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Method for producing a joint member, and a method for producing an angular position holding apparatus by using a joint member produced by the producing method

Abstract

Provided is a novel producing method for enabling to easily produce a high-quality joint member by powder metallurgy, where the joint member has a male engaging portion and a female engaging portion arranged coaxially at different positions in the axial direction. A male member (**14**) having a male engaging portion (**10**) and a female member (**16**) having a female engaging portion (**12**) are formed separately by powder metallurgy, and then, the male member (**14**) and the female member (**16**) are combined in a relatively non-rotatable manner.

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Background/Summary

TECHNICAL FIELD

(1) The present invention relates to a method for producing a joint member, particularly, a joint member comprising a male engaging portion and a female engaging portion arranged coaxially at different positions in the axial direction, and a method for producing an angular position holding apparatus using a joint member produced by the producing method.

BACKGROUND ART

(2) Patent document 1 below discloses an angular position holding apparatus mounted on a shaft that transmits rotation torque from an input-side device such as an electromotive motor to an output-side device such as a hatchback of vehicle. The angular position holding apparatus holds the angular position of the output-side device even when the drive of the input-side device is stopped. In the angular position holding apparatus, when rotation torque is inputted from the input-side device, the shaft rotates against the required braking torque of a braking torque applying means. When no rotation torque is inputted from the input-side device, the shaft is held by the required braking torque.

PRIOR ART DOCUMENT

Patent Document

(3) Patent Document 1: JP6815567

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

(4) In the angular position holding apparatus disclosed in Patent document 1, a shaft extending from the input-side device is directly connected to the output-side device. In another constitutional examples of the input-side device and the output-side device, a shaft for transmitting rotation to both the input-side device and the output-side device is provided. In this example, it may be required to connect the shafts by the angular position holding apparatus. In other words, the angular position holding apparatus may be required to function as a joint to indirectly connect the shaft extending from the input-side device and the shaft extending from the output-side device. Here, in a case where the shaft extending from the input-side device and the shaft extending from the output-side device are both provided with female engagement portions, the shafts can be connected by preparing a joint member comprising male engaging portions to be engaged with both of the female engagement portions. In a case where the shafts are provided with male engagement portions, the shafts can be connected by preparing a joint member comprising female engaging portions to be engaged with both the male engagement portions. Further in a case where either the shaft extending from the input-side device or the shaft extending from the output-side device comprises the female engagement portion and the other shaft comprises the male engagement portion, the prepared joint member may be required to have the male engaging portion and the female engaging portion that are coaxially arranged, respectively.

(5) The braking torque applying means provided to the angular position holding apparatus disclosed in Patent document 1 is a coil spring, and it is mounted on the outer peripheral surface of an inner ring through which the shafts penetrate. The inner ring rotates against the braking torque

