball bearing **29** is fitted onto the fitting cylinder portion **28** without rattling. In the worm **17**, between a flange portion **30** provided on a portion adjacent to the axial one side of the worm tooth **27** and a first rotating member **31** of the torque transmission joint **13** externally fitted and fixed to the base end portion of the worm **17**, the inner ring of the ball bearing **29** is pinched from both sides in the axial direction via a pair of elastic members **32**. The ball bearing **29** has a radial gap between the outer ring and the inner ring and a ball. In short, the fitting cylinder portion **28** of the worm **17** is supported so as to be able to allow rotational and oscillating displacements with respect to the cylindrical surface portion **21** of the worm accommodation portion **19**.
(30) The structure which supports a portion of the worm **17**, which is the portion located further on the axial one side than the worm tooth **27**, with respect to the worm accommodation portion **19** so as to be able to allow rotational and oscillating displacements is not limited to the example described above, and various structures can be adopted.
(31) The worm **17** is provided with a small diameter cylinder portion **33** at the tip portion thereof. The small diameter cylinder portion **33** is supported by a support bearing **34** and a guide member **35** with respect to the guide holding portion **23** of the worm accommodation portion **19** so as to be able to rotate freely and to recede from or approach the worm wheel **16**. An inner ring of the support bearing **34** is externally fitted and fixed to the small diameter cylinder portion **33**. An outer ring of the support bearing **34** is held inside the guide member **35** so as to be able to recede from or approach the worm wheel **16**. The guide member **35** is held inside the guide holding portion **23** in a state where rotation is blocked. The guide member **35** locks an elastic ring **37** to a locking groove **36** provided on an outer peripheral surface over the entire circumference. Then, the elastic ring **37** presses a portion of the outer peripheral surface of the guide member **35** far from the worm wheel **16** against the guide holding portion **23** to suppress rattling with respect to the guide holding portion **23**. The support bearing **34** is elastically urged toward the worm wheel **16** side by a leaf spring **38** arranged at an end on a side far from the worm wheel **16** in a portion between the outer ring of the support bearing **34** and the guide member **35**. This suppresses backlash between the wheel tooth **24** and the worm tooth **27**.
(32) The mechanism for elastically urging the tip portion of the worm **17** toward the worm wheel **16** side is not limited to the example described above, and various structures can be adopted.
(33) The worm **17** has the base end portion connected to the output shaft **14** of the electric motor **11** via the torque transmission joint **13** so that torque can be transmitted. The torque transmission joint **13** includes, for example, as illustrated in FIG. **9**, the first rotating member **31**, a second rotating member **39**, a coupling **40**, a first elastic body **41**, and a second elastic body **42**, each of which is coaxially arranged.
(34) The first rotating member **31** has first convex portions **43** protruding toward the axial one side at a plurality of locations in a circumferential direction on an axial one side surface. Specifically, as illustrated in FIGS. **10**A to **10**C, the first rotating member **31** includes a base portion **44** having a cylindrical shape, a flange portion **45** having an annular shape and protruding from an axial one side end of the base portion **44** toward the outside in a radial direction over the entire circumference, and first convex portions **43** protruding toward the axial one side from radial outer ends of a plurality of equidistant circumferential locations (four locations in the illustrated

