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Yoshida et al.

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(54) **BICYCLE REAR SPROCKET ASSEMBLY**

(71) Applicant: **SHIMANO INC.**, Sakai (JP)

(72) Inventors: **Toyoshi Yoshida**, Sakai (JP); **Toshinari Oishi**, Sakai (JP); **Tsuyoshi Fukumori**, Sakai (JP)

(73) Assignee: **SHIMANO INC.**, Sakai (JP)

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F16H 55/30 (2006.01)
B62M 9/10 (2006.01)
B62M 9/12 (2006.01)

(52) **U.S. Cl.**

CPC **B62M 9/10** (2013.01); **B62M 9/12** (2013.01); **F16H 55/303** (2013.01)

(58) **Field of Classification Search**

CPC **B62M 9/10**; **B62M 9/105**; **B62M 9/12**; **F16H 55/30**; **F16D 41/30**
USPC 474/160
See application file for complete search history.

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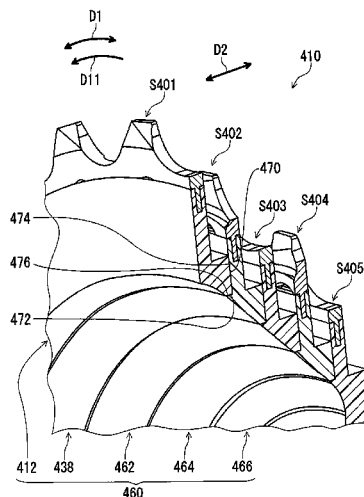
Primary Examiner — Henry Y Liu

(74) *Attorney, Agent, or Firm* — Mori & Ward, LLP

(57) **ABSTRACT**

A bicycle rear sprocket assembly has a rotational center axis. The bicycle rear sprocket assembly comprises a first sprocket and a second sprocket. The first sprocket includes a first sprocket body and a first chain-engagement structure. The first sprocket body is made of a non-metallic material. The first chain-engagement structure is made of a metallic material and is configured to engage with a bicycle chain. The second sprocket includes a second sprocket body and a second chain-engagement structure. The second sprocket body is made of a non-metallic material and attached to the first sprocket body. The second chain-engagement structure is made of a metallic material and is configured to engage with the bicycle chain.

15 Claims, 26 Drawing Sheets



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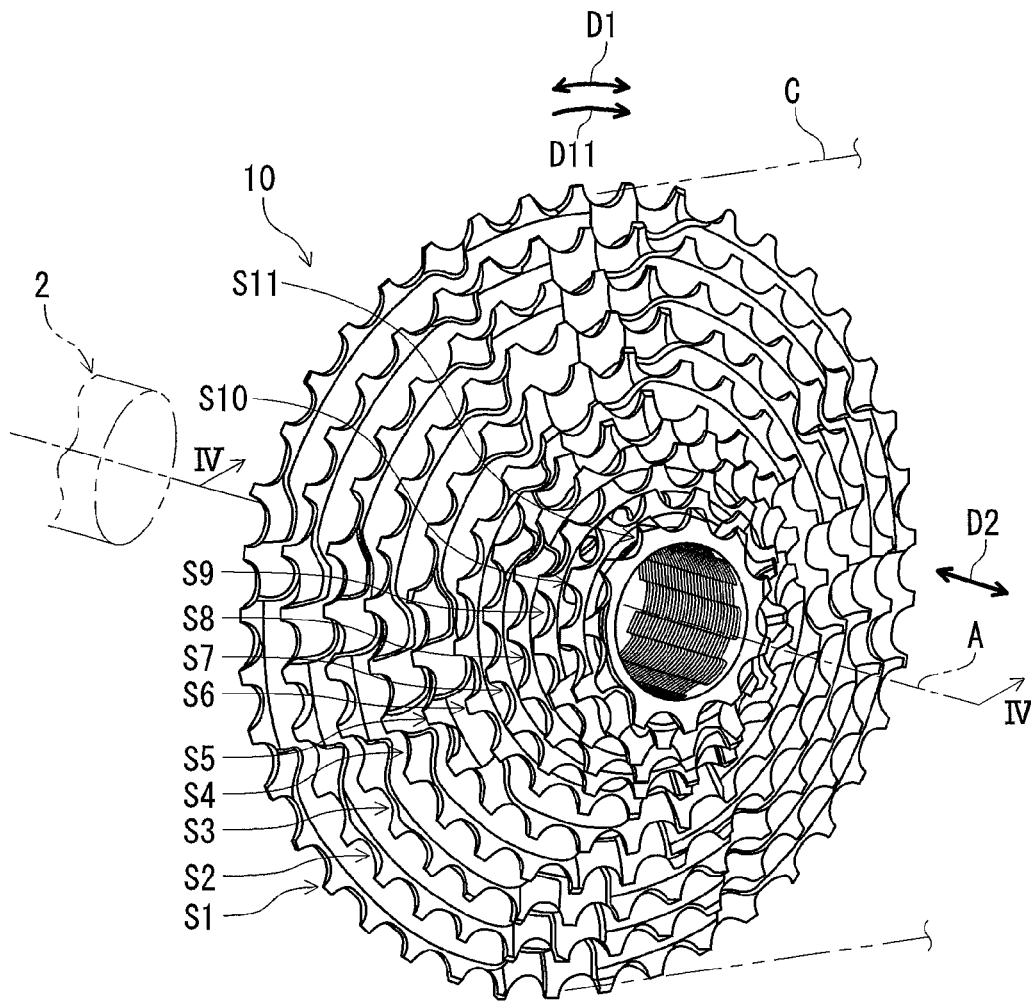