caused by the clamping force of the coil spring, that is, the inner ring slides relative to the coil spring. Therefore, the inner ring is required to have a considerable strength including wear resistance, and it is produced by powder metallurgy.
(6) In a case where the joint member, i.e., the joint member having the male engaging portion and the female engaging portion that are arranged coaxially, is used as the inner ring of the angular position holding apparatus disclosed in Patent document 1, there is a necessity that the joint member is provided with a cylindrical portion on which the coil spring is to be mounted. For this reason, it is impossible to arrange the male engaging portion and the female engaging portion coaxially at the same position in the axial direction, but the engaging portions are required to be arranged coaxially at different positions. As described later in detail with reference to the attached drawings, such a joint member (inner ring) is integrally produced by powder metallurgy using a molding die composed of a female mold having a bottomed recess portion extending in the axial direction and a male mold capable of entering the female mold. The male mold is provided with a protrusion protruding in the axial direction to define the female engaging portion. In production of a joint member by using the molding die, the interior of the female mold is filled with a powder, and then, the male mold is made enter the female mold so as to compress the powder, whereby a compact is formed. Later, the compact is taken out from the molding die and sintered.
(7) The joint member is formed as mentioned above by use of a molding die, more specifically, by making the male mold enter the female mold so as to compress the powder. In the formation, problems as described below may occur, because the protrusion protruding in the axial direction is formed on the pressing surface (lower surface) of the male mold, and the protrusion has an outer peripheral surface for defining the female engaging portion. The problems are: (1) since the protrusion tends to buckle because the axial load due to the compression is concentrated to the free end surface of the protrusion, the male mold is required to have a considerable strength; (2) a part of the powder present in front of the protrusion is forced radially outward rather than axially, and this causes unfavorable fluidity of the powder, so that excessive resistance is generated when making the male mold enter the female mold, i.e. excessive force is required to make the male mold enter the female mold; (3) since only the powder present in front of the protrusion is compressed to a relatively high density, the density distribution of the powder constituting the compact becomes uneven, and cracks may occur in the sintering.
(8) The aforementioned joint member, i.e., a joint member having a male engaging portion and the female engaging portion arranged coaxially at different positions in the axial direction, may be produced to have a high strength in an alternative method of scraping from a metal block. However, this method is unpractical because it is considerably disadvantageous from the viewpoint of production efficiency and cost.
(9) The present invention has been completed in view of these problems. The main technical object is to provide a novel producing method for facilitating production of a high-quality joint member having a male engaging portion and a female engaging portion arranged coaxially at different positions in the axial direction, by employing powder metallurgy for the production.
Means for Solving the Problems
(10) As a result of intense studies, the present inventor has found that the aforementioned main technical object can be achieved by forming a male member comprising a male engaging portion and a female member comprising a female engaging portion separately by powder metallurgy, and then, by combining the male member and the female member in a relatively non-rotatable manner.
(11) That is, the present invention provides, as a method of producing a joint member to achieve the aforementioned main technical objects, a method for producing a joint member having a male engaging portion and a female engaging portion arranged coaxially at different positions in the axial direction. The method is characterized in that a male member comprising the male engaging portion with a locking portion and a female member comprising the female engaging portion with a lock portion are formed separately by powder metallurgy, and then, the locking portion and the lock

portion are locked to combine the male member and the female member in a relatively non-rotatable manner.
(12) Preferably, both the male engaging portion and the female engaging portion are shaped like a gear. In this case, preferably the pitch diameter of the male engaging portion is equal to or less than the pitch diameter of the female engaging portion. Further, the male engaging portion is preferred to be a male serration, and the female engaging portion is preferred to be a female serration. It is preferable that the male member is provided with a flange portion to which one end of the male engaging portion is fixed, and the female member is provided with a recess portion to accept the flange portion, where the locking portion is a protrusion protruding radially outward on the outer peripheral surface of the flange portion, and the lock portion is a depression with which the protrusion is to fit on the inner peripheral surface of the recess portion. An angular position holding apparatus produced in this method comprises a joint member to mutually connect an input-side device and an output-side device and a braking torque applying means to apply required braking torque to the joint member, in which the joint member rotates against the required braking torque when rotation torque is inputted from the input-side device, and the joint member is held by the required braking torque when no rotation torque is inputted from the input-side device. The joint member can be produced by the aforementioned producing method. In this case, it is preferable that at least the female member of the joint member is arranged inside the fixed housing, and the joint member is supported from both axial sides by an end plate provided in the housing and a shield mounted on the housing. It is also preferable that the braking torque applying means is a coil spring composed of a wound portion formed of a helically wound wire and hook portions formed of the wire extending radially outward from the wound portion. The wound portion in a free state has an inner diameter smaller than the outer diameter of the female member of the joint member. The coil spring with the wound portion in a state in which the diameter thereof is enlarged is mounted on the outer peripheral surface of the female member, and the hook portions are to fit with the hook groove formed on the inner peripheral surface of the housing. The coil spring is non-rotatable relative to the housing. When the joint member rotates, the hook portions are pushed in the hook groove in the direction for loosing the coil spring.
Effect of the Invention
(13) According to the present invention, the joint member is produced by forming a male member comprising a male engaging portion and a female member comprising a female engaging portion separately by powder metallurgy, and then, by combining the male member and the female in a relatively non-rotatable manner. As a result, the female member can be formed while any protrusion protruding in the axial direction is not provided on the pressing surface of the male mold. Thereby, a high-quality joint member having a male engaging portion and a female engaging portion arranged coaxially at different positions in the axial direction can be produced easily by powder metallurgy, without facing the aforementioned problems that may occur in a case of integrally producing by powder metallurgy the joint member having the male engaging portion and the female engaging portion arranged coaxially at the different positions.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** includes diagrams showing the overall configuration of a preferred embodiment of an angular position holding apparatus comprising a joint member produced by the producing method of the present invention.
(2) FIG. **2** is a perspective exploded view showing the respective components of the angular position holding apparatus shown in FIG. **1**.
(3) FIG. **3** includes diagrams showing a male member constituting the joint member of the angular

position holding apparatus shown in FIG. **1**.