example) on an axial one side surface of the flange portion **45**. The first convex portion **43** has a fan-shaped end surface shape when viewed from the axial direction. Further, the first rotating member **31** has a protruding portion **46** having a cylindrical shape and protruding from a radial inner end of an axial one side surface of the base portion **44** toward the axial one side over the entire circumference. The protruding portion **46** is a portion for ensuring the fitting length of the first rotating member **31** with respect to a base end portion of the worm **17**.
(35) The first rotating member **31** is externally fitted and fixed to the base end portion of the worm **17** so as to be able to transmit torque. The first rotating member **31** is made of a synthetic resin, a sintered metal, or the like, which has higher rigidity (difficult to elastically deform) than an elastic material such as an elastomer such as rubber forming the first elastic body **41**.
(36) The second rotating member **39** has second convex portions **47** protruding toward axial other side at a plurality of locations in the circumferential direction on an axial other side surface. Specifically, as illustrated in FIGS. **11**A to **11**C, the second rotating member **39** includes a base portion **48** having an annular plate shape and second convex portions **47** protruding from radial outer ends of a plurality of equidistant circumferential locations (four locations in the illustrated example) on an axial other side surface of the base portion **48** toward the axial other side. The second convex portion **47** has a fan-shaped end surface shape when viewed from the axial direction. Further, the second rotating member **39** has a protruding portion **49** having a cylindrical shape and protruding from a radial inner end of the axial other side surface of the base portion **48** toward the axial other side over the entire circumference. The protruding portion **49** is a portion for ensuring the fitting length of the second rotating member **39** with respect to the tip portion of the output shaft **14** of the electric motor **11**.
(37) The second rotating member **39** is externally fitted and fixed to the tip portion of the output shaft **14** of the electric motor **11** so as to be able to transmit torque. The second rotating member **39** is made of a synthetic resin, a sintered metal, or the like, which has higher rigidity (difficult to elastically deform) than an elastic material such as an elastomer such as rubber forming the second elastic body **42**. The second rotating member **39** can be made of the same material as the material forming the first rotating member **31**, or can be made of a different material.
(38) The coupling **40** has a first recess portion **50** and a second recess portion **51**. The first recess portions **50** are opened on an axial other side surface and the outer peripheral surface at a plurality of locations in the circumferential direction of the coupling **40**, and the first recess portion **50** is engaged with each first convex portion **43** of the first rotating member **31** so as to allow relative displacement in the circumferential direction. The second recess portions **51** are opened on an axial one side surface and the outer peripheral surface at a plurality of locations in the circumferential direction deviating from the first recess portions **50** of the coupling **40** in the circumferential direction, and the second recess portion **51** is engaged with each second convex portion **47** of the second rotating member **39** so as to allow relative displacement in the circumferential direction.
(39) In this example, as illustrated in FIGS. **12**A to **12**C, the coupling **40** includes a boss portion **52** having a cylindrical shape, a plurality of arm portions **53**, a plurality of first side plate portions **54**, and a plurality of second side plate portions **55**. The shape of the boss portion **52** is not limited to a cylindrical shape, and may be a columnar shape.
(40) Each of the arm portions **53** is formed in a rectangular plate shape, and the arm portions **53** protrude radially outward from a plurality of circumferential locations of an outer peripheral surface of the boss portion **52**. In this example, side surfaces of the arm portion **53** on both sides in the circumferential direction are formed of flat surfaces parallel to each other.
(41) Each of the first side plate portions **54** protrudes radially outward from a plurality of circumferential locations on an outer peripheral surface of an axial one side end of the boss portion **52**, and connects axial one side ends of a pair of arm portions **53** adjacent to each other in the circumferential direction. Each of the first side plate portions **54** has a fan-shaped end surface shape when viewed from the axial direction.

(42) Each of the second side plate portions **55** protrude radially outward from a plurality of circumferential locations deviating from the first side plate portions **54** in the circumferential direction on an outer peripheral surface of an axial other side end of the boss portion **52**, and connects axial other side ends of the pair of arm portions **53** adjacent to each other in the circumferential direction. That is, the first side plate portion **54** and the second side plate portion **55** are alternately arranged on the outer peripheral surface of the boss portion **52** in the circumferential direction. Each of the second side plate portions **55** has a fan-shaped end surface shape when viewed from the axial direction.

(43) Each of the first recess portions **50** is defined by the outer peripheral surface of the boss portion **52**, each axial other side surface of the first side plate portion **54**, and circumferential side surfaces of a pair of arm portions **53** facing each other with axial one side ends connected to each of the first side plate portion **54**. Each of the first convex portions **43** of the first rotating member **31** is engaged with each of the first recess portions **50** so as to allow relative displacement in the circumferential direction. That is, in a state where the first convex portion **43** is placed inside the first recess portion **50**, there is a circumferential gap between at least one of portions between the inner surfaces on both circumferential sides of the first recess portion **50** and the outer surfaces on both circumferential sides of the first convex portion **43**. Further, there is a radial gap between the radial inner surface of the first convex portion **43** and the outer peripheral surface of the boss portion **52**.

(44) Each of the second recess portions **51** is defined by the outer peripheral surface of the boss portion **52**, each axial one side surface of the second side plate portion **55**, and circumferential side surfaces of a pair of arm portions **53** facing each other with axial other side ends connected to each of the second side plate portion **55**. Each of the second convex portions **47** of the second rotating member **39** is engaged with each of the second recess portions **51** so as to allow relative displacement in the circumferential direction. That is, in a state where the second convex portion **47** is placed inside the second recess portion **51**, there is a circumferential gap between at least one of portions between the inner surfaces on both circumferential sides of the second recess portion **51** and the outer surfaces on both circumferential sides of the second convex portion **47**. Further, there is a radial gap between the radial inner surface of the second convex portion **47** and the outer peripheral surface of the boss portion **52**.

(45) In other words, each of the first convex portions **43** of the first rotating member **31** and each of the second convex portions **47** of the second rotating member **39** are alternately arranged in the circumferential direction. Further, the arm portion **53** of the coupling **40** is arranged so as to allow circumferential displacement between the outer surface in the circumferential direction of the first convex portion **43** and the outer surface in the circumferential direction of the second convex portion **47**.

(46) Further, in a state where the first convex portion **43** is arranged inside the first recess portion **50** and the second convex portion **47** is arranged inside the second recess portion **51**, at least a part of the first convex portion **43** and the second convex portion **47** overlap in the axial direction. That is, as illustrated in FIG. **4**, in the C-C cross section of FIG. **3**B, the first convex portion **43** and the second convex portion **47** face each other in the circumferential direction. Therefore, even when the coupling **40** is damaged, the torque transmission function can be maintained by the first convex portion **43** and the second convex portion **47**.