FIG. 1

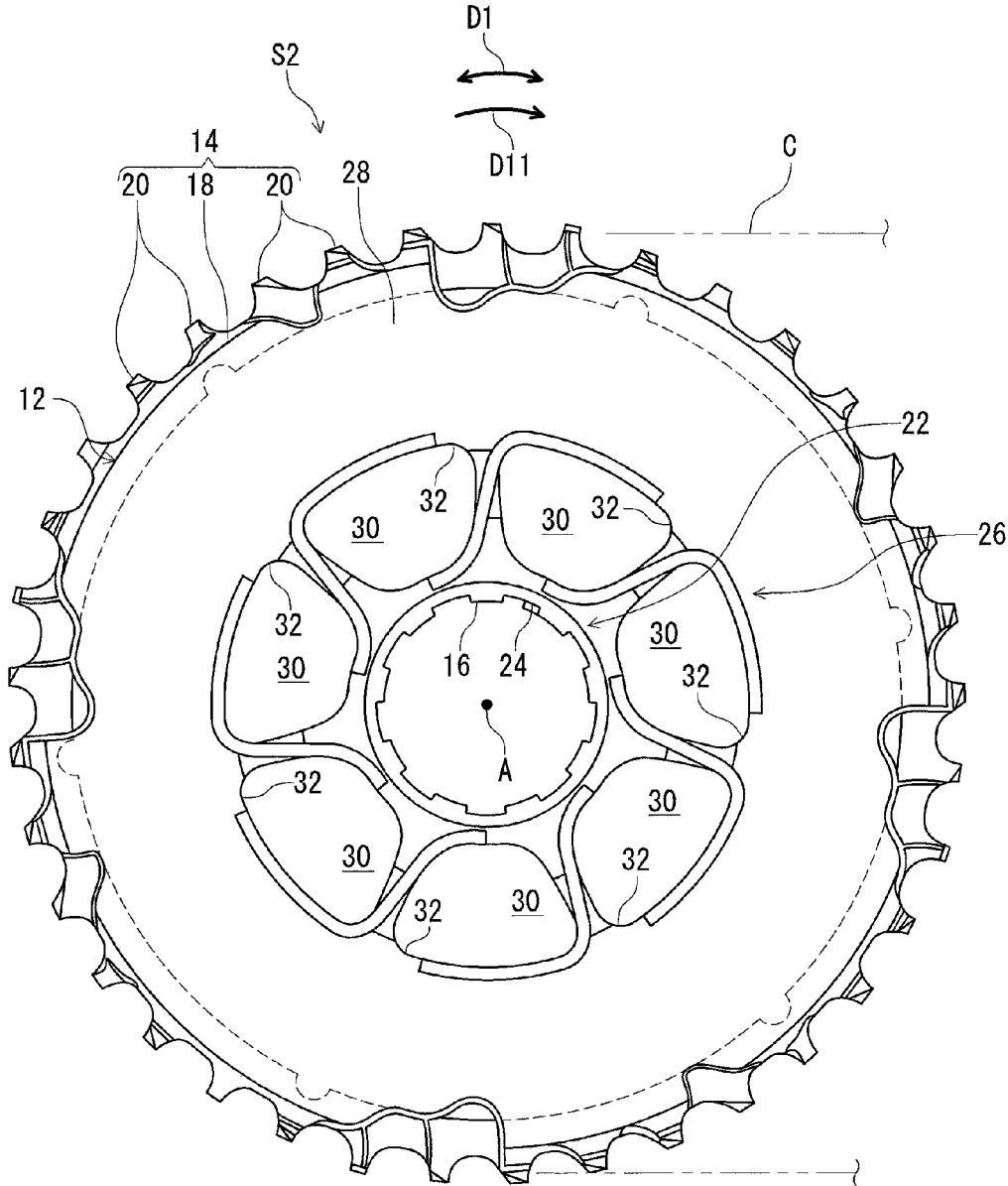


FIG. 2

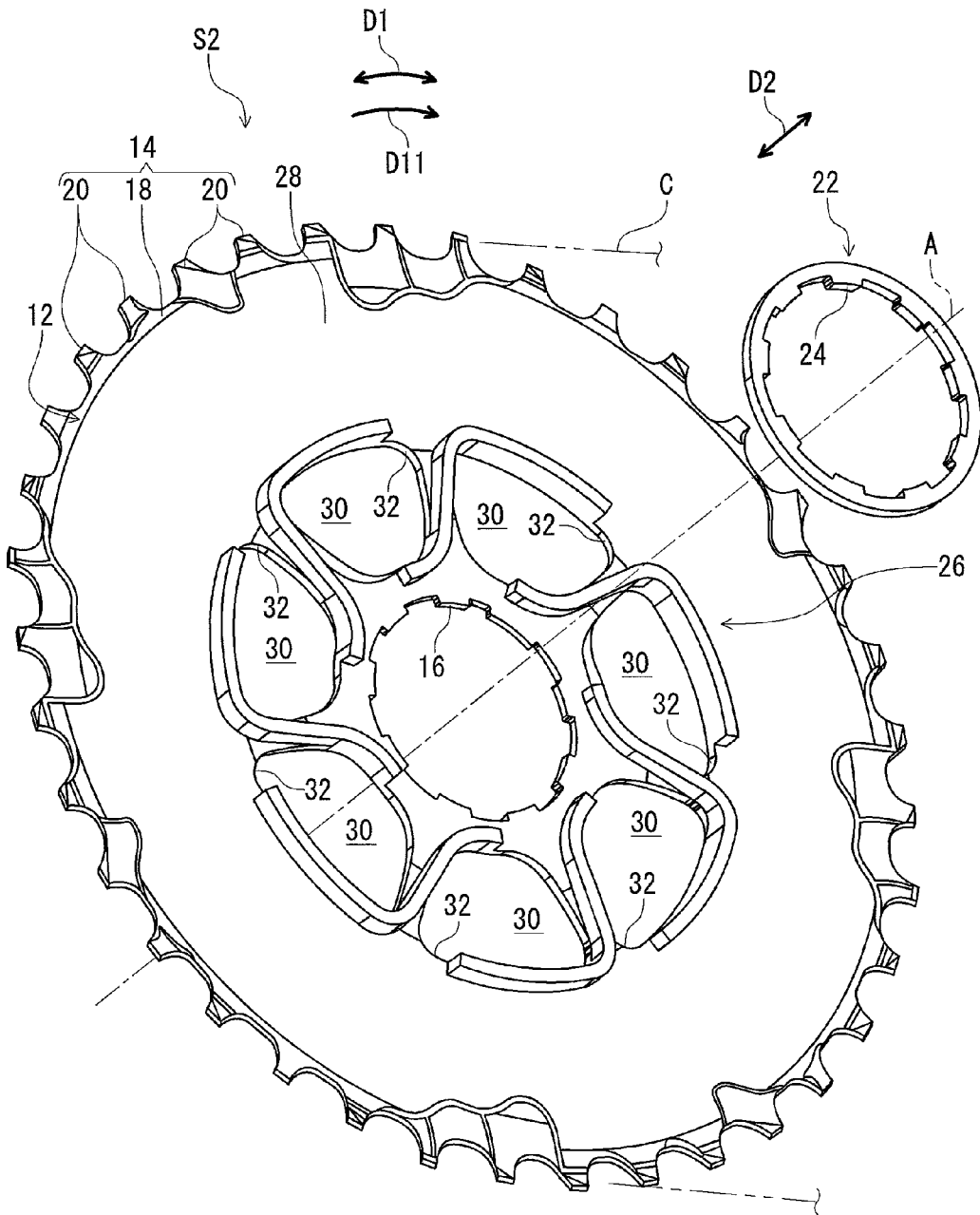


FIG. 3

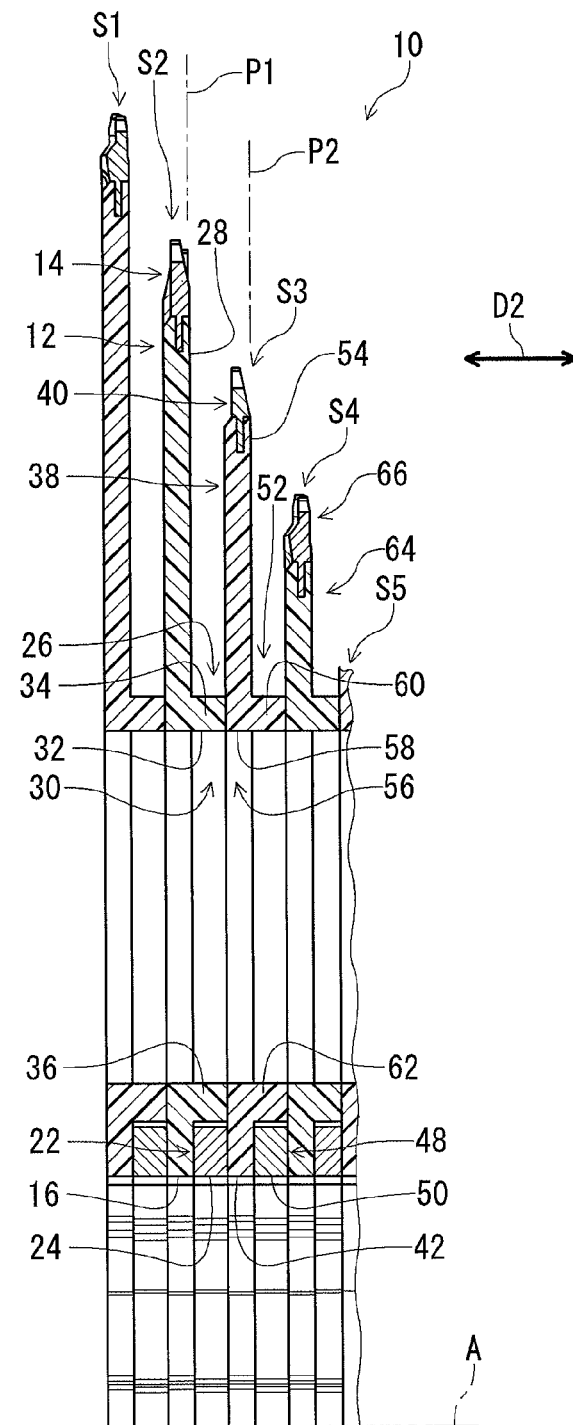


FIG. 4

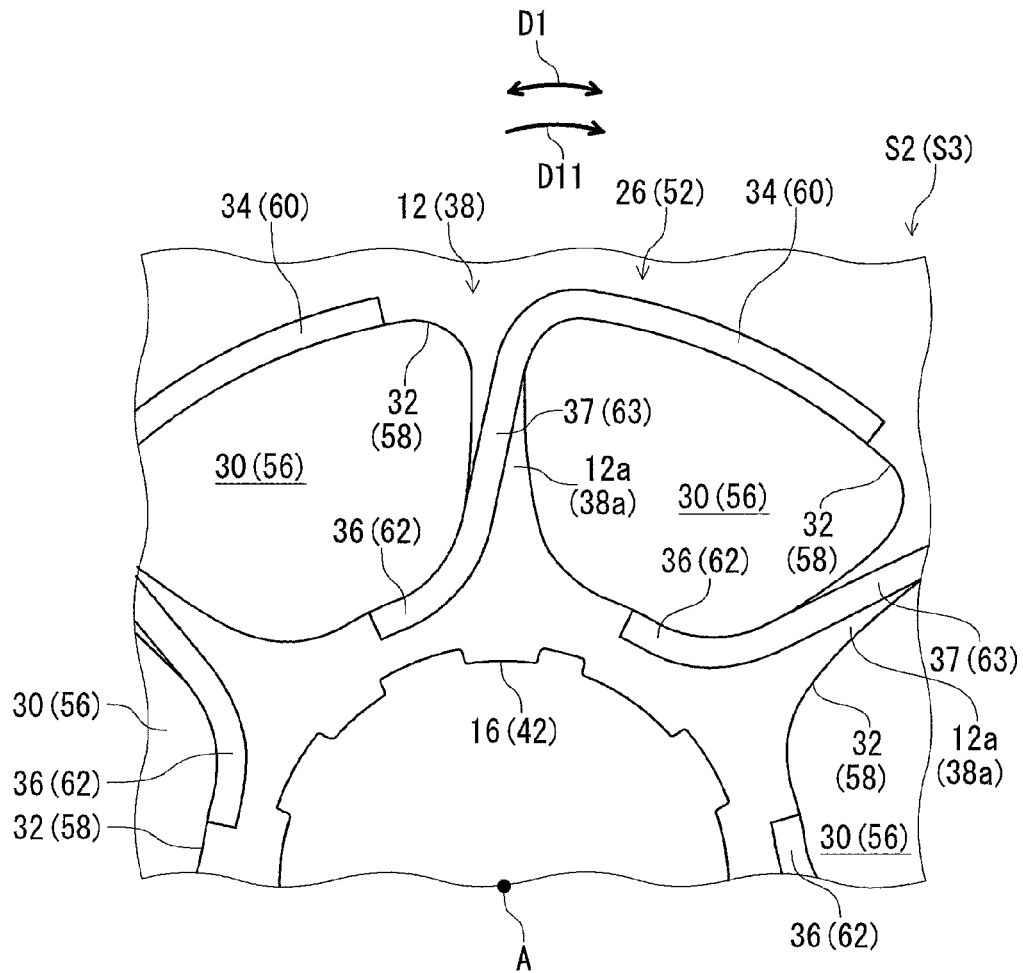


FIG. 5

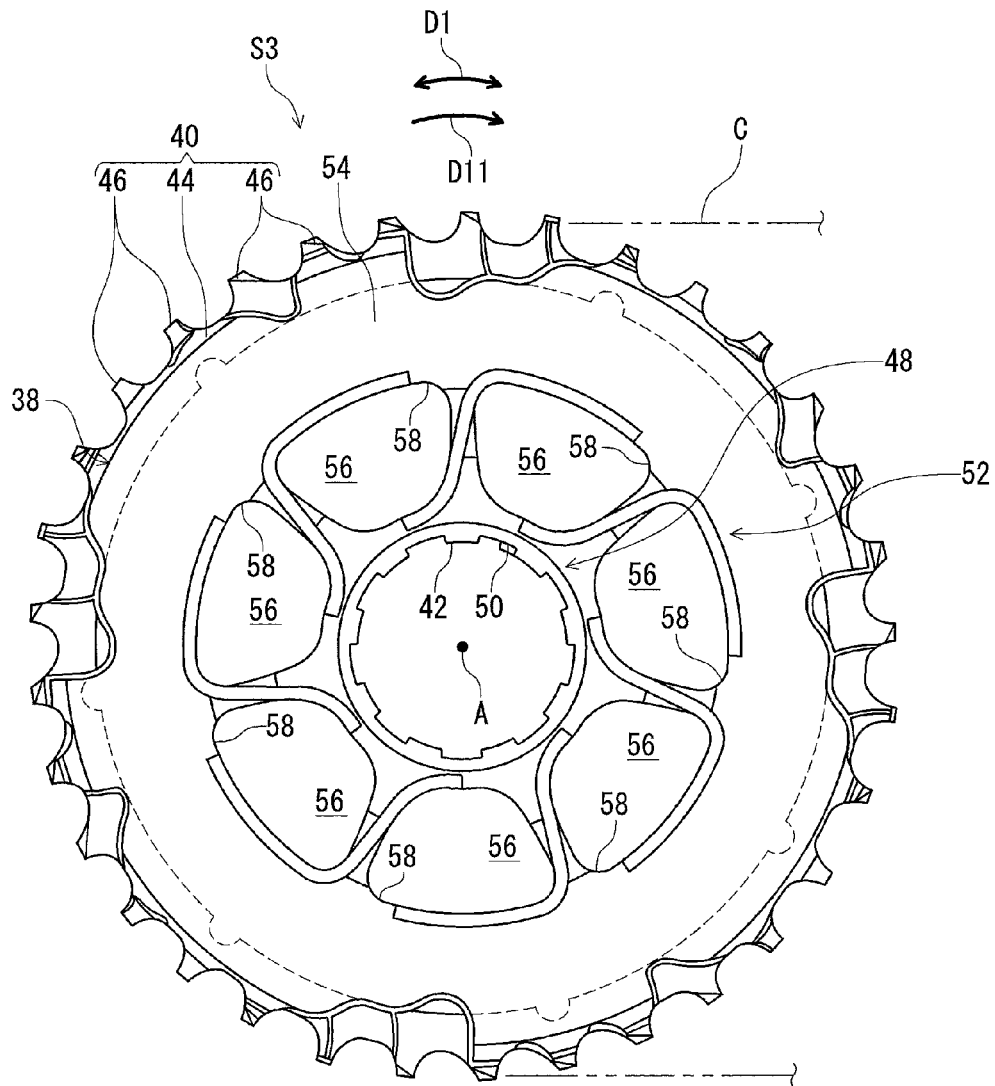


FIG. 6

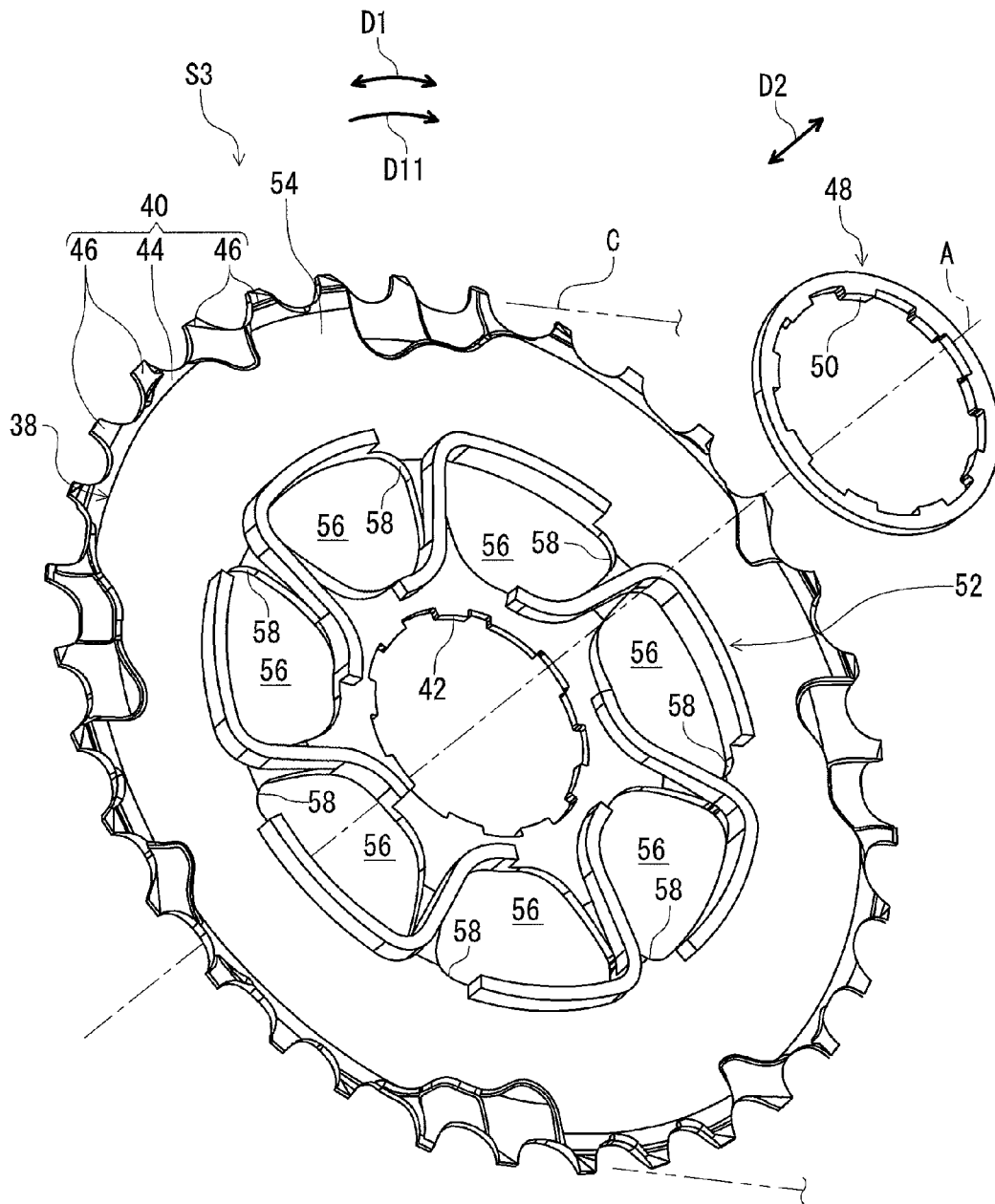
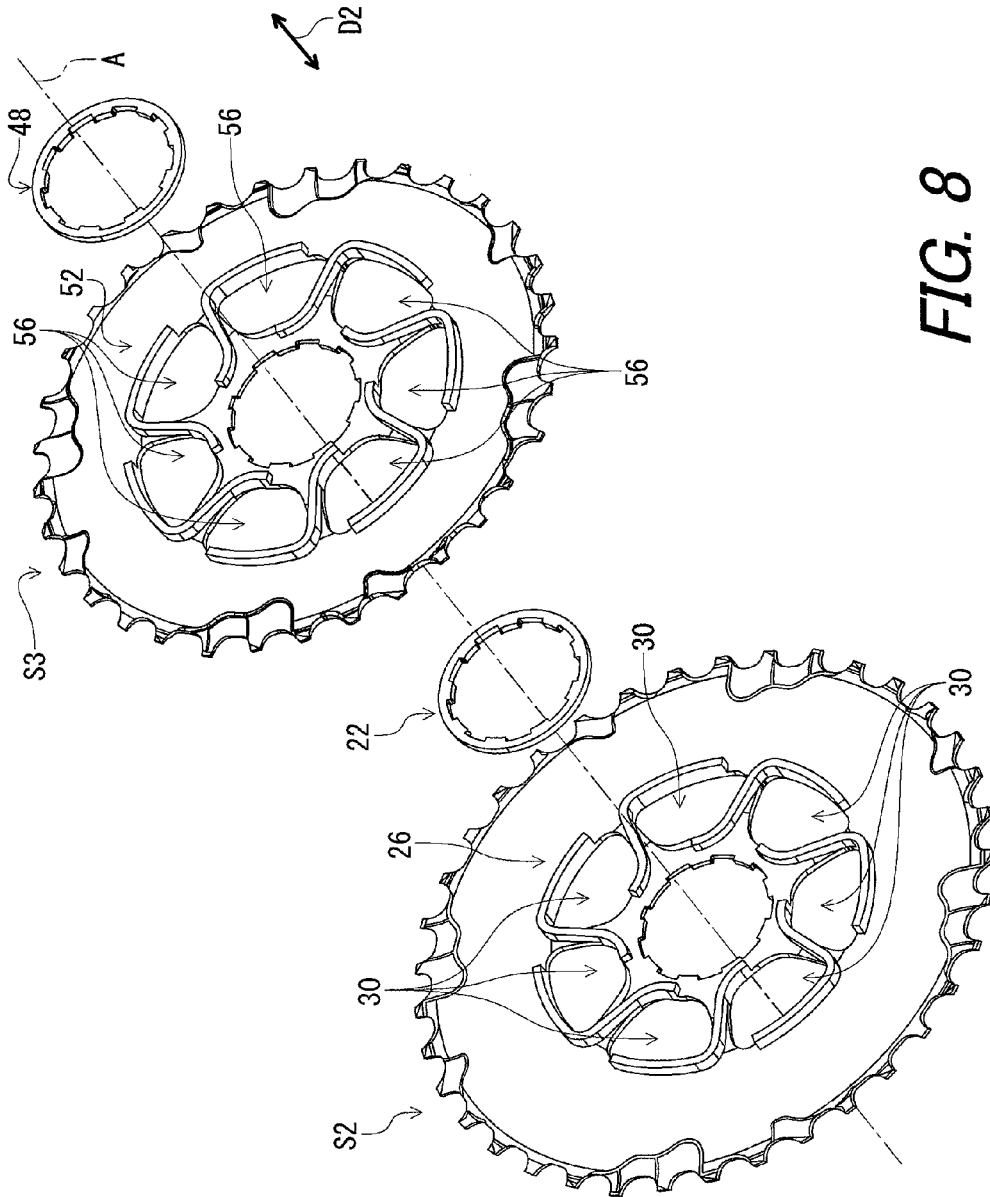