(4) FIG. **4** includes diagrams showing a female member constituting the joint member of the angular position holding apparatus shown in FIG. **1**.

(5) FIG. **5** includes diagrams showing a housing of the angular position holding apparatus shown in FIG. **1**.

(6) FIG. **6** includes diagrams showing a shield of the angular position holding apparatus shown in FIG. **1**.

(7) FIG. **7** is a diagram showing a molding die for integrally molding the joint member of the angular position holding apparatus shown in FIG. **1**.

(8) FIGS. **8**(*a*) and **8**(*b*) include diagrams for explaining problems at the time of formation using the molding die shown in FIG. **7**.

(9) FIG. **9** is a diagram showing an example of a molding die for forming the male member shown in FIG. **3**.

(10) FIG. **10** is a diagram showing an example of a molding die for forming the female member shown in FIG. **4**.

(11) FIG. **11** includes diagrams showing a male member constituting a modification of the joint member constituted by the producing method according to the present invention.

(12) FIG. **12** includes diagrams showing a female member to be combined with the male member shown in FIG. **11**.

(13) FIG. **13** includes diagrams showing a male member constituting another modification of the joint member produced by the producing method according to the present invention.

(14) FIG. **14** includes diagrams showing a female member to be combined with the male member shown in FIG. **13**.

MODE FOR CARRYING OUT THE INVENTION

(15) Hereinafter, preferred embodiments of the method for producing a joint member constituted according to the present invention and also an angular position holding apparatus comprising the joint member produced by the producing method are described in further detail with reference to the attached drawings. In this context, “axial first side” indicates the left side in the A-A cross section of FIG. **1**, and “axial second side” indicates the right side in the same view unless otherwise specified.

(16) The following explanation is made referring to FIGS. **1** and **2**. An angular position holding apparatus denoted with numeral **2** comprises a joint member **4**, a braking torque applying means **6** for applying required braking torque to the joint member **4**, and a fixed housing **8**. In the B-B cross-section of FIG. **1**, the braking torque applying means **6** (this is a coil spring in the illustrated embodiment, as will be described later) is shadowed for clarification.

(17) The joint member **4** is a member that connects a shaft S**1** extending from the input-side device and a shaft S**2** extending from the output-side device so as to transmit rotation of the shaft S**1** to the shaft S**2**. The rotational axis of the joint member **4** is indicated as ‘o’. The shaft S**1** comprises a female engagement portion Sla, and the shaft S**2** comprises a male engagement portion S**2***a*. The joint member **4** comprises a male engaging portion **10** to be engaged with the female engagement portion Sla, and also a female engaging portion **12** to be engaged with the male engagement portion S**2***a*. As will be described later, since the male engaging portion **10** is a male serration and the female engaging portion **12** is female serration in the illustrated embodiment, the female engagement portion Sla is a female serration and the male engagement portion S**2***a* is a male serration. Since the joint member **4** rotates while slipping (i.e., slides) relative to the braking torque applying means (coil spring) **6** as described below, the joint member **4** is required to have a considerable strength including abrasion resistance, and thus, the joint member **4** is produced by powder metallurgy. In the present invention, it is important that the joint member **4** is produced by forming separately a male member **14** comprising the male engaging portion **10** and a female member **16** comprising the female engaging portion **12** by powder metallurgy, and then, combining

the male member **14** and the female member **16** in a relatively non-rotatable manner.