(47) Further, the coupling **40** has a first support portion **56** for supporting the first elastic body **41** on an axial other side surface of each of the second side plate portions **55**. Also, the coupling **40** has a second support portion **57** for supporting the second elastic body **42** on an axial one side surface of each of the first side plate portions **54**.

(48) Each of the first support portions **56** has a fan-shaped end surface shape when viewed from the axial direction, and protrudes from the axial other side surface of the second side plate portion **55** toward the axial other side. In this example, each of the first support portions **56** has a first locking

groove **58** extending circumferentially on the radial outer surface.
(49) Each of the second support portions **57** has a fan-shaped end surface shape when viewed from the axial direction, and protrudes from an axial one side surface of the first side plate portion **54** toward the axial one side. In this example, each of the second support portions **57** has a second locking groove **59** extending in the circumferential direction on the radial outer surface.
(50) The coupling **40** is made of a material that is more rigid (difficult to elastically deform) than the materials forming the first elastic body **41** and the second elastic body **42**, and that can reduce the impact of contact with the first convex portion **43** of the member **31** and the second convex portion **47** of the second rotating member **39**. Specifically, the coupling **40** can be made of polyphenylene sulfide (PPS), polyetheretherketone (PEEK), or nylon, a resin obtained by mixing reinforcing fibers with these, an elastomer such as rubber, a belt material obtained by reinforcing rubber with woven cloth, or the like.
(51) The first elastic body **41** has a plurality of first elastic pieces **60** pinched in the circumferential direction between the respective first convex portions **43** of the first rotating member **31** and the coupling **40**. Specifically, as illustrated in FIGS. **14**A to **14**C, the first elastic body **41** includes a plurality of (eight in the illustrated example) first elastic pieces **60**, a plurality of (four each in the illustrated example) first inner diameter side connection pieces **61** and first outer diameter side connection pieces **62**, which are arranged alternately in the circumferential direction, and a plurality of (four in the illustrated example) first locking pieces **63**.
(52) Each of the first elastic pieces **60** is formed in a rectangular columnar shape and is arranged in the radial direction.
(53) Each of the first inner diameter side connecting pieces **61** connects radial inner ends of a pair of first elastic pieces **60** adjacent to each other in the circumferential direction. Each of the first inner diameter side connecting pieces **61** has an arcuate end surface shape when viewed from the axial direction.
(54) Each of the first outer diameter side connection pieces **62** is arranged at a position deviated from the first inner diameter side connection piece **61** in the circumferential direction. In addition, each of the first outer diameter side connecting pieces **62** connects radial outer ends of a pair of first elastic pieces **60** adjacent to each other in the circumferential direction. Each of the first outer diameter side connection pieces **62** has an arcuate end surface shape when viewed from the axial direction.
(55) Each of the first locking pieces **63** is placed at a position where the circumferential phase of the first locking piece **63** coincides with that of the first outer diameter side connection piece **61**, in other words, at a position deviating from the first outer diameter side connection piece **62** in the circumferential direction. In addition, each of the first locking pieces **63** connects radial outer ends of a pair of first elastic pieces **60** adjacent to each other in the circumferential direction. Each of the first locking pieces **63** has an arcuate end surface shape when viewed from the axial direction. That is, the first outer diameter side connection piece **62** and the first locking piece **63** are alternately arranged in the circumferential direction so as to form an annular shape as a whole.
(56) In this example, the axial thickness of the first locking piece **63** is made smaller than the axial thickness of the first elastic piece **60**, the first inner diameter side connection piece **61**, and the first outer diameter side connection piece **62**. Specifically, the axial thickness of the first locking piece **63** is set to about half the axial thickness of the first elastic piece **60**, the first inner diameter side connection piece **61**, and the first outer diameter side connection piece **62**. The axial thicknesses of the first elastic piece **60**, the first inner diameter side connection piece **61**, and the first outer diameter side connection piece **62** are all the same. That is, the axial other side surface of the first locking piece **63** of the first elastic body **41** is located further on the axial one side than the axial other side surfaces of remaining portions.
(57) Further, the circumferential dimension of a portion between a pair of first elastic pieces **60** having radial outer ends connected to the first outer diameter side connection piece **62** is smaller

than the circumferential dimension of the first recess portion **50** of the coupling **40**.

(58) The first elastic body **41** has a first supported portion **73** having a substantially trapezoidal annular shape and including a pair of first elastic pieces **60** adjacent to each other in the circumferential direction, the first inner diameter side connection piece **61**, and the first locking piece **63**. Then, by engaging (fitting) each of the first supported portions **73** with each of the first support portions **56**, the first elastic body **41** is supported by the axial other side end of the coupling **40**. Specifically, the first locking piece **63** is locked to the first locking groove **58**, and the first support portion **56** is elastically pinched from both sides in the circumferential direction by a pair of first elastic pieces **60**, and the radial outer surface of the first inner diameter side connection piece **61** is elastically abutted onto the radial inner surface of the first support portion **56**, in such a manner that the first elastic body **41** is supported at the axial other side end of the coupling **40**.