FIG. 7



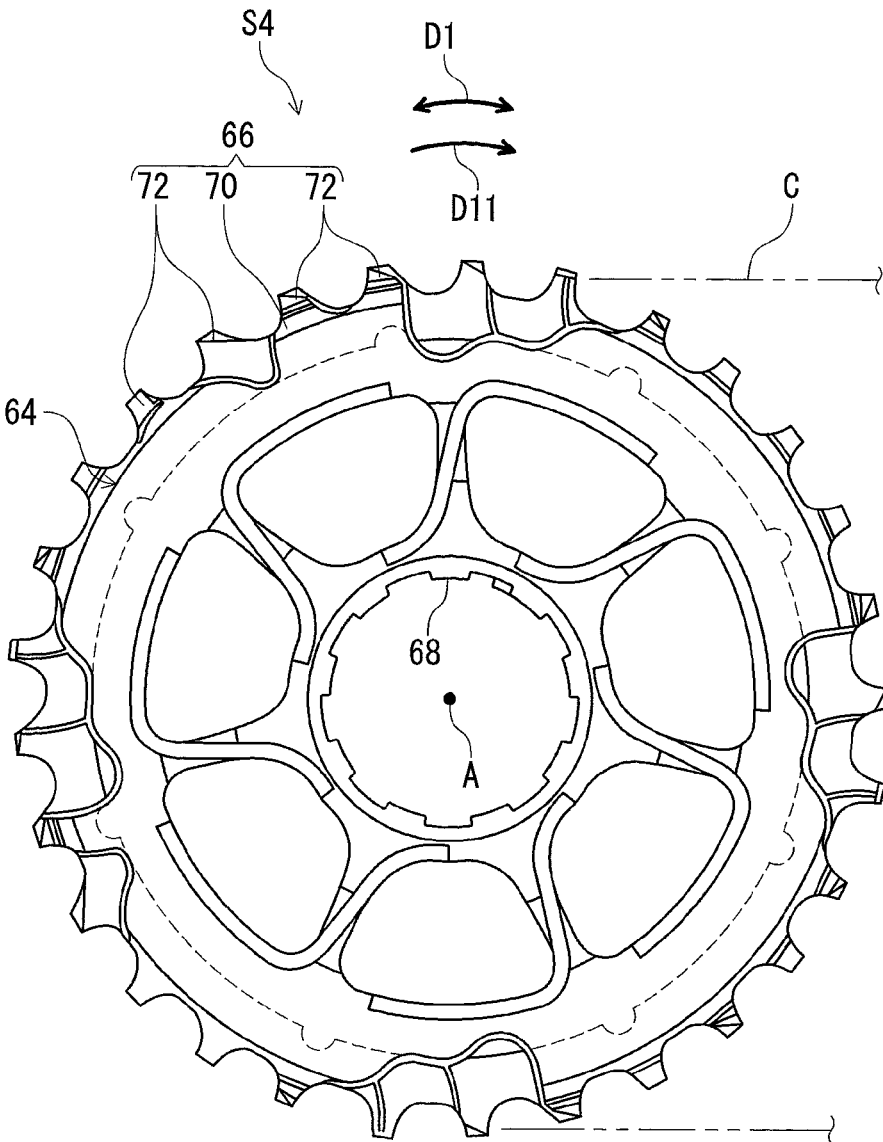


FIG. 9

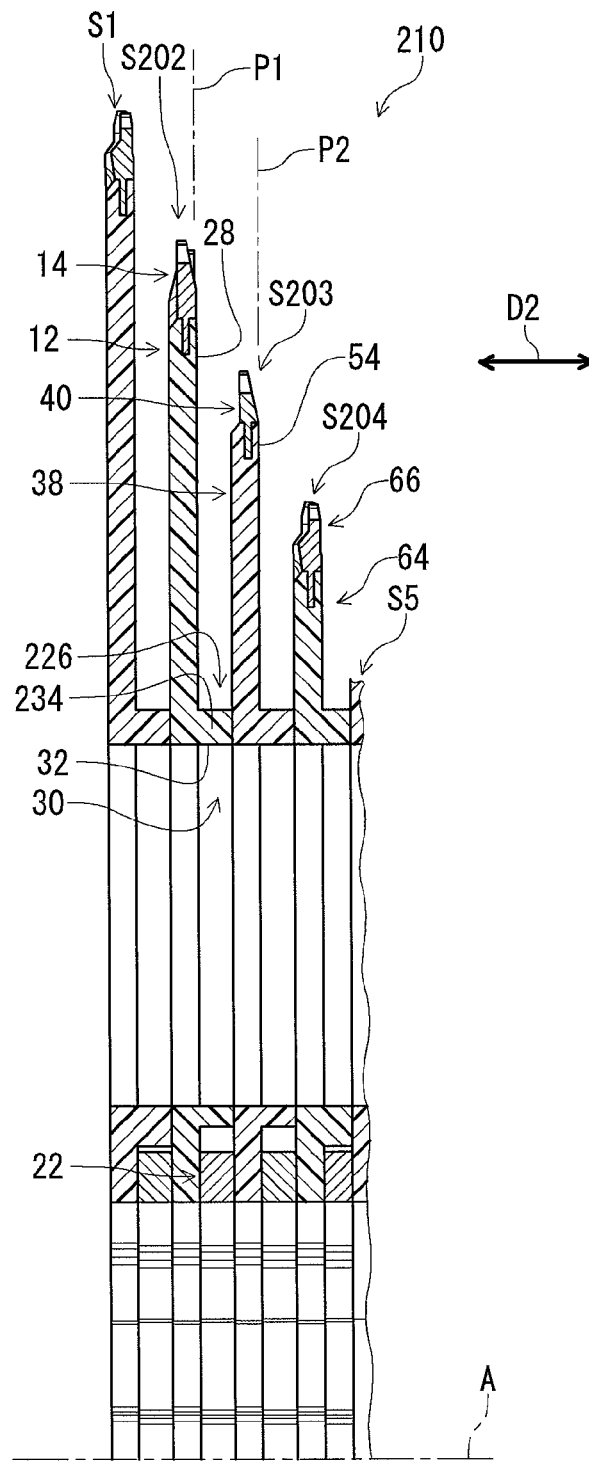


FIG. 10

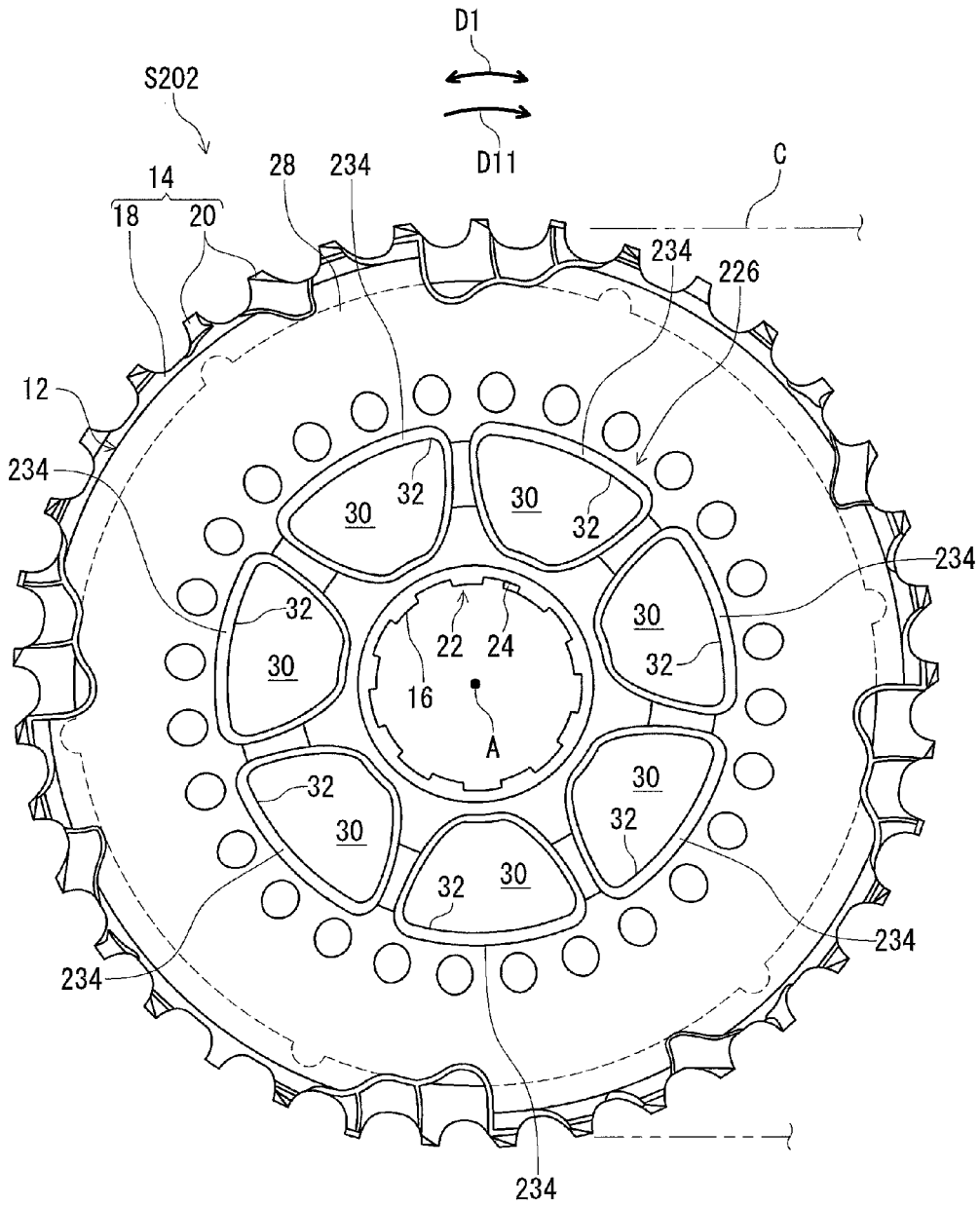


FIG. 11

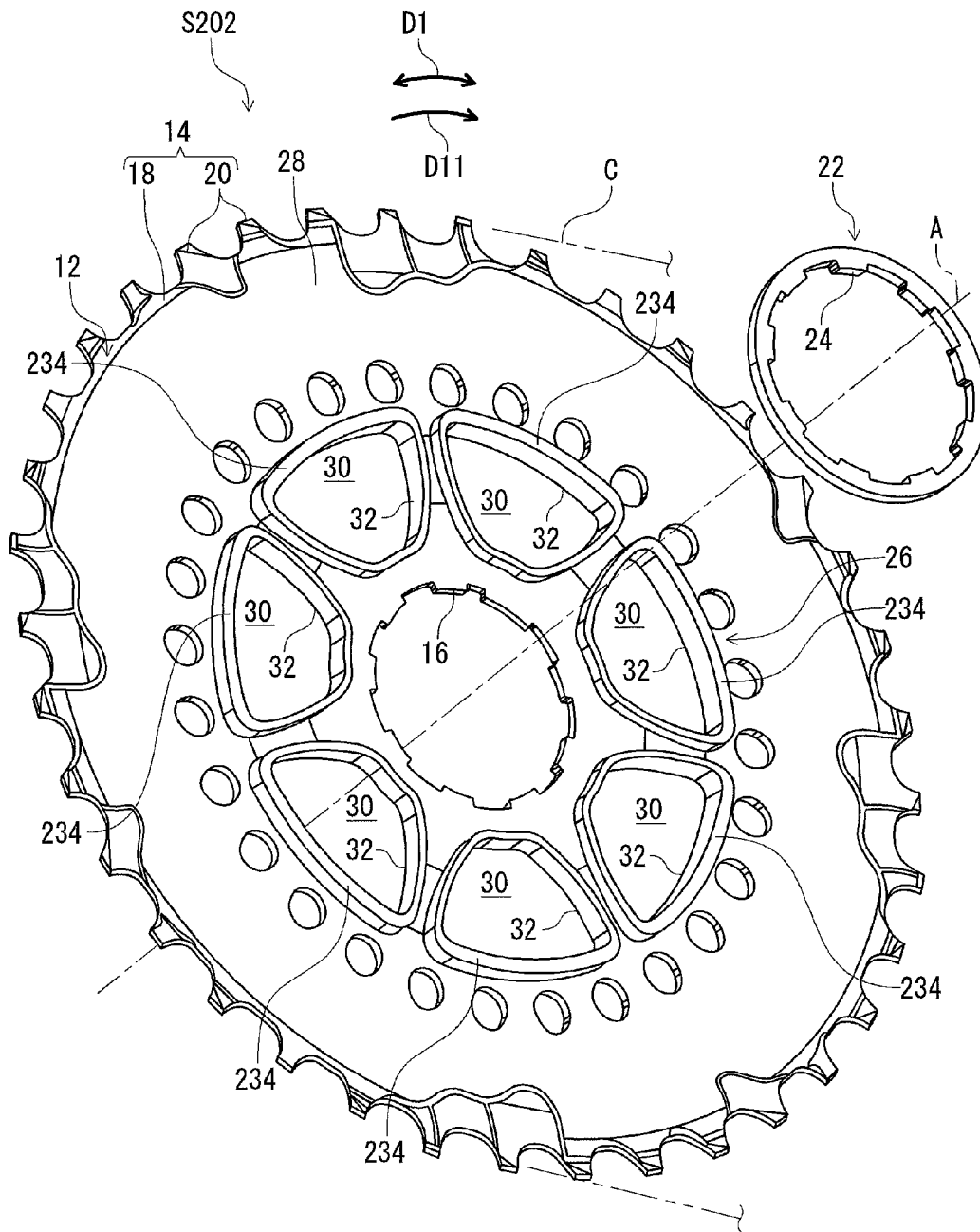


FIG. 12

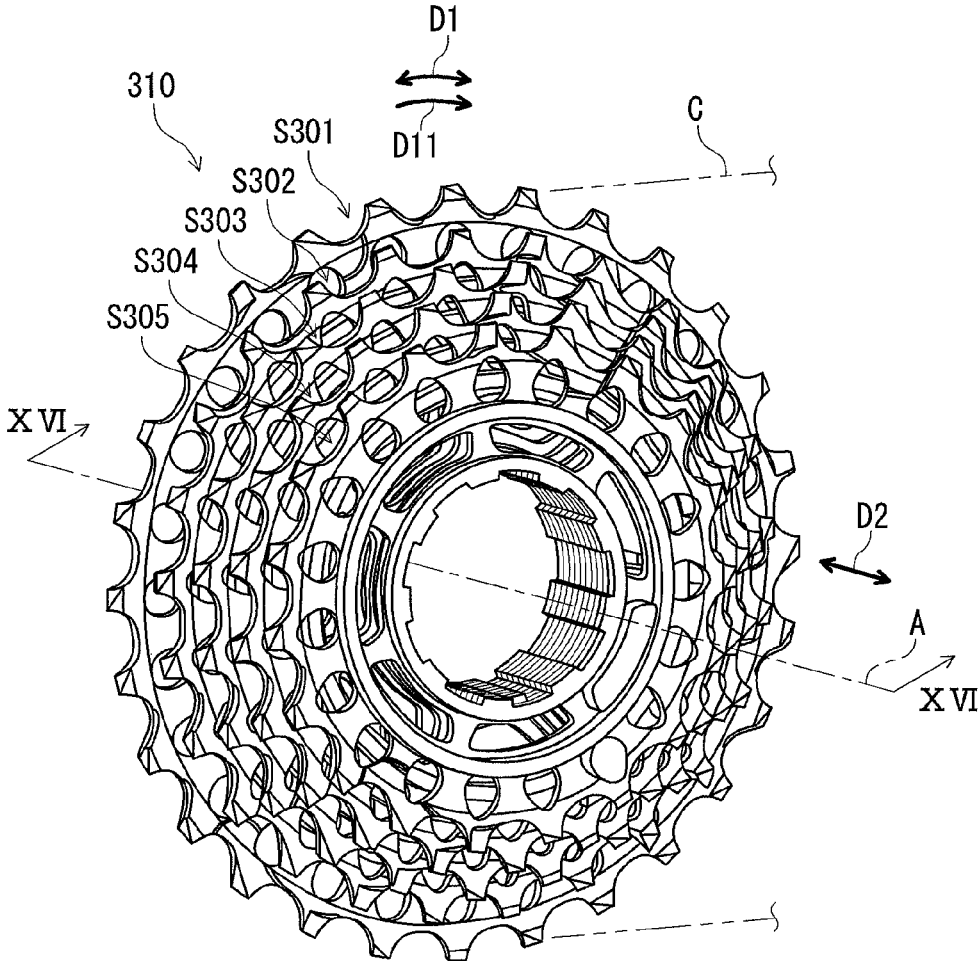


FIG. 13

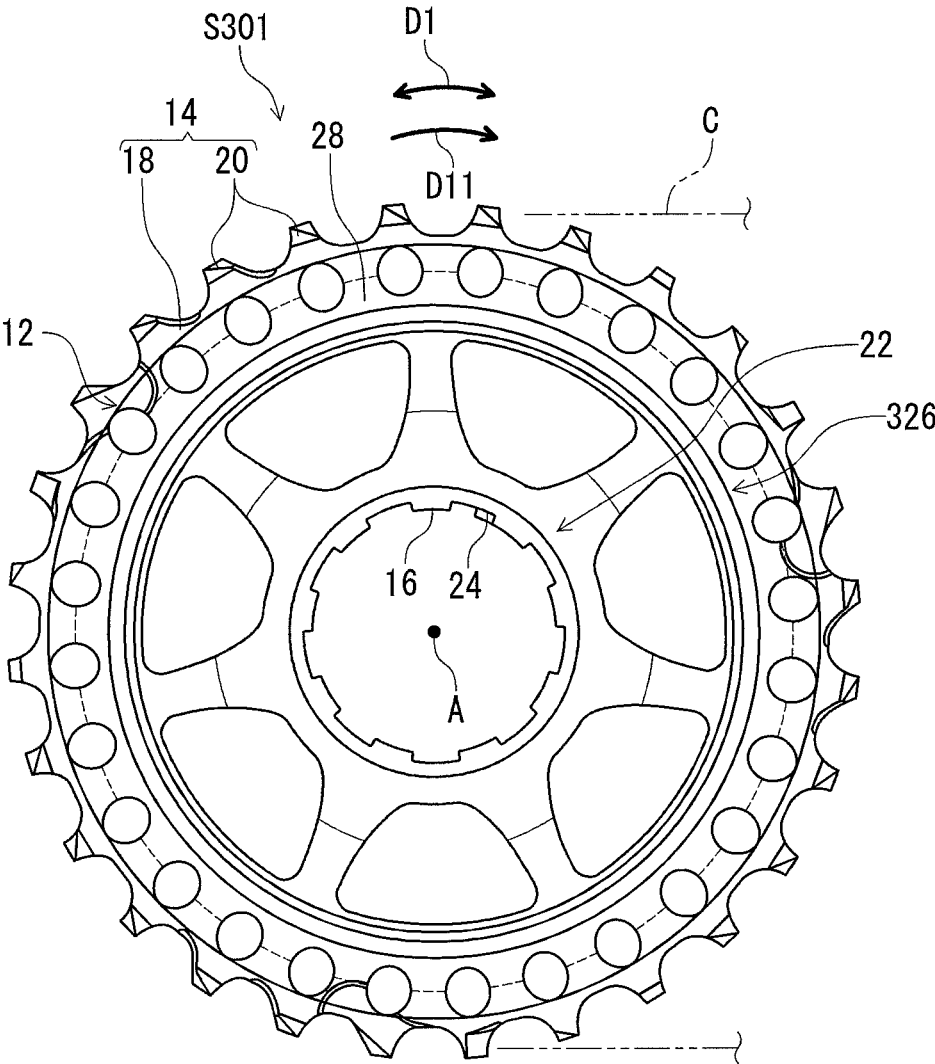


FIG. 14