(18) The following explanation is made referring to FIG. **3**, together with FIGS. **1** and **2**. The male engaging portion **10** of the male member **14** is a male serration in the illustrated embodiment, and it is composed of a number of external teeth **20** linearly extending in the axial direction on the outer peripheral surface of a cylindrical shaft portion **18** extending in the axial direction. One end of the male engaging portion **10**, namely, the end in the axial second side is fixed to the flange portion **22**. A plurality of locking portions **24** (eight in the illustrated embodiment) each composed of a protrusion protruding radially outward are formed on the outer peripheral surface of the flange portion **22**, more particularly, at the axial second side portion. The locking portions **24** are formed at equal angular intervals in the circumferential direction. In the illustrated embodiment, the locking portions **24** constitute a male square spline. The central axes of the male engaging portion **10** and the flange portion **22** are identical to the rotational axis o. The male member **14** is formed with a through hole **26** extending linearly in the axial direction along the rotational axis o.

(19) The following explanation is made referring to FIG. **4**, together with FIGS. **1** and **2**. The female member **16** has a cylindrical shape and has a through hole **28** extending linearly in the axial direction along the rotational axis o. In the illustrated embodiment, the female engaging portion **12** is a female serration, and it is constituted with a number of internal teeth **30** extending linearly in the axial direction on the inner peripheral surface of the female member **16**. The pitch diameter of the male serration of the male engaging portion **10** and that of the female serration of the female engaging portion **12** are the same. The pitch diameter of the male engaging portion **10** is preferably equal to or less than the pitch diameter of the female engaging portion **12**. Recess portions **32** are formed by partly increasing the inner diameter at the axial first side end portion of the female member **16**. On the inner peripheral surfaces of the recess portions **32**, a plurality of protrusions **34** protruding radially inward are formed. The protrusions **34** (therefore, eight in the illustrated embodiment) are formed at equal angular intervals in the circumferential direction so as to correspond to the locking portion **24** provided on the male member **14**, and between each pair of the protrusions **34** adjacent to each other, a lock portion **35** depressed radially outward is defined. In the illustrated embodiment, the lock portions **35** constitute a female square spline. The recess portions **32** of the female member **16** accept the flange portion **22** of the male member **14**, and the locking portions **24** of the male member **14** fit with the lock portions **35** of the female member **16**, so that the male member **14** and the female member **16** are locked in a relatively non-rotatable manner. A cylindrical supported wall **36** continuously extending in the circumferential direction along the outer peripheral edge is formed on the axial second side end surface of the female member **16**. The supported wall **36** is supported by the supportive wall **54** of the housing **8** and a connection portion **50** of the end plate **42**, as described below.

(20) As shown in FIGS. **1** and **2**, in the illustrated embodiment, the braking torque applying means **6** is a coil spring formed of a metal wire (hereinafter, the coil spring is denoted with the numeral **6**). The coil spring **6** comprises a wound portion **38** formed of a helically wound wire and hook portions **40** extending radially outward from the wound portion **38**. The hook portions **40** are formed at both axial ends of the wound portion **38**. When the coil spring **6** is in a free state, i.e. when the coil spring **6** is in a state of not applied with any external force, the inner diameter of the wound portion **38** is smaller than the outer diameter of the female member **16** of the joint member **4**, and the coil spring **6** with the wound portion **38** in a state in which the diameter thereof is enlarged is mounted on the outer peripheral surface of the female member **16**. The two hook portions **40** are fitted with a hook groove **62**, which is described below, formed together on the housing **8**, so that the coil spring **6** becomes non-rotatable relative to the housing **8**.

(21) The following explanation is made referring to FIG. **5**, together with FIGS. **1** and **2**. The housing **8** formed from an appropriate synthetic resin is shaped as a cup comprising an end plate **42** arranged perpendicular to the rotational axis o and a cylindrical outer peripheral wall **44** extending toward the axial first side from the outer peripheral edge of the end plate **42**. The female member