(59) The first convex portion **43** of the first rotating member **31** is inserted in the portion between the pair of first elastic pieces **60** having the radial outer ends connected to the first outer diameter side connection piece **62** of the first elastic body **41**. That is, each of the first elastic pieces **60** is pinched between a circumferential side surface of each of the first convex portions **43** of the first rotating member **31** and a circumferential side surface of each of the first support portions **56** of the coupling **40**. The radial outer surface of the first convex portion **43** may be in contact with the radial inner surface of the first outer diameter side connection piece **62**, or may be non-contact therewith.

(60) Further, the first elastic body **41** has a plurality of (four in the illustrated example) first protrusions **64** protruding toward the axial other side on the axial other side surface. Specifically, the first elastic body **41** has the first protrusion **64** at a center position in the circumferential direction of an axial other side surface of each of the first inner diameter side connection pieces **61**. When a central axis of the coupling **40** matches a central axis of the worm **17** and/or a central axis of the output shaft **14** (when the coupling **40** is not tilted with respect to the axial direction), each of the first protrusions **64** is not brought into contact with an axial one side surface of the flange portion **45** of the first rotating member **31**. On the contrary, when the central axis of the coupling **40** does not match the central axis of the worm **17** and/or the central axis of the output shaft **14** (when the coupling **40** is tilted with respect to the axial direction), each of the first protrusions **64** is elastically brought into contact with the axial one side surface of the flange portion **45** of the first rotating member **31**.

(61) The second elastic body **42** has a plurality of second elastic pieces **65** pinched in the circumferential direction between the respective second convex portions **47** of the second rotating member **39** and the coupling **40**. In this example, the second elastic body **42** has the same specifications as the first elastic body **41** (same shape, dimensions, and material). That is, as illustrated in FIGS. **14**A to **14**C, the second elastic body **42** includes the plurality of (eight in the illustrated example) second elastic pieces **65**, a plurality of (four each in the illustrated example) second inner diameter side connection pieces **66** and second outer diameter side connection pieces **67**, which are arranged alternately in the circumferential direction, and a plurality of (four in the illustrated example) second locking pieces **68**.

(62) The second elastic body **42** has a second supported portion **74** having a substantially trapezoidal annular shape and including a pair of second elastic pieces **65** adjacent to each other in the circumferential direction, the second inner diameter side connection piece **66**, and the second locking piece **68**. Then, by engaging (fitting) each of the second supported portions **74** with each of the second support portions **57**, the second elastic body **42** is supported by an axial one side end of the coupling **40**. Specifically, the second locking piece **68** is locked to the second locking groove **59**, and the second support portion **57** is elastically pinched from both sides in the circumferential direction by a pair of second elastic pieces **65**, and the radial outer surface of the second inner diameter side connection piece **66** is elastically abutted onto the radial inner surface of the second support portion **57**, in such a manner that the second elastic body **42** is supported at the axial one

side end of the coupling **40**.

(63) The second convex portion **47** of the second rotating member **39** is inserted in the portion between the pair of second elastic pieces **65** having the radial outer ends connected to the second outer diameter side connection piece **67** of the second elastic body **42**. That is, each of the second elastic pieces **65** is pinched between a circumferential side surface of each of the second convex portions **47** of the second rotating member **39** and a circumferential side surface of each of the second support portions **57** of the coupling **40**. The radial outer surface of the second convex portion **47** may be in contact with the radial inner surface of the second outer diameter side connection piece **67**, or may be non-contact therewith.

(64) Further, the second elastic body **42** has a plurality of (four in the illustrated example) second protrusions **69** protruding toward the axial one side on the axial one side surface. Specifically, the second elastic body **42** has the second protrusion **69** at a center position in the circumferential direction of an axial one side surface of each of the second inner diameter side connection pieces **66**. When a central axis of the coupling **40** matches the central axis of the worm **17** and/or the central axis of the output shaft **14** (when the coupling **40** is not tilted with respect to the axial direction), each of the second protrusions **64** is not brought into contact with the axial other side surface of the base portion **48** of the second rotating member **39**. On the contrary, when the central axis of the coupling **40** does not match the central axis of the worm **17** and/or the central axis of the output shaft **14** (when the coupling **40** is tilted with respect to the axial direction), each of the second protrusions **64** is elastically brought into contact with the axial other side surface of the base portion **48** of the second rotating member **39**.