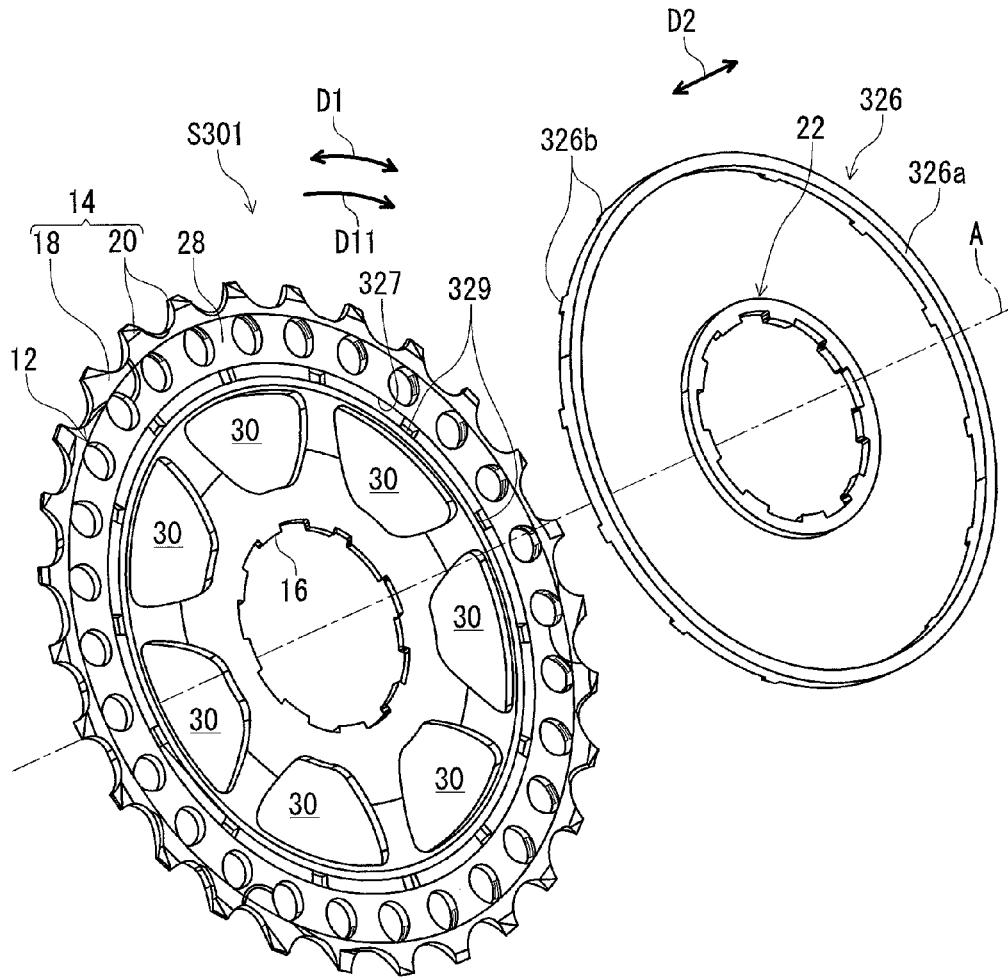


FIG. 15

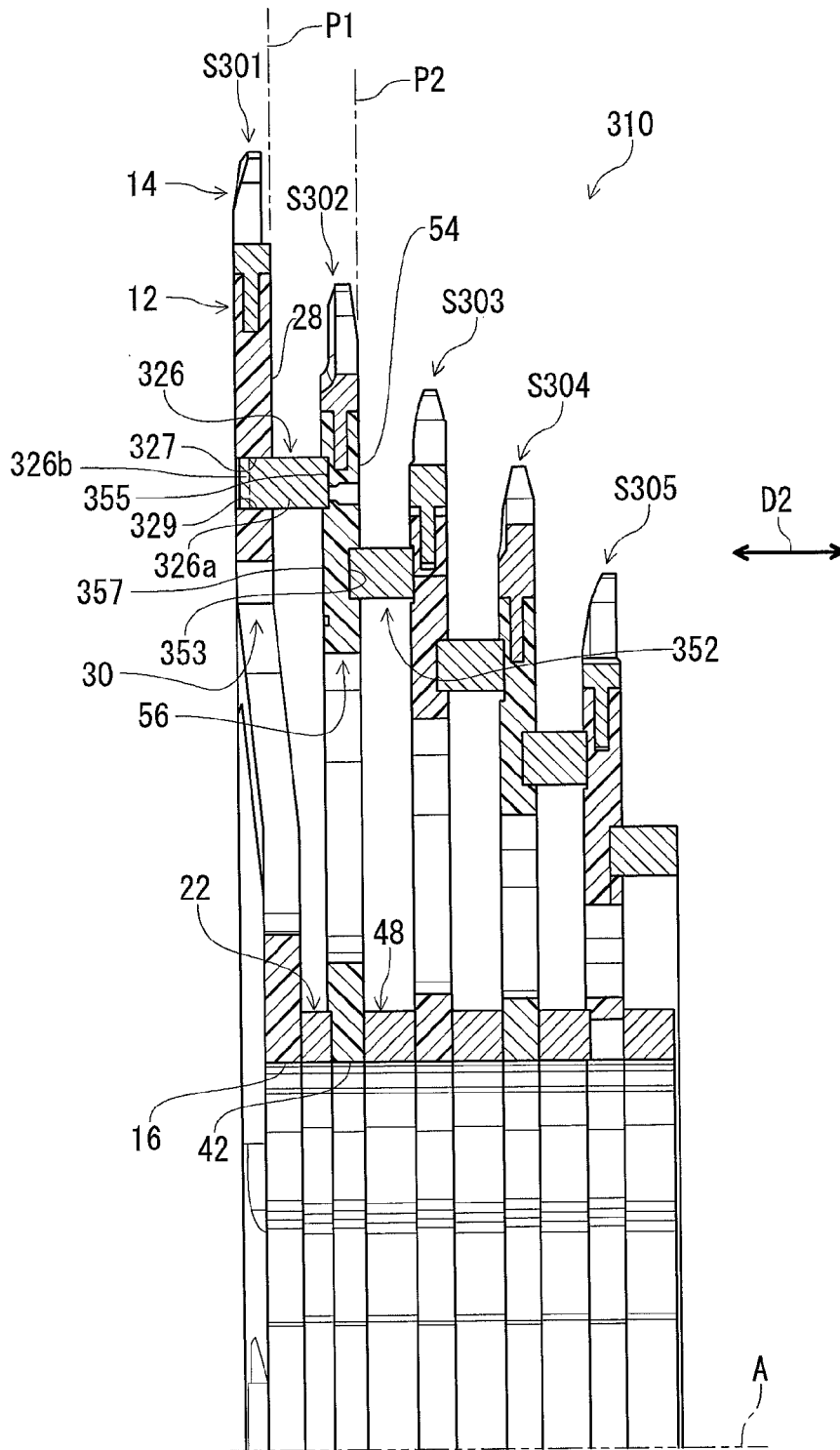


FIG. 16

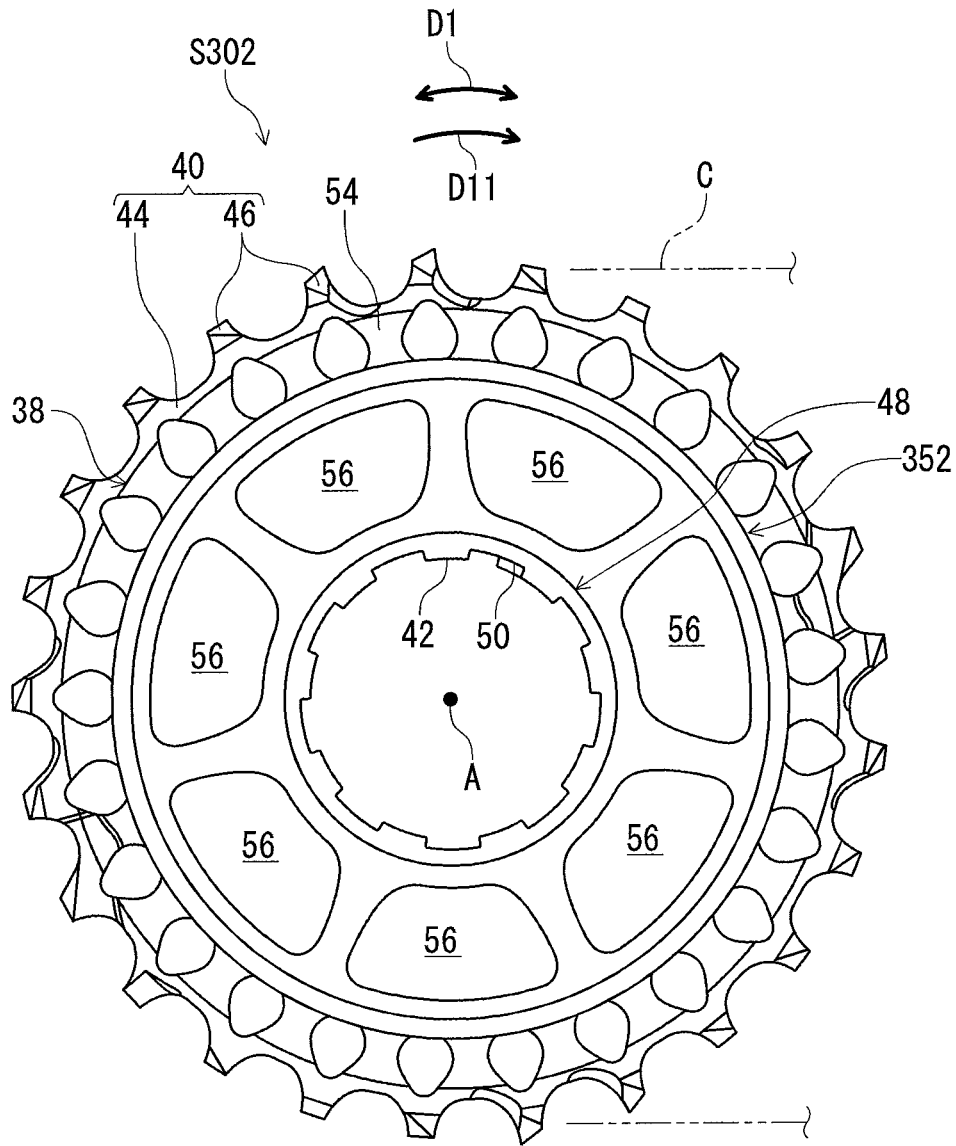


FIG. 17

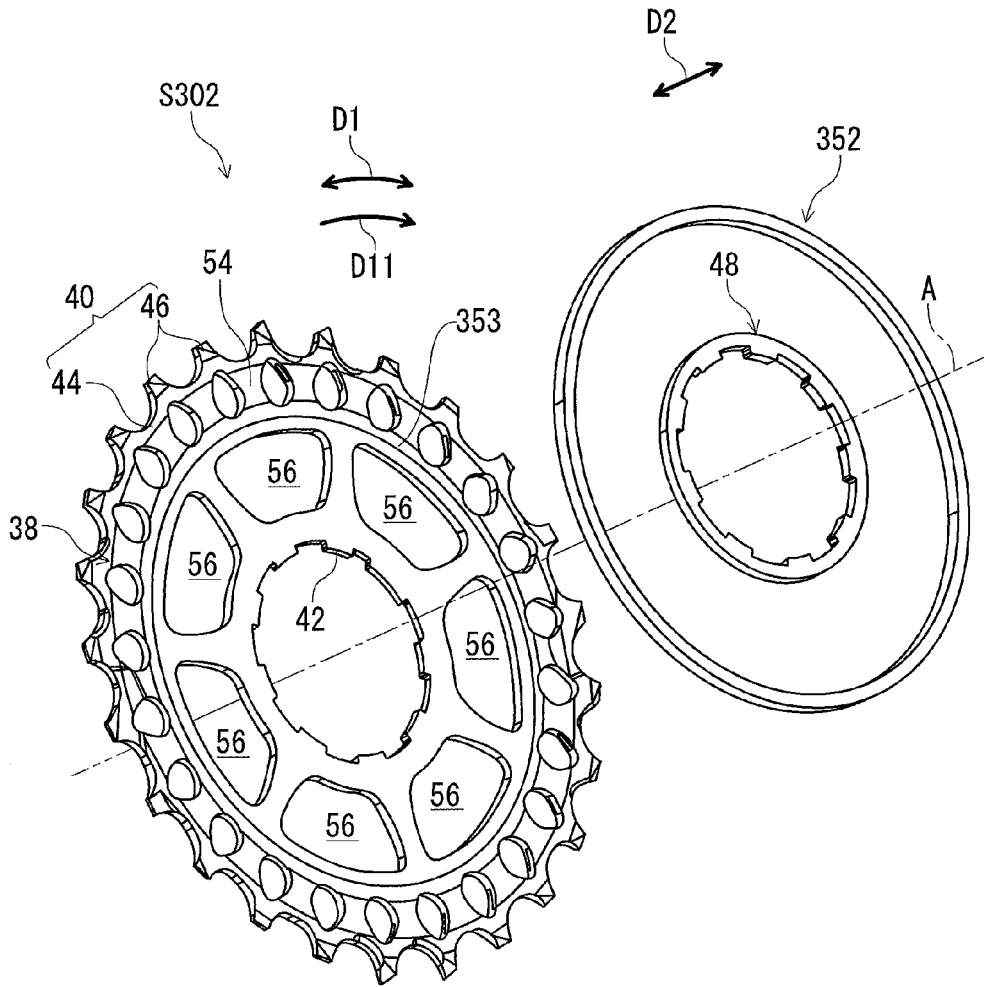


FIG. 18

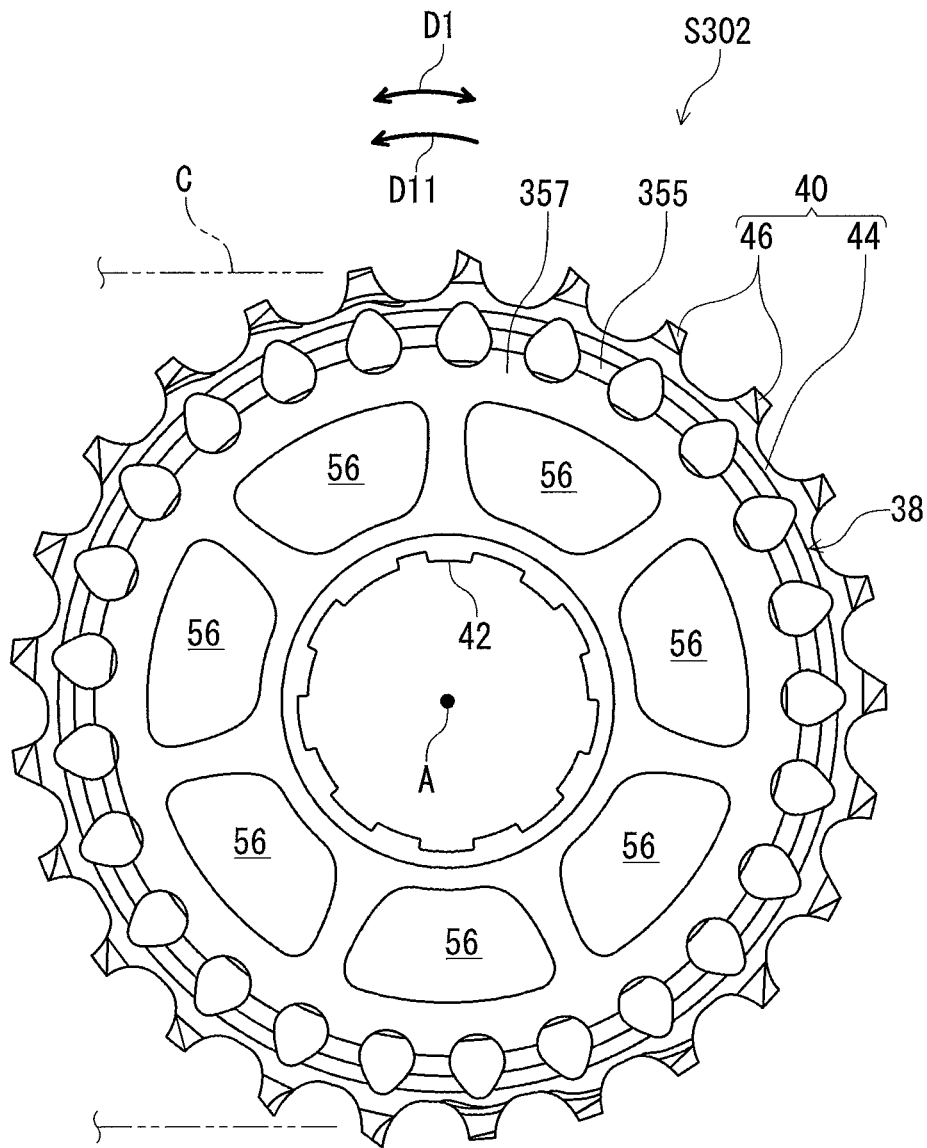


FIG. 19

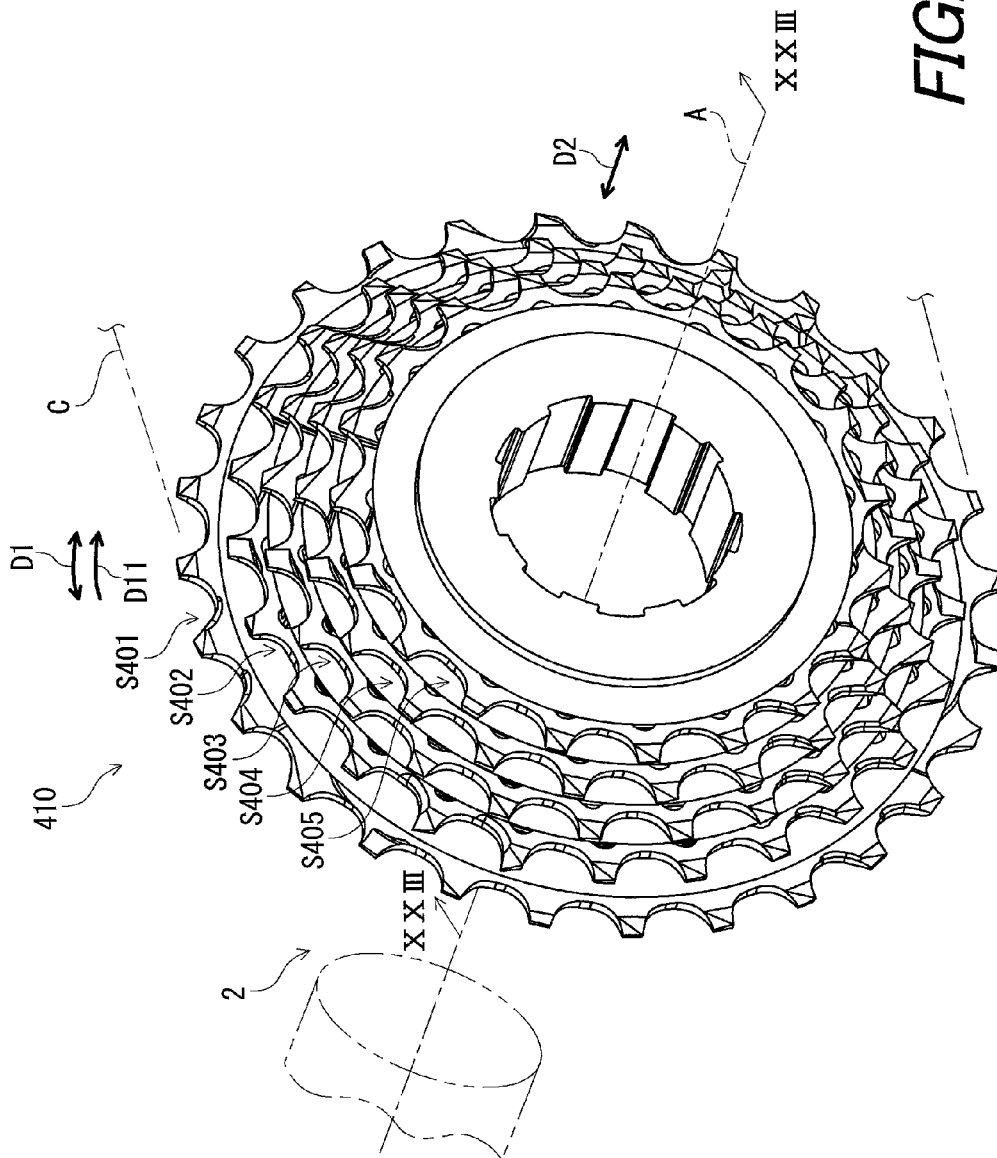


FIG. 20

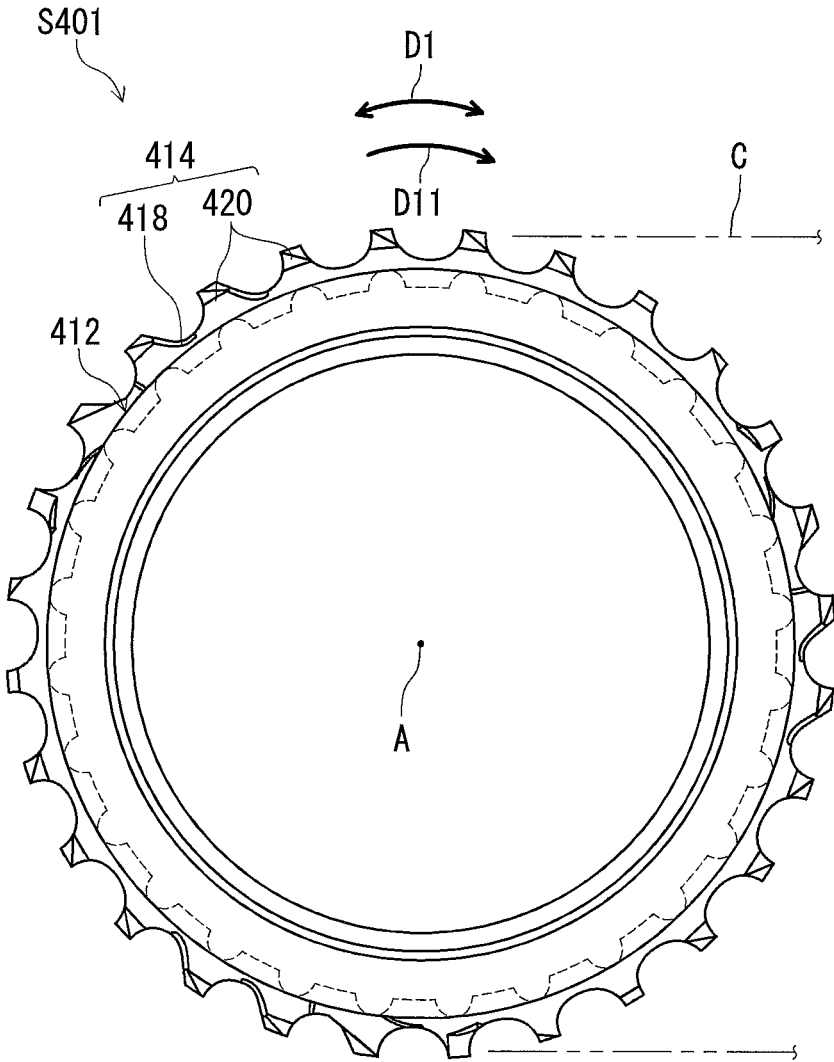