16 of the joint member **4** is housed inside. Though the end plate **42** is circular when viewed in the axial direction, its circular central portion **46** is slightly displaced to the axial second side relative to the annular outer peripheral portion **48**. Between the outer peripheral edge of the central portion **46** and the inner peripheral edge of the outer peripheral portion **48**, a cylindrical connection portion **50** is provided. The central portion **46** and the connection portion **50** constitute a circular bearing recess portion **52** to bear the axial second side end portion of the female member **16** of the joint member **4**. At the outer peripheral edge portion of the axial first side surface of the central portion **46** of the end plate **42**, a cylindrical supportive wall **54** continuously extending in the circumferential direction is formed. A supported wall **36** formed on the female member **16** enters between the supportive wall **54** and the connection portion **50** of the end plate **42**, so that the joint member **4** can stably rotate relative to the housing **8**. A circular through hole **56** penetrating in the axial direction is formed at the center of the end plate **42**. The male engagement portion S**2***a* of the shaft S**2** passes through the through hole **56** so as to be engaged with the female engaging portion **12** formed in the female member **16** of the joint member **4**. On the outer peripheral portion **48** of the axial second side surface of the end plate **42**, ribs **58** of a predetermined shape are arranged to stand up toward the axial second side, whereby four fixed recess portions **60** open toward the axial second side and radially outward are formed on the end plate **42**. The fixed recess portions **60** are formed at equal angular intervals in the circumferential direction, and they are used at the time of fixing the housing **8** to a vehicle or the like.

(22) On the inner peripheral surface of the outer peripheral wall **44**, an arc-shape hook groove **62** is formed by increasing the inner diameter over a predetermined angular range. The hook groove **62** extends linearly in the axial direction. As shown in B-B cross-section of FIG. **1**, both of the two hook portions **40** of the coil spring **6** are fitted with the hook groove **62**. In the illustrated embodiment, a dummy groove **64** having the same shape as the hook groove **62** is formed on the side radially opposite to the hook groove **62** on the inner peripheral surface of the outer peripheral wall **44**. The dummy groove **64** is formed in consideration of assemblability, so that the dummy groove **64** can be used as the hook groove **62**. On the free end surface, i.e., on the axial first side end surface of the outer peripheral wall **44**, six arc-shape circumferential locking pieces **66**, each further extending toward the axial first side, are provided at circumferentially equal angular intervals. On the extending end portion on the inner side surface of each circumferential locking piece **66**, an axial locking protrusion **68** protruding radially inward is formed.

(23) The open end of the housing **8**, that is, the axial first side end of the outer peripheral wall **44** is closed by a shield **70**. The following explanation will be made by referring to FIG. **6** together with FIGS. **1** and **2**. The shield **70** made of a synthetic resin has an annular shape as a whole. On the outer peripheral surface of the shield **70**, arc-shaped circumferentially lock pieces **72** extending radially outward are provided. On the outer peripheral surface of the shield **70**, axially lock protrusions **74** protruding radially outward are provided further. The circumferentially lock pieces **72** and the circumferentially locking pieces **66** are locked in the circumferential direction while axially lock protrusions **74** and the axially locking protrusions **68** are locked in the axial direction, whereby the shield **70** is fixed to the housing **8**. At the axial second side end of the inner peripheral surface of the shield **70**, an annular supportive piece **76** extending radially inward and also extending continuously in the circumferential direction is formed. The supportive piece **76** supports the male member **14** and the female member **16** of the joint member **4** simultaneously from the axial first side. As it can be understood by referring to A-A cross-section of FIG. **1**, the axial second side surface of the supportive piece **76** is opposed to the axial first side surfaces of the locking portions **24** provided on the male member **14**, and also opposed to the axial first side surfaces of the protrusions **34** of the female member **16**. On the inner peripheral edge portion of the axial second side surface of the shield **70**, a cylindrical supportive wall **78** protruding toward the axial second side and extending continuously in the circumferential direction is formed. The supportive wall **78** rotatably bears the axial first side end portion of the female member **16** of the joint member **4**

disposed inside thereof, and also limits axial movement of the coil spring **6**.

(24) The angular position holding apparatus **2** operates as follows. Specifically, the shaft S**1** extending from the input-side device, the joint member **4** and the shaft S**2** extending from the output-side device are formed integrally. Therefore, when the rotation torque is inputted from the input-side device, the joint member **4** begins to rotate together with the coil spring **6**. However, as mentioned above, since the coil spring **6** is not rotatable relative to the housing **8**, in the hook groove **62** formed in the housing **8**, one of the two hook portions **40** is pushed in the direction relatively to loosen the coil spring **6** by the inner side surface of the housing **8** for defining the hook groove **62**, whereby the joint member **4** rotates relative to the coil spring **6** (and to the housing **8**) against the braking torque caused by the clamping force of the coil spring **6**. That is, the rotation torque from the input-side device is transmitted to the output-side device, thereby driving the same. When the rotation torque from the input-side device is not inputted, the joint member **4** is held by the required braking torque from the coil spring **6**, whereby the angular position of the output-side device is also held.