(65) In the worm reducer-attached electric motor **10** of this example, when the torque transmitted between the output shaft **14** of the electric motor **11** and the worm **17** is relatively small, as the output shaft **14** rotates, the circumferential outer surface of the second convex portion **47** of the second rotating member **39** presses the circumferential outer surface of the second support portion **57** of the coupling **40** in the circumferential direction via the second elastic piece **65** of the second elastic body **42**. Then, as the coupling **40** rotates, the circumferential outer surface of the first support portion **56** of the coupling **40** presses the circumferential outer surface of the first convex portion **43** of the first rotating member **31** via the first elastic piece **60** of the first elastic body **41**. In this way, the rotational torque of the output shaft **14** is transmitted to the worm **17**.

(66) On the other hand, when the torque transmitted between the output shaft **14** and the worm **17** becomes large, the second elastic piece **65** of the second elastic body **42** is elastically crushed in the circumferential direction between the circumferential outer surface of the second support portion **57** of the coupling **40** and the circumferential outer surface of the second convex portion **47** of the second rotating member **39**, and the first elastic piece **60** of the first elastic body **41** is elastically crushed in the circumferential direction between the circumferential outer surface of the first support portion **56** of the coupling **40** and the circumferential outer surface of the first convex portion **43** of the first rotating member **31**. Then, the circumferential outer surface of the second convex portion **47** of the second rotating member **39** and the circumferential inner surface of the second recess portion **51** of the coupling **40** are in direct collision-contact (abutment) with each other, and the circumferential outer surface of the first convex portion **43** of the first rotating member **31** and the circumferential inner surface of the first recess portion **50** of the coupling **40** are in direct collision-contact with each other. Since the momentum of this collision-contact is weakened by the first elastic body **41** and the second elastic body **42**, with the collision-contact, it is possible to prevent abnormal noise such as a jarring rattling noise from being generated at an abutment portion between the circumferential outer surface of the second convex portion **47** and the circumferential inner surface of the second recess portion **51** and an abutment portion between the circumferential outer surface of the first convex portion **43** and the circumferential inner surface of the first recess portion **50**. Further, in this state, most of the rotational torque of the output shaft **14** is transmitted to the coupling **40** from the abutment portion between the circumferential outer

surface of the second convex portion **47** and the circumferential inner surface of the second recess portion **51**, and most of the torque transmitted to the coupling **40** is transmitted to the worm **17** from the abutment portion between the circumferential outer surface of the first convex portion **43** and the circumferential inner surface of the first recess portion **50**.

(67) Further, in the worm reducer-attached electric motor **10** of this example, even when the worm **17** is oscillated and displaced, or the central axis of the worm **17** and the central axis of the output shaft **14** do not match due to eccentricity, the coupling **40** is tilted with respect to the central axis of the worm **17** and/or the central axis of the output shaft **14** while elastically deforming the first elastic body **41** and/or the second elastic body **42**, in such a manner that the torque transmission between the output shaft **14** and the worm **17** can be performed smoothly.

(68) Further, in this example, the first elastic body **41** has the first protrusion **64** at the center position in the circumferential direction of an axial other side surface of each of the first inner diameter side connection pieces **61**. When the central axis of the coupling **40** matches the central axis of the worm **17** and/or the central axis of the output shaft **14** (when the coupling **40** is not tilted with respect to the axial direction), each of the first protrusions **64** is not brought into contact with the axial one side surface of the flange portion **45** of the first rotating member **31**. On the contrary, when the central axis of the coupling **40** does not match the central axis of the worm **17** and/or the central axis of the output shaft **14** (when the coupling **40** is tilted with respect to the axial direction), each of the first protrusions **64** is elastically brought into contact with the axial one side surface of the flange portion **45** of the first rotating member **31**. Therefore, when the coupling **40** is tilted with respect to the central axis of the worm **17** and/or the central axis of the output shaft **14**, the velocity at which the axial one side surface of the flange portion **45** of the first rotating member **31** collides with the first protrusion **64** can be made smaller (slower) than when the first protrusion **64** is arranged in a radial outer portion. Therefore, it is possible to suppress the abnormal noise caused by the axial one side surface of the flange portion **45** of the first rotating member **31** colliding with the first protrusion **64**.

(69) Similarly, the second elastic body **41** has the second protrusion **69** at the center position in the circumferential direction of an axial other side surface of each of the second inner diameter side connection pieces **66**. When the central axis of the coupling **40** matches the central axis of the worm **17** and/or the central axis of the output shaft **14** (when the coupling **40** is not tilted), each of the second protrusions **69** is not brought into contact with the axial other side surface of the base portion **48** of the second rotating member **39**. On the contrary, when the central axis of the coupling **40** does not match the central axis of the worm **17** and/or the central axis of the output shaft **14** (when the coupling **40** is tilted), each of the second protrusions **69** is elastically brought into contact with the axial other side surface of the base portion **48** of the second rotating member **39**. Therefore, when the coupling **40** is tilted with respect to the central axis of the worm **17** and/or the central axis of the output shaft **14**, the velocity at which the axial other side surface of the base portion **48** of the second rotating member **39** collides with the second protrusion **69** can be made smaller (slower). Therefore, it is possible to suppress the abnormal noise caused by the axial other side surface of the base portion **48** of the second rotating member **39** colliding with the second protrusion **64**.