FIG. 21

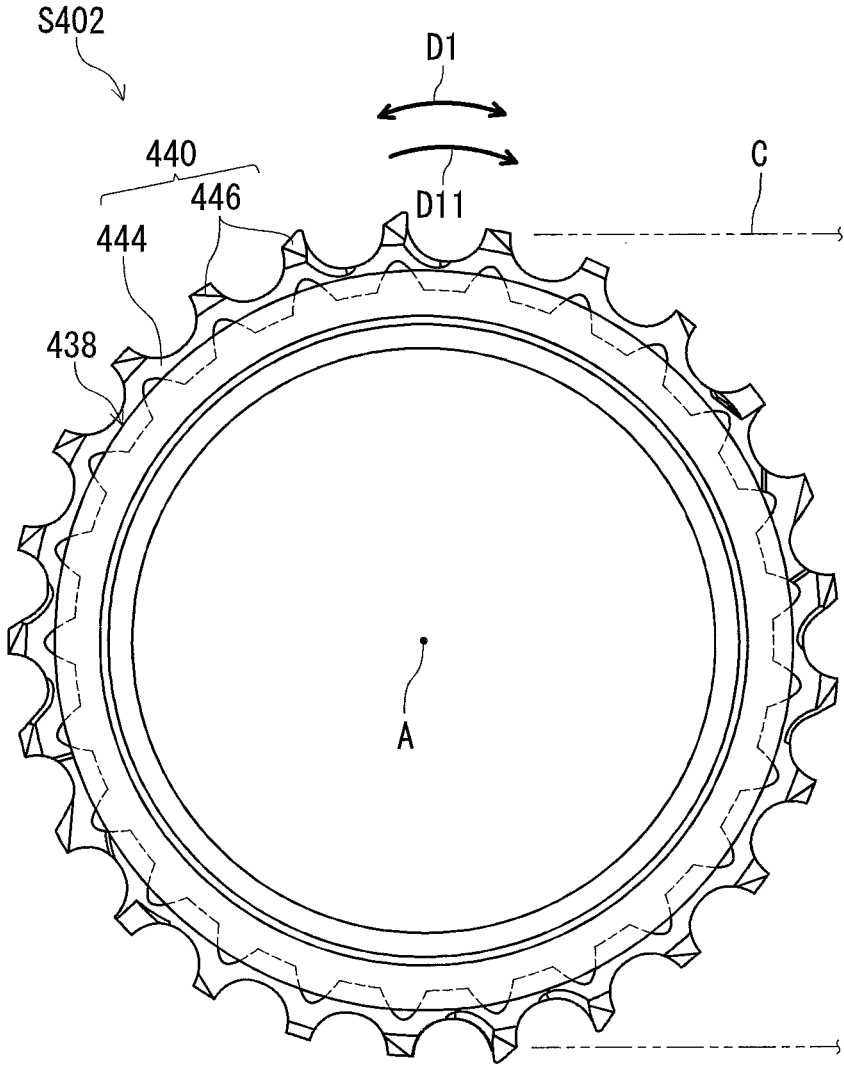


FIG. 22

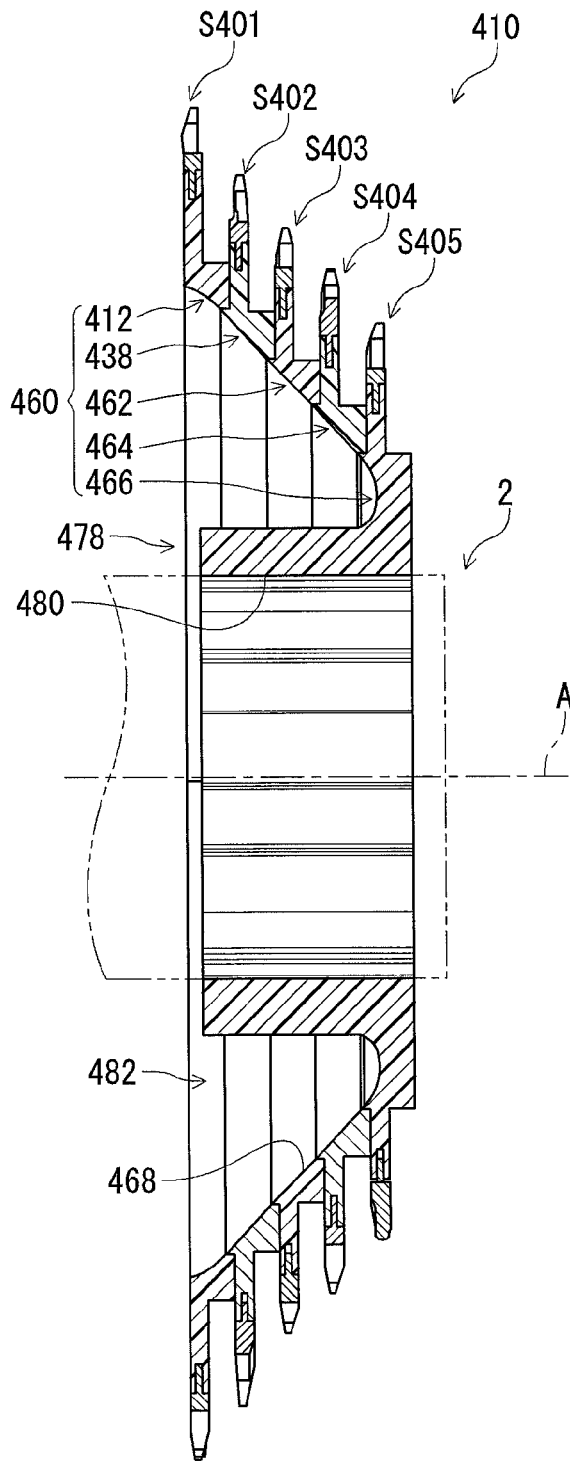


FIG. 23

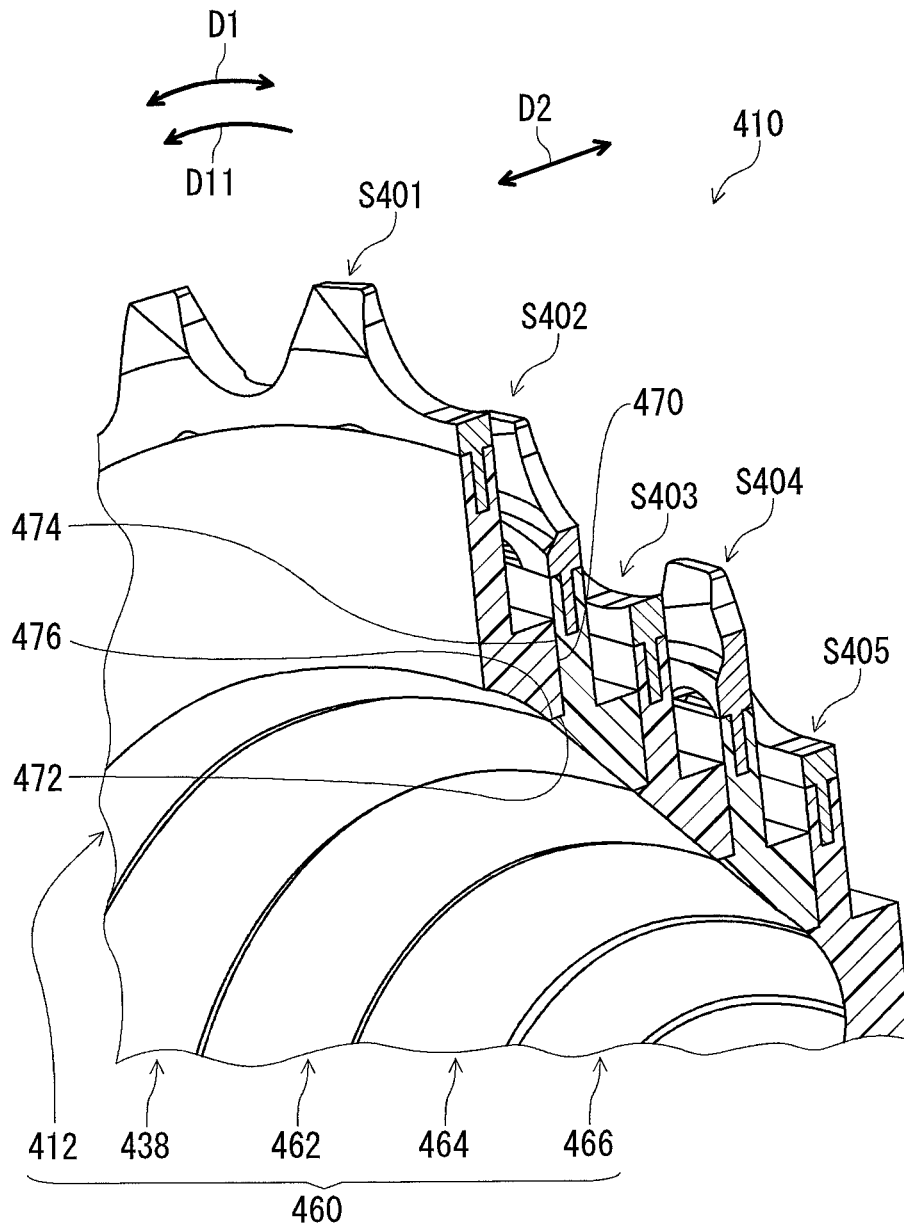


FIG. 24

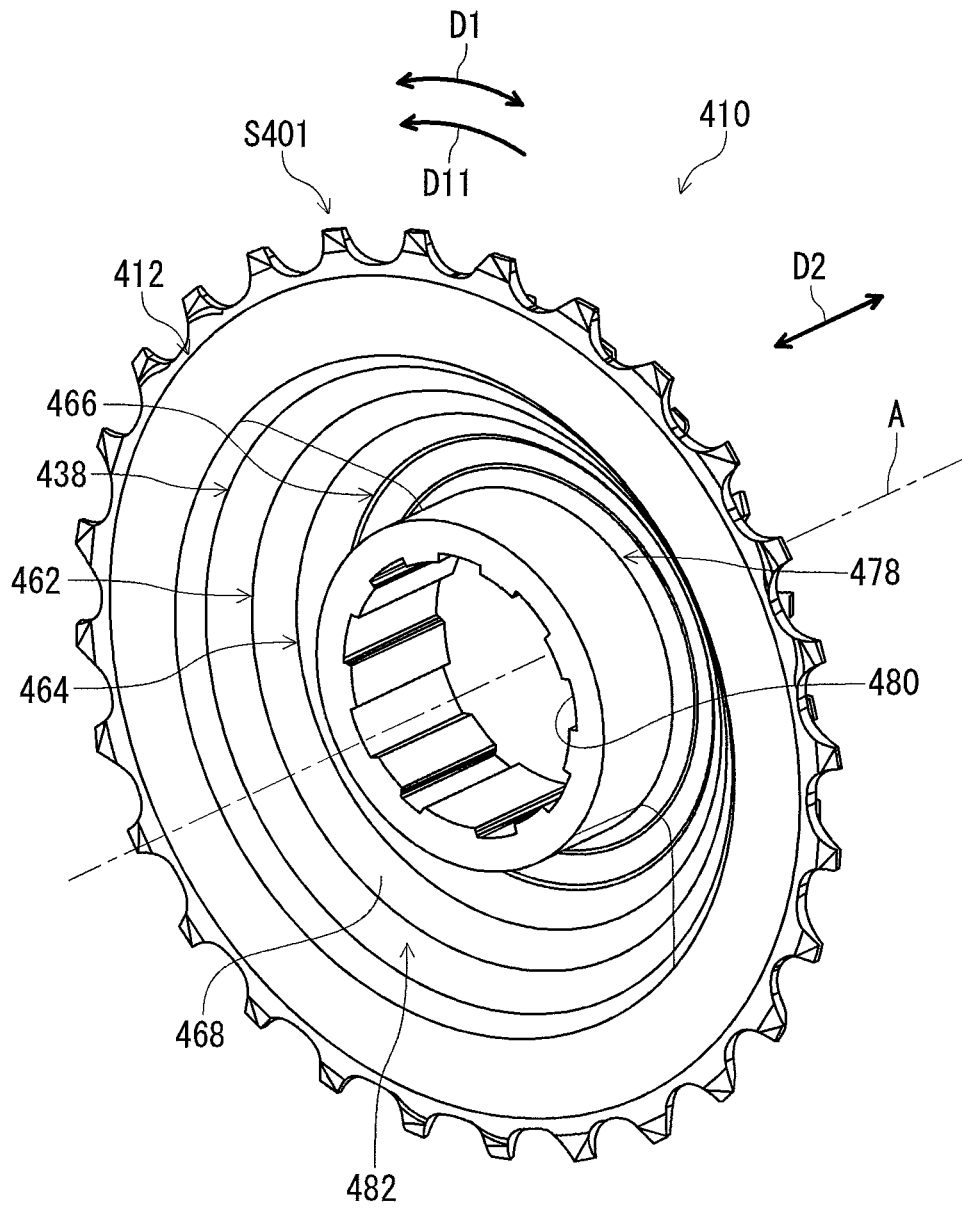


FIG. 25

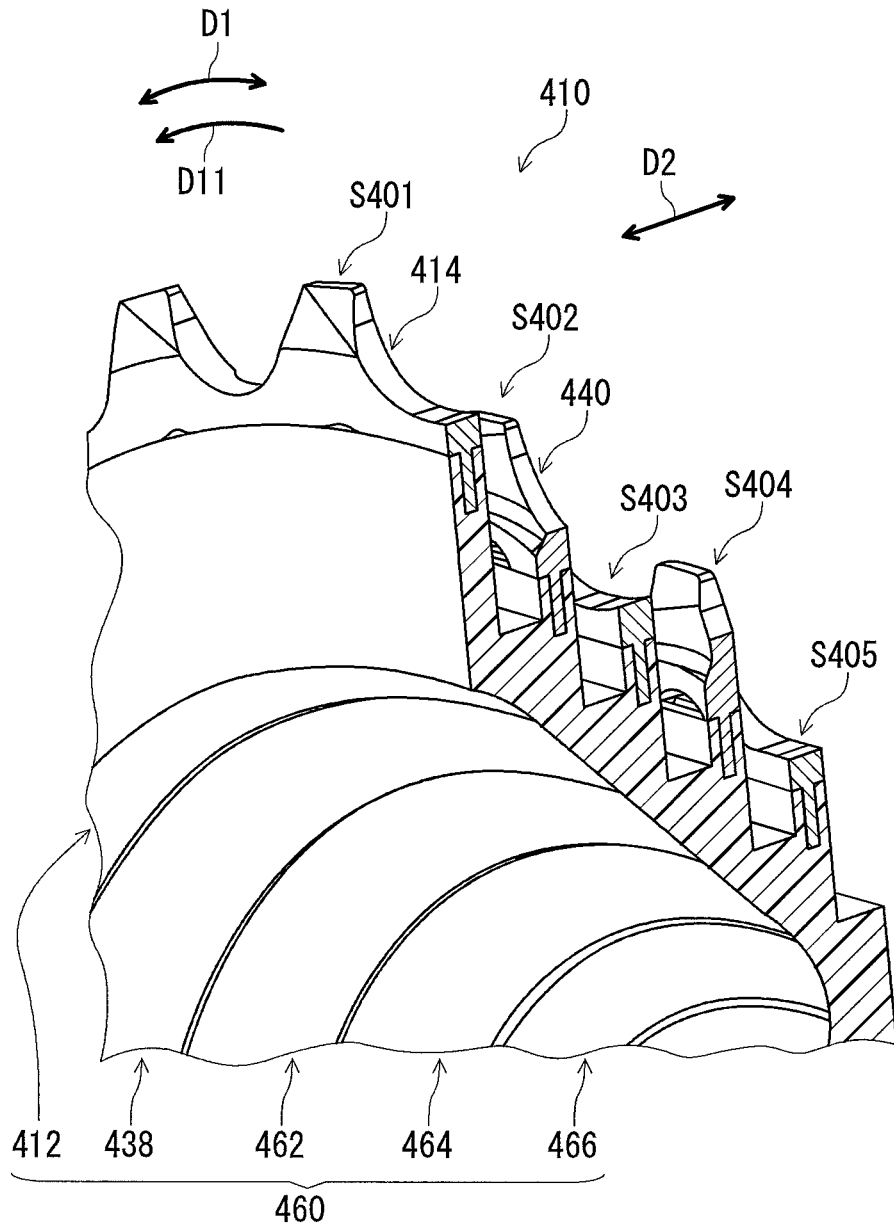


FIG. 26

BICYCLE REAR SPROCKET ASSEMBLY**CROSS-REFERENCE TO RELATED APPLICATIONS**

The present application is a continuation application of the U.S. patent application Ser. No. 14/615,364 filed Feb. 5, 2015. The contents of this application are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION**Field of the Invention**

The present invention relates to a bicycle rear sprocket assembly.