(25) As described above, it is important in the method of producing the joint member **4** of the present invention that the male member **14** comprising the male engaging portion **10** and the female member **16** comprising the female engaging portion **12** are formed separately by powder metallurgy, and then, the male member **14** and the female member **16** are combined in a relatively non-rotatable manner. It may be also possible to integrally forming a joint member **4′** (denoted with a chain double-dashed line in FIG. **7**) comprising a male engaging portion **10′** and a female engaging portion **12′** arranged coaxially at different positions in the axial direction by powder metallurgy, but this method is not favorable due to the reasons described below. In the following description, parts belonging to the joint member **4′** and corresponding to the parts of above-described joint member **4** are given the same reference numerals attached with "′". In the case of forming the joint member **4′** by powder metallurgy, it is necessary to set the axial direction of the joint member **4′** to the vertical direction. For the reasons, in the following description, the axial first side will be regarded as the lower region and the axial second side will be regarded as the upper region.

(26) FIG. **7** shows a molding die **100** for forming the joint member **4′** by powder metallurgy. The molding die **100** comprises a fixed female mold **102** and a male mold **104** movable in the vertical direction relative to the female mold **102**. The female mold **102** comprises a bottomed recess portion extending in the vertical direction, and the bottomed recess portion has an inner peripheral surface **106** for defining the outer peripheral surface of the joint member **4′**, and an inner bottom surface **108** for defining the axial first side end surface (lower end surface) of the joint member **4′**. An inner peripheral surface lower portion **110** extends upward from the outer peripheral edge of the inner bottom surface **108** of the inner peripheral surface **106**, so that it defines a male engaging portion **10′** of the joint member **4′**. The male mold **104** is capable of entering the bottomed recess portion of the female mold **102**, and it has a lower surface **112** for defining the axial second side end surface (upper end surface) of the joint member **4′**. At the center of the lower surface **112**, a protrusion **114** protruding downward to the inner bottom surface **108** of the female mold **102** is formed, and an outer peripheral surface **116** of the projection **114** defines a female engaging portion **12′** of the joint member **4′**.

(27) The following explanation is made with reference to FIGS. **8**(*a*) and **8**(*b*). In producing the joint member **4′**, first, the female mold **102** is filled with a metal powder P as shown in FIG. **8**(*a*). Then, as shown in FIG. **8**(*b*), the male mold **104** is lowered to enter the female mold **102**, thereby compressing a powder P to form a compact as indicated with an arrow in the figure. Later, the molding die **100** is opened (i.e., the male mold **104** is lifted to be distanced from the female mold **102**), from which the compact is taken out and sintered.

(28) As for the joint member **4′** to be formed by use of the molding die **100**, a protrusion **114** protruding in the axial direction is provided on a lower surface **112** (pressing surface) of the male