(70) In addition, when carrying out the present invention, it is possible to make the rigidity of the first elastic body and the rigidity of the second elastic body different from each other, and it is also possible to make the circumferential gap between the first convex portion and the first recess portion and the circumferential gap between the second convex portion and the second recess portion different from each other. As a result, the magnitude of the transmission torque at which the circumferential outer surface of the first convex portion and the circumferential inner surface of the first recess portion are brought into collision-contact with each other can be different from the magnitude of the transmission torque at which the circumferential outer surface of the second convex portion and the circumferential inner surface of the second recess portion are brought into

collision-contact with each other. As a result, the torque transmission characteristics between the output shaft of the electric motor and the worm can be divided into multiple stages, and thus the operation feeling of the steering wheel can be improved.

Modification Example of One Example of Embodiment

(71) A modification example of the example according to the embodiment of the present invention will be described with reference to FIG. **15**. In this modification example, each of first recess portions **50***a* has a larger circumferential width dimension between axial other side portions of inner surfaces facing each other in the circumferential direction than a circumferential width dimension between axial one side portions, and each of the second recess portions **51***a* has a larger circumferential width dimension between axial one side portions of inner surfaces facing each other in the circumferential direction than a circumferential width dimension between axial other side portions.

(72) Specifically, stepped portions **72***a* are formed at axially intermediate portions of the circumferential inner surfaces (circumferential side surfaces, facing each other, of a pair of arm portions **53***a* with axial one side ends connected to the first side plate portion **54**) on both sides of the first recess portion **50***a* so as to be inclined in a direction away from each other as the stepped portions **72***a* extend toward the axial other side. As a result, the circumferential width dimension between the axial other side portions of the inner surfaces of the first recess portion **50***a* is made larger than the circumferential width dimension between the axial one side portions. In addition, stepped portions **72***b* are formed in a part of the axially intermediate portions of the circumferential inner surfaces (circumferential side surfaces, facing each other, of a pair of arm portions **53***a* with axial other side ends connected to the second side plate portion **55**) on both sides of the second recess portion **51***a*, which is the portion located further on the axial one side than the stepped portion **72***a*, so as to be inclined in a direction away from each other as the stepped portions **72***b* extend toward the axial one side. The circumferential width dimension between the axial one side portions of the inner surfaces of the second recess portion **51** is made larger than the circumferential width dimension between the axial other side portions.

(73) When transmitting a large torque between the output shaft **14** and the worm **17**, an axial one side portion (a portion surrounded by the chain line α in FIG. **15**) of the circumferential inner surface of the first recess portion **50***a* abuts on the circumferential outer surface of the first convex portion **43**, and the axial other side portion (a portion surrounded by the chain line β in FIG. **15**) of the circumferential inner surface of the second recess portion **51***a* abuts on the circumferential outer surface of the second convex portion **47**. As is clear from FIG. **15**, an axial other side end of the abutment portion between the circumferential inner surface of the first recess portion **50***a* and the circumferential outer surface of the first convex portion **43** and an axial one side end of the abutment portion between the circumferential inner surface of the second recess portion **51***a* and the circumferential outer surface of the second convex portion **47** overlap in the circumferential direction. Therefore, torque can be stably transmitted between the output shaft **14** and the worm **17** via the torque transmission joint **13**.

(74) Further, according to this modification example, even when the coupling **40***a* is tilted with respect to the central axis of the worm **17** and/or the central axis of the output shaft **14**, or is displaced relative to the axial direction, the abutment position of the circumferential inner surface of the first recess portion **50***a* with respect to the circumferential outer surface of the first convex portion **43** can be set to be close to the axial center position of the coupling **40***a*, and the abutment position of the circumferential inner surface of the second recess portion **51***a* with respect to the circumferential outer surface of the second convex portion **47** can be set to be close to the axial center position of the coupling **40***a*. That is, when the coupling **40***a* is tilted with respect to the central axis of the worm **17** and/or the central axis of the output shaft **14**, the coupling **40***a* can be tilted about the vicinity of the axial center position. From this aspect as well, torque can be stably transmitted between the output shaft **14** and the worm **17** via the torque transmission joint **13**.