Discussion of the Background

Bicycling is becoming an increasingly more popular form of recreation as well as a means of transportation. Moreover, bicycling has become a very popular competitive sport for both amateurs and professionals. Whether the bicycle is used for recreation, transportation or competition, the bicycle industry is constantly improving the various components of the bicycle. One bicycle component that has been extensively redesigned is a bicycle sprocket assembly.

SUMMARY OF THE INVENTION

In accordance with a first aspect of the present invention, a bicycle rear sprocket assembly has a rotational center axis. The bicycle rear sprocket assembly comprises a first sprocket and a second sprocket. The first sprocket includes a first sprocket body and a first chain-engagement structure. The first sprocket body is made of a non-metallic material. The first chain-engagement structure is made of a metallic material and is configured to engage with a bicycle chain. The second sprocket includes a second sprocket body and a second chain-engagement structure. The second sprocket body is made of a non-metallic material and attached to the first sprocket body. The second chain-engagement structure is made of a metallic material and is configured to engage with the bicycle chain.

In accordance with a second aspect of the present invention, the bicycle rear sprocket assembly according to the first aspect is configured so that the first sprocket body and the second sprocket body provide a base portion having a truncated conical shape

In accordance with a third aspect of the present invention, the bicycle rear sprocket assembly according to the first aspect is configured so that the first chain-engagement structure of the first sprocket includes a first annular member and a plurality of first teeth circumferentially arranged on an outer periphery of the first annular member. The second chain-engagement structure of the second sprocket includes a second annular member and a plurality of second teeth circumferentially arranged on an outer periphery of the second annular member. The first annular member is at least partly embedded in the first sprocket body. The second annular member is at least partly embedded in the second sprocket body.

In accordance with a fourth aspect of the present invention, the bicycle rear sprocket assembly according to the third aspect is configured so that the first annular member is at least partly embedded in the first sprocket body by integral molding. The second annular member is at least partly embedded in the second sprocket body by integral molding.

In accordance with a fifth aspect of the present invention, the bicycle rear sprocket assembly according to the first

aspect is configured so that the first sprocket body is attached to the second sprocket body by adhesive.

In accordance with a sixth aspect of the present invention, the bicycle rear sprocket assembly according to the first aspect is configured so that the first sprocket body is attached to the second sprocket body through a concavo-convex structure.

In accordance with a seventh aspect of the present invention, the bicycle rear sprocket assembly according to the first aspect further comprises a tubular member positioned coaxially with the rotational center axis. The tubular member has a hub engagement profile configured to engage with a bicycle hub assembly.

In accordance with an eighth aspect of the present invention, the bicycle rear sprocket assembly according to the seventh aspect further comprises an internal space provided between the base portion and the tubular member in a radial direction with respect to the rotational center axis.

In accordance with a ninth aspect of the present invention, the bicycle rear sprocket assembly according to the first aspect is configured so that the first sprocket body and the second sprocket body are integral with each other as a single unitary member.

In accordance with a tenth aspect of the present invention, the bicycle rear sprocket assembly according to the first aspect is configured so that the second sprocket body is directly attached to the first sprocket body.

In accordance with an eleventh aspect of the present invention, the bicycle rear sprocket assembly according to the first aspect is configured so that the second sprocket body is attached to the first sprocket body via an intervening member.

In accordance with a twelfth aspect of the present invention, the bicycle rear sprocket assembly according to the eleventh aspect is configured so that the intervening member is made of a metallic material.

In accordance with a thirteenth aspect of the present invention, the bicycle rear sprocket assembly according to the eleventh aspect is configured so that the intervening member has a hub engagement profile configured to engage with the bicycle hub assembly.

In accordance with a fourteenth aspect of the present invention, the bicycle rear sprocket assembly according to the first aspect is configured so that the first sprocket body has a first hub engagement profile configured to engage with a bicycle hub assembly.

In accordance with a fifteenth aspect of the present invention, the bicycle rear sprocket assembly according to the fourteenth aspect is configured so that the second sprocket body has a second hub engagement profile configured to engage with the bicycle hub assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 is a perspective view of a bicycle sprocket assembly in accordance with a first embodiment;

FIG. 2 is an elevational view of a first sprocket, a first intervening member and a second intervening member of the bicycle sprocket assembly illustrated in FIG. 1;

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FIG. 3 is an exploded perspective view of the first sprocket, the first intervening member and the second intervening member of the bicycle sprocket assembly illustrated in FIG. 1;

FIG. 4 is a partial cross-sectional view of the bicycle sprocket assembly taken along line IV-IV of FIG. 1;

FIG. 5 is an enlarged side elevational view of the first sprocket and the first intervening member of the bicycle sprocket assembly illustrated in FIG. 1;

FIG. 6 is an elevational view of a second sprocket, a third intervening member and a fourth intervening member of the bicycle sprocket assembly illustrated in FIG. 1;

FIG. 7 is an exploded perspective view of the second sprocket, the third intervening member and the fourth intervening member of the bicycle sprocket assembly illustrated in FIG. 1;

FIG. 8 is an exploded perspective view of the first sprocket, the first intervening member, the second intervening member, the second sprocket, the third intervening member and the fourth intervening member of the bicycle sprocket assembly illustrated in FIG. 1;

FIG. 9 is an elevational view of a third sprocket and other intervening members of the bicycle sprocket assembly illustrated in FIG. 1;

FIG. 10 is a partial cross-sectional view of a bicycle sprocket assembly in accordance with a second embodiment;

FIG. 11 is an elevational view of a first sprocket, a first intervening member and a second intervening member of the bicycle sprocket assembly illustrated in FIG. 10;

FIG. 12 is an exploded perspective view of the first sprocket, the first intervening member and the second intervening member of the bicycle sprocket assembly illustrated in FIG. 10;

FIG. 13 is a perspective view of a bicycle sprocket assembly in accordance with a third embodiment;

FIG. 14 is an elevational view of a first sprocket, a first intervening member and a second intervening member of the bicycle sprocket assembly illustrated in FIG. 13;

FIG. 15 is an exploded perspective view of the first sprocket, the first intervening member and the second intervening member of the bicycle sprocket assembly illustrated in FIG. 13;

FIG. 16 is a partial cross-sectional view of the bicycle sprocket assembly taken along line XVI-XVI of FIG. 13;

FIG. 17 is an elevational view of a second sprocket, a third intervening member and a fourth intervening member of the bicycle sprocket assembly illustrated in FIG. 13;

FIG. 18 is an exploded perspective view of the second sprocket, the third intervening member and the fourth intervening member of the bicycle sprocket assembly illustrated in FIG. 13;

FIG. 19 is an elevational view of the second sprocket of the bicycle sprocket assembly illustrated in FIG. 13;

FIG. 20 is a perspective view of a bicycle sprocket assembly in accordance with a fourth embodiment;

FIG. 21 is an elevational view of a first sprocket of the bicycle sprocket assembly illustrated in FIG. 20;

FIG. 22 is an elevational view of a second sprocket of the bicycle sprocket assembly illustrated in FIG. 20;

FIG. 23 is a partial cross-sectional view of the bicycle sprocket assembly taken along line XXIII-XXIII of FIG. 20;

FIG. 24 is a partial perspective cross-sectional view of the bicycle sprocket assembly illustrated in FIG. 20;

FIG. 25 is a perspective view of the bicycle sprocket assembly illustrated in FIG. 20; and

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FIG. 26 is a partial perspective cross-sectional view of a bicycle sprocket assembly in accordance with a modified embodiment.

DESCRIPTION OF THE EMBODIMENTS

The embodiments will now be described with reference to the accompanying drawings, wherein like reference numerals designate corresponding or identical elements throughout the various drawings.

First Embodiment

Referring initially to FIG. 1, a bicycle sprocket assembly 10 in accordance with a first embodiment comprises a plurality of bicycle sprockets. The bicycle sprocket assembly 10 is configured to engage with a bicycle chain C. In the illustrated embodiment, the bicycle sprocket assembly 10 comprises eleven bicycle sprockets S1 to S11. The bicycle sprocket assembly 10 has a rotational center axis A. The bicycle sprocket assembly 10 is configured to be rotated about the rotational center axis A in a rotational driving direction D11 during pedaling. The rotational driving direction D11 is defined along a circumferential direction D1 of the bicycle sprocket assembly 10. The bicycle sprockets S1 to S11 are arranged in an axial direction D2 parallel to the rotational center axis A.

While the bicycle sprocket assembly 10 is a bicycle rear sprocket assembly in the illustrated embodiment, constructions of the bicycle sprocket assembly 10 can be applied to a bicycle front sprocket assembly if needed and/or desired. In the illustrated embodiment, the bicycle sprocket assembly 10 is configured to be mounted on a bicycle hub assembly 2.

In the present application, the following directional terms “front”, “rear”, “forward”, “rearward”, “left”, “right”, “transverse”, “upward” and “downward” as well as any other similar directional terms refer to those directions which are determined on the basis of a user (e.g., a rider) who sits on a saddle (not shown) of a bicycle with facing a handlebar (not shown). Accordingly, these terms, as utilized to describe the bicycle sprocket assembly 10, should be interpreted relative to the bicycle equipped with the bicycle sprocket assembly 10 as used in an upright riding position on a horizontal surface.

As seen in FIG. 1, the bicycle sprocket assembly 10 comprises a first sprocket and a second sprocket. In the illustrated embodiment, the bicycle sprocket S2 is also referred to as the first sprocket S2, and the bicycle sprocket S3 is also referred to as the second sprocket S3. The bicycle sprocket assembly 10 further comprises a third sprocket. In the illustrated embodiment, the bicycle sprockets S4 is also referred to as the third sprocket S4. However, other sprockets of the bicycle sprocket assembly 10 can be referred to as the first sprocket, the second sprocket, and the third sprocket if needed and/or desired.

As seen in FIGS. 2 and 3, the first sprocket S2 includes a first sprocket body 12 and a first chain-engagement structure 14. The first sprocket body 12 has a first hub engagement profile 16 configured to engage with the bicycle hub assembly 2 (FIG. 1). The first chain-engagement structure 14 is configured to engage with the bicycle chain C. The first chain-engagement structure 14 includes a first annular member 18 and a plurality of first teeth 20. The plurality of first teeth 20 circumferentially are arranged on an outer periphery of the first annular member 18.

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In the illustrated embodiment, for example, the first annular member **18** and the plurality of first teeth **20** are made of a metallic material. While the first teeth **20** is integral with the first annular member **18** in the illustrated embodiment, at least one of the first teeth **20** can be a separate member from the first annular member **18** if needed and/or desired.

The first sprocket body **12** is made of a non-metallic material. The first sprocket body **12** is made of a resin material. The first annular member **18** is attached to the first sprocket body **12** by integral molding. In the illustrated embodiment, the first annular member **18** is attached to the first sprocket body **12** by integral molding such as insert molding. However, the first annular member **18** can be attached to the first sprocket body **12** by adhesive if needed and/or desired.

The first sprocket body **12** can be made of non-metallic materials other than the resin material if needed and/or desired. Furthermore, the first sprocket body **12** can be made of a metallic material same as or different from the material of the first teeth **20** and the first annular member **18** if needed and/or desired. For example, the first sprocket body **12** can be made of a light weight metallic material such as aluminum whereas the first teeth **20** and the first annular member **18** can be made of a rigid metallic material such as iron or titanium.

As seen in FIGS. **2** and **3**, the bicycle sprocket assembly **10** comprises a first intervening member **22**. While the first intervening member **22** has an annular shape in the illustrated embodiment, the first intervening member **22** can have other shapes if needed and/or desired. The first intervening member **22** preferably has a hub engagement profile **24** configured to engage with the bicycle hub assembly **2** (FIG. **1**). The hub engagement profile **24** of the first intervening member **22** has substantially the same as the first hub engagement profile **16** of the first sprocket body **12** when viewed from the axial direction **D2**. The first intervening member **22** is disposed to be coaxial with respect to the rotational center axis **A** of the bicycle sprocket assembly **10**.

The bicycle sprocket assembly **10** comprises a second intervening member **26**. The second intervening member **26** is provided radially outwardly from the first intervening member **22** with respect to the rotational center axis **A**. The first intervening member **22** and the second intervening member **26** are spaced apart from each other in a radial direction with respect to the rotational center axis **A**. While the second intervening member **26** includes a plurality of separate parts in the illustrated embodiment, the second intervening member **26** can be integrally provided as a single unitary member if needed and/or desired. Furthermore, while the first intervening member **22** is a separate member from the second intervening member **26** in the illustrated embodiment, the first intervening member **22** can be integrally provided with the second intervening member **26** as a single unitary member if needed and/or desired.

As seen in FIGS. **3** and **4**, the second intervening member **26** has an elongated shape extending along a first reference plane **P1** (FIG. **4**) perpendicular to the rotational center axis **A**. In the illustrated embodiment, the first sprocket **S2** includes a side surface **28** provided on the first sprocket body **12** to face the second sprocket **S3** in the axial direction **D2** (FIG. **3**). The first reference plane **P1** is defined on the side surface **28** of the first sprocket **S2**. Namely, the second intervening member **26** has an elongated shape extending along the side surface **28** perpendicular to the rotational center axis **A**. The second intervening member **26** extends from the first sprocket body **12** in the axial direction **D2**.

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As seen in FIG. **4**, the first intervening member **22** is positioned between the first sprocket **S2** and the second sprocket **S3** in the axial direction **D2** parallel to the rotational center axis **A**. The second intervening member **26** is positioned between the first sprocket **S2** and the second sprocket **S3** in the axial direction **D2**. The first sprocket **S2** is adjacent to the second sprocket **S3** without another sprocket intervening between the first sprocket **S2** and the second sprocket **S3** in the axial direction **D2**. The second sprocket **S3** is adjacent to the third sprocket **S4** without another sprocket intervening between the second sprocket **S3** and the third sprocket **S4** in the axial direction **D2**. The second sprocket **S3** is positioned between the first sprocket **S2** and the third sprocket **S4** in the axial direction **D2**.

The first intervening member **22** is a separate member from the first sprocket **S2** and the second sprocket **S3**. However, the first intervening member **22** can be integrally provided with at least one of the first sprocket **S2** and the second sprocket **S3** if needed and/or desired.

As seen in FIG. **4**, the first intervening member **22** is attached to at least one of the first sprocket **S2** and the second sprocket **S3** by adhesive. In the illustrated embodiment, the first intervening member **22** is attached to the first sprocket **S2** and the second sprocket **S3** by adhesive. However, the first intervening member **22** can be attached to at least one of the first sprocket **S2** and the second sprocket **S3** via other structures if needed and/or desired. Furthermore, the first intervening member **22** can be attached to at least one of the first sprocket **S2** and the second sprocket **S3** by diffusion bonding if needed and/or desired. In such an embodiment, the first intervening member **22** and the at least one of the first sprocket **S2** and the second sprocket **S3** are at least partly made of a metallic material.