mold **104**. Since the outer peripheral surface of the protrusion **114** defines the female engaging portion **12′**, problems mentioned below may be caused at the time of making the male mold **104** enter the female mold **102** so as to compress the powder. That is, (1) since vertical load due to the compression is concentrated to the free end surface of the protrusion **114**, the protrusion **114** will easily buckle, and thus, the male mold **104** comprising the protrusion **114** is required to have a considerable strength; (2) since a part of the powder present in front of the protrusion **114** (the lower region in the illustrated embodiment) is forced laterally rather than downward, the flowability of the powder is not favorable, and excessive resistance may be generated at the time of making the male mold **104** enter the female mold **102**, which means that excessive power is required for making the male mold **104** enter the female mold **102**; and (3) since only the powder present in front of the protrusion **114** is compressed to a relatively high density, the density distribution of the powder constituting the compact becomes uneven, and thus, cracks may occur at the time of sintering.
(29) In contrast, in the producing method of the present invention, the male member **14** comprising the male engaging portion **10** and the female member **16** comprising the female engaging portion **12** are produced separately by powder metallurgy. According to this method, the female member can be formed without providing a protrusion protruding in the axial direction on the lower surface (pressing surface) of the male mold, and thus, the aforementioned problems may not be caused. Hereinafter, an example of process for producing the male member **14** and the female member **16** will be described with reference to FIGS. **9** and **10**.
(30) FIG. **9** shows an example of a molding die **200** for molding the male member **14** indicated with a chain double-dashed line in the figure. The molding die **200** comprises a fixed female mold **202**, a male mold **204** that is vertically movable relative to the female mold **202**, and a core cylinder **206** extending linearly in the vertical direction inside the female mold **202**. The female mold **202** comprises a bottomed recess portion extending in the vertical direction. The bottomed recess portion has an inner peripheral surface **208** for defining the outer peripheral surface of the male member **14** and an inner bottom surface **210** for defining the axial first side end surface (lower end surface) of the male member **14**. An inner peripheral surface lower portion **212** extending upward from the outer peripheral edge of the inner bottom surface **210** of the inner peripheral surface **208** defines the male engaging portion **10** of the male member **14**. The male mold **204** is capable of entering the bottomed recess portion of the female mold **202**, and it has a flat lower surface **214** for defining the axial second side end surface (upper end surface) of the male member **14**. A hole through which the core cylinder **206** penetrates is coaxially formed in the lower surface **214** and in the inner bottom surface **210**, and the core cylinder **206** penetrates the hole to define the through hole **26**. In the molding die **200**, the female mold **202** is filled with a metal powder, and then, the male mold **204** is lowered to enter the female mold **202**, thereby compressing the powder. In this manner, the male member **14** can be formed without applying axial load to the core cylinder **206**.
(31) FIG. **10** shows an example of a molding die **300** for molding the female member **16** denoted with a chain double-dashed line in the figure. The molding die **300** is constituted of a fixed female mold **302**, a male mold **304** that is vertically movable relative to the female mold **302**, and a core cylinder **306** extending linearly in the vertical direction inside the female mold **302**. The female mold **302** comprises a bottomed recess portion extending in the vertical direction. The bottomed recess portion has an inner peripheral surface **308** for defining the outer peripheral surface of the female member **16**, and an inner bottom surface **310** for defining the axial first side end surface (lower end surface) of the female member **16**. The male mold **304** is capable of entering the bottomed recess portion of the female mold **302**, and it has a flat lower surface **312** for defining the axial second end surface (upper end surface) of the female member **16**. A hole through which the core cylinder **306** penetrates is coaxially formed in the lower surface **312** and in the inner bottom surface **310**, and the core cylinder **306** penetrates the holes, and the female engaging portion **12**

(internal teeth **30**) is defined by the outer peripheral surface of the core cylinder **306**. When the molding die **300** is used, the female mold **302** is filled with a metal powder, and then, the male mold **304** is lowered to enter the female mold **302**, thereby compressing the powder. In this manner, the female member **16** can be formed without applying axial load to the core cylinder **306**.

(32) Therefore, according to the producing method of the present invention, the joint member **4** is produced by forming separately the male member **14** comprising the male engaging portion **10** and the female member **16** comprising the female engaging portion **12** by powder metallurgy, and then, combining the male member **14** and the female member **16** in a relatively non-rotatable manner. Accordingly, the female member **16** can be formed without providing an axially protruding protrusion on the pressing surface of the male mold. According to this method, a high-quality joint member having a male engaging portion and a female engaging portion arranged coaxially at different positions can be produced easily by powder metallurgy, without facing the aforementioned problems that may occur in a case of integrally producing by powder metallurgy a joint member having a male engaging portion and a female engaging portion arranged coaxially at different positions.