(75) When carrying out this modification example, the circumferential width dimension of the axial other side portions of the inner surfaces facing each other in the circumferential direction of the first recess portion can be made constant over the axial direction and made larger than the circumferential width dimension of the axial one side portions, and the circumferential width dimension of the axial one side portions of the inner surfaces facing each other in the circumferential direction of the second recess portion can be made constant over the axial direction and made larger than the circumferential width dimension of the axial other side portions.
(76) The worm reducer-attached electric motor of the present invention is not limited to the column assist type electric power steering device, and can be incorporated into electric power steering devices having various structures.
(77) Specifically, for example, when the worm reducer-attached electric motor of the present invention is incorporated into a pinion assist type electric power steering device **1***a* as illustrated in FIG. **16**, the worm wheel **16** of the worm reducer **12** is supported and fixed to the input shaft **4***a* of the steering gear unit **3***a*.
(78) When the worm reducer-attached electric motor of the present invention is incorporated into a double pinion type electric power steering device **1***b* as illustrated in FIG. **17**, a rotation shaft **70** to which the worm wheel **16** is fitted and fixed is placed at a portion of the steering gear unit **3** that is deviated from the input shaft **4** in a width direction of a vehicle, and pinion tooth provided at a tip portion of the rotation shaft **70** are engaged with tooth portion of a rack **71** forming the steering gear unit **3**.
(79) Further, the worm reducer-attached electric motor of the present invention can be incorporated not only in the electric power steering device but also in various mechanical devices. Further, the torque transmission joint of the present invention is not limited to the worm reducer-attached electric motor, and can be used by being incorporated between a pair of rotating shafts arranged coaxially with each other in a torque transmission path of various mechanical devices.
(80) This application is based on a Japanese Patent Application No. 2019-219337 filed on Dec. 4, 2019, the contents of which are incorporated herein by reference.
REFERENCE SIGNS LIST
(81) **1**, **1***a*, **1***b*: electric power steering device **2**: steering wheel **3**, **3***a*: steering gear unit **4**, **4***a*: input shaft **5**: steering shaft **6***a*, **6***b*: universal joint **7**: intermediate shaft **8**: tie rod **9**: steering column **10**: worm reducer-attached electric motor **11**: electric motor **12**: worm reducer **13**: torque transmission joint **14**: output shaft **15**: housing **16**: worm wheel **17**: worm **18**: wheel accommodation portion **19**: worm accommodation portion **20**: lid body **21**: cylindrical surface portion **22**: step portion **23**: guide holding portion **24**: wheel tooth **25**: inner wheel element **26**: outer wheel element **27**: worm tooth **28**: fitting cylinder portion **29**: ball bearing **30**: flange portion **31**: first rotating member **32**: elastic member **33**: small diameter cylinder portion **34**: support bearing **35**: guide member **36**: locking groove **37**: elastic ring **38**: leaf spring **39**: second rotating member **40**: coupling **41**: first elastic body **42**: second elastic body **43**: first convex portion **44**: base portion **45**: flange portion **46**: protruding portion **47**: second convex portion **48**: base portion **49**: protruding portion **50**, **50***a*: first recess portion **51**, **51***a*: second recess portion **52**: boss portion **53**, **53***a*: arm portion **54**: first side plate portion **55**: second side plate portion **56**: first support portion **57**: second support portion **58**: first locking groove **59**: second locking groove **60**: first elastic piece **61**: first inner diameter side connection piece **62**: first outer diameter side connection piece **63**: first locking piece **64**: first protrusion **65**: second elastic piece **66**: second inner diameter side connection piece **67**: second outer diameter side connection piece **68**: second locking piece **69**: second protrusion **70**: rotation shaft **71**: rack **72***a*, **72***b*: stepped portion **73**: first supported portion **74**: second supported portion

Claims

1. A torque transmission joint, comprising: a first rotating member having first convex portions protruding toward axial one side at a plurality of locations in a circumferential direction on an axial one side surface; a second rotating member having second convex portions protruding toward axial other side at a plurality of locations in the circumferential direction on an axial other side surface; a coupling having first recess portions which are opened at least on the axial other side surface and with which the first convex portions are respectively engaged to allow relative displacement in the circumferential direction at a plurality of locations in the circumferential direction and second recess portions which are opened at least on the axial one side surface and with which the second convex portions are respectively engaged to allow relative displacement in the circumferential direction at a plurality of locations in the circumferential direction which deviate from the first recess portions in the circumferential direction; a first elastic body having a plurality of first elastic pieces pinched in the circumferential direction between the respective first convex portions and the coupling; and a second elastic body having a plurality of second elastic pieces pinched in the circumferential direction between the respective second convex portions and the coupling, wherein: the coupling includes: a boss portion having a cylindrical or columnar shape; a plurality of arm portions protruding outward in a radial direction from a plurality of circumferential locations on an outer peripheral surface of the boss portion; a plurality of first side plate portions which protrude outward in the radial direction from a plurality of circumferential locations on an outer peripheral surface of an axial one side end of the boss portion and connect axial one side ends of a pair of the arm portions adjacent in the circumferential direction in the circumferential direction; and a plurality of second side plate portions which protrude outward in the radial direction from a plurality of circumferential locations deviating from the first side plate portions in the circumferential direction of an outer peripheral surface of an axial other side end of the boss portion and connect axial other side ends of a pair of the arm portions adjacent in the circumferential direction in the circumferential direction; each of the first recess portions is defined by an outer peripheral surface of the boss portion, an axial other side surface of each of the first side plate portions, and circumferential side surfaces of a pair of the arm portions facing each other with axial one side ends connected to each of the first side plate portions; and each of the second recess portions is defined by the outer peripheral surface of the boss portion, an axial one side surface of each of the second side plate portions, and circumferential side surfaces of a pair of the arm portions facing each other with axial other side ends connected to each of the second side plate portions.
2. The torque transmission joint according to claim 1, wherein the coupling has a first support portion for supporting the first elastic body on an axial other side surface of each of the second side plate portions and has a second support portion for supporting the second elastic body on an axial one side surface of each of the first side plate portions.
3. The torque transmission joint according to claim 2, wherein: the first elastic body further includes a plurality of first inner diameter side connection pieces and a plurality of first outer diameter side connection pieces which are arranged alternately in the circumferential direction, and first locking pieces; the first inner diameter side connection piece connects radial inner ends of a pair of the first elastic pieces adjacent in the circumferential direction; the first outer diameter side connection piece connects radial outer ends of a pair of the first elastic pieces adjacent in the circumferential direction; the first locking piece connects radial outer ends of a pair of the first elastic pieces with the radial inner ends connected by the first inner diameter side connection piece; the first elastic body is supported by the coupling by fitting a first supported portion formed of a pair of the first elastic pieces adjacent in the circumferential direction, the first inner diameter side connection piece, and the first locking piece onto the first support portion; the second elastic body further includes a plurality of second inner diameter side connection pieces and a plurality of second outer diameter side connection pieces which are arranged alternately in the circumferential

direction, and second locking pieces; the second inner diameter side connection piece connects radial inner ends of a pair of the second elastic pieces adjacent in the circumferential direction; the second outer diameter side connection piece connects radial outer ends of a pair of the second elastic pieces adjacent in the circumferential direction; the second locking piece connects radial outer connection portions of a pair of the second elastic pieces with the radial inner ends connected by the second inner diameter side connection piece; and the second elastic body is supported by the coupling by fitting a second supported portion formed of a pair of the second elastic pieces adjacent in the circumferential direction, the second inner diameter side connection piece, and the second locking piece onto the second support portion.
4. The torque transmission joint according to claim 3, wherein the coupling has a first locking groove extending circumferentially on a radial outer surface of the first support portion to lock the first locking piece, and has a second locking groove extending circumferentially on a radial outer surface of the second support portion to lock the second locking piece.
5. The torque transmission joint according to claim 1, wherein: the first recess portion has a larger circumferential width dimension between axial other side portions of inner surfaces facing each other in the circumferential direction than a circumferential width dimension between axial one side portions; and the second recess portion has a larger circumferential width dimension between axial one side portions of inner surfaces facing each other in the circumferential direction than a circumferential width dimension between axial other side portions.
6. The torque transmission joint according to claim 5, wherein in a state where the first elastic piece is elastically crushed in the circumferential direction and a circumferential inner surface of the first recess portion abuts on a circumferential outer surface of the first convex portion, and the second elastic piece is elastically crushed in the circumferential direction and a circumferential inner surface of the second recess portion abuts on a circumferential outer surface of the second convex portion, an axial other side portion of a portion abutting on a circumferential outer surface of the first convex portion of a circumferential inner surface of the first recess portion and an axial one side portion of a portion abutting on a circumferential outer surface of the second convex portion of a circumferential inner surface of the second recess portion overlap in the circumferential direction.
7. The torque transmission joint according to claim 1, wherein: the first elastic body has a plurality of first protrusions protruding toward the axial other side on an axial other side surface; and the second elastic body has a plurality of second protrusions protruding toward the axial one side on an axial one side surface.
8. The torque transmission joint according to claim 1, wherein: when the coupling is not tilted with respect to the axial direction, the plurality of first protrusions are not brought into contact with an axial one side surface of the first rotating member and the plurality of second protrusions are not brought into contact with an axial other side surface of the second rotating member; and when the coupling is tilted with respect to the axial direction, the plurality of first protrusions are brought into contact with the axial one side surface of the first rotating member and the plurality of second protrusions are brought into contact with the axial other side surface of the second rotating member.
9. The torque transmission joint according to claim 1, wherein the first elastic body and the second elastic body have the same shape and dimensions, and are made of the same material.
10. A worm reducer-attached electric motor, comprising: an electric motor which has an output shaft; a worm reducer which includes a worm wheel having a wheel tooth on an outer peripheral surface and a worm having a worm tooth which meshes with the wheel tooth on an outer peripheral surface; and a torque transmission joint which connects the output shaft and the worm so as to allow torque transmission, wherein: the torque transmission joint is composed of the torque transmission joint according to claim 1; the first rotating member is composed of the worm or is supported and fixed to the worm; and the second rotating member is composed of the output shaft or is supported and fixed to the output shaft.