(33) The method for producing a joint member configured in accordance with the present invention and also an angular position holding apparatus including the joint member produced by the method are described above in detail with reference to the attached drawings. The present invention is not limited to the aforementioned embodiment, but any appropriate modifications can be made in a range without departing from the present invention. For instance in the illustrated embodiment, the male engaging portion is a male serration and the female engaging portion is a female serration. Any male engaging portion and any female engaging portion can be employed as long as each of them is shaped as a gear like a spline. The pitch diameter of the male serration and that of the female serration may not necessarily be the same. Any method or means can be employed to lock the male member and the female member in a relatively non-rotatable manner. In the illustrated embodiment, the locking portions **24** provided to the male member **14** constitute a male square spline, and the lock portions **35** provided to the female member **16** constitute a female square spline. The locking portions **24** and the lock portions **35** may be splines shaped otherwise (for instance, involute splines) or serrations of modified examples shown in FIGS. **11** and **12** (in FIGS. **11** and **12**, the same components as those shown in FIGS. **3** and **4** are given the same reference numerals attached with “′”). It is also possible to form the portions to be polygons (a regular octagon in the illustrated embodiment) as in the other modified examples shown in FIGS. **13** and **14** (in FIGS. **13** and **14**, the same components as those shown in FIGS. **3** and **4** are given the same reference numerals attached with “″”). In the illustrated embodiment, a coil spring is employed as the braking torque applying means to apply required braking torque to the female member in the angular position holding apparatus. The braking torque applying means may be a leaf spring, a tolerance ring, a wheel spring or the like, and thus, the braking torque applying means may not necessarily be non-rotatable relative to the housing. In addition, the “joint member” in the present invention can be applied not only to the aforementioned angular position holding apparatus but it may be applied also to other apparatuses, or may be used as a single unit, namely as a “joint” that simply connects two members.

EXPLANATIONS OF LETTERS OR NUMERALS

(34) **2**: Angular position holding apparatus **4**: Joint member **6**: Braking torque applying means (coil spring) **8**: Housing **10**: Male engaging portion **12**: Female engaging portion **14**: Male member **16**: Female member **24**,**24′**,**24″**: Locking portions **35**,**35′**,**35″**: Lock portions

Claims

1. A method for producing a joint member having a male engaging portion and a female engaging portion arranged coaxially at different positions in an axial direction, the method comprising:

forming a male member comprising the male engaging portion and a locking portion, and a female member comprising the female engaging portion and a lock portion, separately by powder metallurgy; and locking the locking portion and the lock portion so as to combine the male member and the female member in a relatively non-rotatable manner, wherein the male member is provided with a flange portion to which one end of the male engaging portion is fixed, the female member is provided with a recess portion to accept the flange portion, the locking portion is a protrusion that protrudes radially outward on an outer peripheral surface of the flange portion, and the lock portion is a depression with which the protrusion is fitted on an inner peripheral surface of the recess portion.

2. The method for producing a joint member according to claim 1, wherein the male engaging portion and the female engaging portion are shaped like a gear.

3. The method for producing a joint member according to claim 2, wherein a pitch diameter of the male engaging portion is equal to or less than a pitch diameter of the female engaging portion.

4. The method for producing a joint member according to claim 2, wherein the male engaging portion is a male serration and the female engaging portion is a female serration.

5. A method for producing an angular position holding apparatus that comprises: a joint member to mutually connect an input-side device and an output-side device; a braking torque applying means to apply required braking torque to the joint member; a fixed housing; and a shield mounted on the fixed housing, so that the joint member is supported from both sides in an axial direction by an end plate of the fixed housing and the shield, the joint member rotates against the required braking torque when a rotation torque is inputted from the input-side device, and the joint member is held by the required braking torque when no rotation torque is inputted from the input-side device, wherein the joint member has a male engaging portion and a female engaging portion arranged coaxially at different positions in the axial direction, and the joint member is produced by: forming a male member comprising the male engaging portion and a locking portion, and a female member that is arranged inside the fixed housing and comprises the female engaging portion and a lock portion, separately by powder metallurgy; and locking the locking portion and the lock portion so as to combine the male member and the female member in a relatively non-rotatable manner.

6. The method for producing an angular position holding apparatus according to claim 5, wherein the braking torque applying means is a coil spring that comprises a wound portion comprising a helically wound wire and hook portions formed of the wire extending radially outward from the wound portion, the wound portion in a free state has an inner diameter smaller than an outer diameter of the female member of the joint member, and the coil spring is mounted on an outer peripheral surface of the female member in a state in which a diameter of the wound portion is enlarged, and the hook portions fit with a hook groove formed on an inner peripheral surface of the fixed housing, the coil spring being non-rotatable relative to the fixed housing, so that the hook portions are pushed in the hook groove in a direction to loosen the coil spring when the joint member rotates.