The second intervening member **26** is attached to at least one of the first sprocket **S2** and the second sprocket **S3**. The second intervening member **26** is attached to at least one of the first sprocket **S2** and the second sprocket **S3** by adhesive. The second intervening member **26** is integral with one of the first sprocket **S2** and the second sprocket **S3** as a single unitary member. In the illustrated embodiment, the second intervening member **26** is integral with the first sprocket **S2** as a single unitary member and is a separate member from the second sprocket **S3**. The second intervening member **26** is attached to the second sprocket **S3** by adhesive. However, the second intervening member **26** can be a separate member from the first sprocket **S2** if needed and/or desired. In such an embodiment, the second intervening member **26** is attached to the first sprocket **S2** and the second sprocket **S3**. Furthermore, the second intervening member **26** can be attached to at least one of the first sprocket **S2** and the second sprocket **S3** by diffusion bonding if needed and/or desired. In such an embodiment, the second intervening member **26** and the at least one of the first sprocket **S2** and the second sprocket **S3** are at least partly made of a metallic material.

As seen in FIGS. **2** and **3**, the first sprocket **S2** has a first opening **30** and a first inner periphery **32**. The first opening **30** is provided on the first sprocket body **12**. The first inner periphery **32** defines the first opening **30**. In the illustrated embodiment, the first sprocket **S2** has first openings **30** and first inner peripheries **32**. The first openings **30** are provided on the first sprocket body **12**. The first inner peripheries **32** respectively define the first openings **30**. A total number of the first openings **30** is not limited to the illustrated embodiment. While the first openings **30** has the same shape in the illustrated embodiment, at least one of the first openings **30** can have other shapes different from each other if needed and/or desired.

As seen in FIG. 5, the second intervening member 26 includes a first elongated portion 34 at least partly extending along the first inner periphery 32. In the illustrated embodiment, the second intervening member 26 includes first elongated portions 34 and first additional elongated portions 36. The first elongated portions 34 each at least partly extend along one of the first inner peripheries 32. The first additional elongated portions 36 each at least partly extend along another of the first inner peripheries 32 which is adjacent to the one of the first inner peripheries 32. While the first elongated portions 34 are provided radially outward of the first additional elongated portions 36 in the illustrated embodiment, the first elongated portions 34 can be provided radially inward of the first additional elongated portions 36 or provided at radial positions equal to radial positions of the first additional elongated portions 36 if needed and/or desired. A total number of each of the first elongated portions 34 and the first additional elongated portions 36 is not limited to the illustrated embodiment.

The second intervening member 26 includes a first intermediate portion 37 coupling the first elongated portion 34 to the first additional elongated portion 36. In the illustrated embodiment, the second intervening member 26 includes first intermediate portions 37 respectively coupling the first elongated portions 34 to the first additional elongated portions 36. The first sprocket body 12 includes first arm portions 12a radially extending relative to the rotational center axis A. Each of the first arm portions 12a is provided between adjacent two of the first openings 30. The first intermediate portions 37 are respectively provided on the first arm portions 12a.

In the illustrated embodiment, the first elongated portion 34 extends in the circumferential direction D1. The first additional elongated portion 36 extends in the circumferential direction D1. The first intermediate portion 37 substantially radially extends relative to the rotational center axis A.

As seen in FIGS. 6 and 7, the second sprocket S3 includes a second sprocket body 38 and a second chain-engagement structure 40. The second chain-engagement structure 40 is configured to engage with the bicycle chain C. The second sprocket body 38 has a second hub engagement profile 42 configured to engage with the bicycle hub assembly 2 (FIG. 1). The second chain-engagement structure 40 includes a second annular member 44 and a plurality of second teeth 46. The plurality of second teeth 46 circumferentially are arranged on an outer periphery of the second annular member 44.

In the illustrated embodiment, for example, the second annular member 44 and the plurality of second teeth 46 are made of a metallic material. While the second teeth 46 is integral with the second annular member 44 in the illustrated embodiment, at least one of the second teeth 46 can be a separate member from the second annular member 44 if needed and/or desired. The second sprocket body 38 is made of a non-metallic material. For example, the second sprocket body 38 is made of a resin material. The second annular member 44 is attached to the second sprocket body 38 by integral molding. However, the second annular member 44 can be attached to the second sprocket body 38 by adhesive if needed and/or desired.

The second sprocket body 38 can be made of non-metallic materials other than the resin material if needed and/or desired. Furthermore, the second sprocket body 38 can be made of a metallic material same as or different from the material of the second teeth 46 the second annular member 44 if needed and/or desired. For example, the second sprocket body 38 can be made of a light weight metallic

material such as aluminum whereas the second teeth 46 and the second annular member 44 can be made of a rigid metallic material such as iron or titanium.

As seen in FIG. 4, the second sprocket body 38 is attached to the first sprocket body 12. In the illustrated embodiment, the second sprocket body 38 is attached to the first sprocket body 12 via an intervening member. The second sprocket body 38 is attached to the first sprocket body 12 via the first intervening member 22 and the second intervening member 26. However, the second sprocket body 38 can be directly attached to the first sprocket body 12 if needed and/or desired.

As seen in FIGS. 2 and 6, the plurality of first teeth 20 have a first total number. The plurality of second teeth 46 have a second total number. The first total number is larger than the second total number. However, the first total number can be smaller than the second total number if needed and/or desired.

As seen in FIGS. 6 and 7, the bicycle sprocket assembly 10 further comprises a third intervening member 48. While the third intervening member 48 has an annular shape in the illustrated embodiment, the third intervening member 48 can have other shapes if needed and/or desired. The third intervening member 48 preferably has a hub engagement profile 50 configured to engage with the bicycle hub assembly (FIG. 1). The hub engagement profile 50 of the third intervening member 48 has substantially the same as the second hub engagement profile 42 of the second sprocket body 38 when viewed from the axial direction D2. The third intervening member 48 is disposed to be coaxial with respect to the rotational center axis A of the bicycle sprocket assembly 10.

As seen in FIGS. 6 and 7, the bicycle sprocket assembly 10 further comprises a fourth intervening member 52. The fourth intervening member 52 is provided radially outwardly from the third intervening member 48 with respect to the rotational center axis A. The third intervening member 48 and the fourth intervening member 52 are spaced apart from each other in a radial direction with respect to the rotational center axis A. While the fourth intervening member 52 includes a plurality of separate parts in the illustrated embodiment, the fourth intervening member 52 can be integrally provided as a single unitary member if needed and/or desired. Furthermore, while the third intervening member 48 is a separate member from the fourth intervening member 52 in the illustrated embodiment, the third intervening member 48 can be integrally provided with the fourth intervening member 52 if needed and/or desired.

As seen in FIGS. 4 and 7, the fourth intervening member 52 has an elongated shape extending along a second reference plane P2 (FIG. 4) perpendicular to the rotational center axis A. In the illustrated embodiment, the second sprocket S3 includes a side surface 54 provided on the second sprocket body 38 to face the third sprocket S4 in the axial direction D2 (FIG. 7). The second reference plane P2 is defined on the side surface 54 of the second sprocket S3. Namely, the fourth intervening member 52 has an elongated shape extending along the side surface 54 perpendicular to the rotational center axis A. The fourth intervening member 52 extends from the second sprocket body 38 in the axial direction D2.

As seen in FIG. 4, the third intervening member 48 is positioned between the second sprocket S3 and the third sprocket S4 in the axial direction D2. The fourth intervening member 52 is positioned between the second sprocket S3 and the third sprocket S4 in the axial direction D2.

The third intervening member 48 is a separate member from the second sprocket S3 and the third sprocket S4.

However, the third intervening member **48** can be integrally provided with at least one of the second sprocket **S3** and the third sprocket **S4** if needed and/or desired.

As seen in FIG. **4**, the third intervening member **48** is attached to at least one of the second sprocket **S3** and the third sprocket **S4** by adhesive. In the illustrated embodiment, the third intervening member **48** is attached to the second sprocket **S3** and the third sprocket **S4** by adhesive. However, the third intervening member **48** can be attached to at least one of the second sprocket **S3** and the third sprocket **S4** by other structures if needed and/or desired. Furthermore, the third intervening member **48** can be attached to at least one of the second sprocket **S3** and the third sprocket **S4** by diffusion bonding if needed and/or desired. In such an embodiment, the third intervening member **48** and the at least one of the second sprocket **S3** and the third sprocket **S4** are made of a metallic material.

The fourth intervening member **52** is attached to at least one of the second sprocket **S3** and the third sprocket **S4**. The fourth intervening member **52** is attached to at least one of the second sprocket **S3** and the third sprocket **S4** by adhesive. The fourth intervening member **52** is integral with one of the second sprocket **S3** and the third sprocket **S4** as a single unitary member. In the illustrated embodiment, the fourth intervening member **52** is integral with the second sprocket **S3** as a single unitary member and is a separate member from the third sprocket **S4**. However, the fourth intervening member **52** can be a separate member from the second sprocket **S3** if needed and/or desired. In such an embodiment, the fourth intervening member **52** is attached to the second sprocket **S3** and the third sprocket **S4**. Furthermore, the fourth intervening member **52** can be attached to the at least one of the second sprocket **S3** and the third sprocket **S4** by diffusion bonding if needed and/or desired. In such an embodiment, the fourth intervening member **52** and the at least one of the second sprocket **S3** and the third sprocket **S4** are at least partly made of a metallic material.

As seen in FIGS. **6** and **7**, the second sprocket **S3** has a second opening **56** and a second inner periphery **58**. The second opening **56** is provided on the second sprocket body **38**. The second inner periphery **58** defines the second opening **56**. In the illustrated embodiment, the second sprocket **S3** has second openings **56** and second inner peripheries **58**. The second openings **56** are provided on the second sprocket body **38**. The second inner peripheries **58** respectively define the second openings **56**. A total number of the second openings **56** is not limited to the illustrated embodiment. While the second openings **56** has the same shape in the illustrated embodiment, at least one of the second openings **56** can have other shapes different from each other if needed and/or desired.

As seen in FIG. **5**, the fourth intervening member **52** includes a second elongated portion **60** at least partly extending along the second inner periphery **58**. In the illustrated embodiment, the fourth intervening member **52** includes second elongated portions **60** and second additional elongated portions **62**. The second elongated portions **60** each at least partly extend along one of the second inner peripheries **58**. The second additional elongated portions **62** each at least partly extend along another of the second inner peripheries **58** which is adjacent to the one of the second inner peripheries **58**. While the second elongated portions **60** are provided radially outward of the second additional elongated portions **62** in the illustrated embodiment, the second elongated portions **60** can be provided radially inward of the second additional elongated portions **62** or provided at radial positions equal to radial positions of the

second additional elongated portions **62** if needed and/or desired. A total number of each of the second elongated portions **60** and the second additional elongated portions **62** is not limited to the illustrated embodiment.

The fourth intervening member **52** includes a second intermediate portion **63** coupling the first elongated portion **60** to the first additional elongated portion **62**. In the illustrated embodiment, the fourth intervening member **52** includes second intermediate portions **63** respectively coupling the second elongated portions **60** to the second additional elongated portions **62**. The second sprocket body **38** includes second arm portions **38a** radially extending relative to the rotational center axis **A**. Each of the second arm portions **38a** is provided between adjacent two of the first openings **30**. The second intermediate portions **63** are respectively provided on the second arm portions **38a**.

In the illustrated embodiment, the second elongated portion **60** extends in the circumferential direction **D1**. The second additional elongated portion **62** extends in the circumferential direction **D1**. The second intermediate portion **63** substantially radially extends relative to the rotational center axis **A**.

As seen in FIG. **8**, the first opening **30** is aligned with the second opening **56** in the axial direction **D2**. While the first openings **30** has the same shape as the shape of the second openings **56** in the illustrated embodiment, the shapes of the first openings **30** and the second openings **56** can be different from each other if needed and/or desired. In the illustrated embodiment, the fourth intervening member **52** of the second sprocket **S3** has the same shape as that of the second intervening member **26** of the first sprocket **S2**. However, the shape of the fourth intervening member **52** can be different from the shape of the second intervening member **26** if needed and/or desired.

As seen in FIGS. **9** and **10**, the third sprocket **S4** includes a third sprocket body **64** and a third chain-engagement structure **66**. The third chain-engagement structure **66** is configured to engage with the bicycle chain **C**. The third sprocket body **64** has a third hub engagement profile **68** configured to engage with the bicycle hub assembly **2** (FIG. **1**). The third chain-engagement structure **66** includes a third annular member **70** and a plurality of third teeth **72**. The plurality of third teeth **72** circumferentially are arranged on an outer periphery of the third annular member **70**.

In the illustrated embodiment, for example, the third annular member **70** and the plurality of third teeth **72** are made of a metallic material. While the third teeth **72** is integral with the third annular member **70** in the illustrated embodiment, at least one of the third teeth **72** can be a separate member from the third annular member **70** if needed and/or desired. The third sprocket body **64** is made of a non-metallic material. For example, the third sprocket body **64** is made of a resin material. The third annular member **70** is attached to the third sprocket body **64** by integral molding. However, the third annular member **70** can be attached to the third sprocket body **64** by adhesive if needed and/or desired.

The third sprocket body **64** can be made of non-metallic materials other than the resin material if needed and/or desired. Furthermore, the third sprocket body **64** can be made of a metallic material same as or different from the material of the third teeth **72** and the third annular member **70** if needed and/or desired. For example, the third sprocket body **64** can be made of a light weight metallic material such as aluminum whereas the third teeth **72** and the third annular member **70** can be made of a rigid metallic material such as iron or titanium.

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Since the third sprocket **S4** and/or other sprockets has substantially the same structures as those of the first and second sprockets **S2** and **S3**, they will not be described and/or illustrated in detail here for the sake of brevity.

With the bicycle sprocket assembly **10**, the second intervening member **26** is attached to at least one of the first sprocket **S2** and the second sprocket **S3** and has an elongated shape extending along the first reference plane **P1** perpendicular to the rotational center axis **A**. Accordingly, it is possible to obtain the desired strength of the bicycle sprocket assembly **10** while it is also possible to achieve desired weight saving of each sprocket.

Second Embodiment

A bicycle sprocket assembly **210** in accordance with a second embodiment will be described below referring to FIGS. **10** to **12**. The bicycle sprocket assembly **210** has the same configuration as the bicycle sprocket assembly **10** except for the second intervening member. Thus, elements having substantially the same function as those in the first embodiment will be numbered the same here, and will not be described and/or illustrated again in detail here for the sake of brevity.

As seen in FIG. **10**, the bicycle sprocket assembly **210** comprises a first sprocket **S202** and a second sprocket **S203** instead of the first sprocket **S2** and the second sprocket **S3**. The bicycle sprocket assembly **210** further comprises a third sprocket **S204** instead of the third sprocket **S4**. Other sprockets of the bicycle sprocket assembly **210** can be referred to as the first sprocket **S202**, the second sprocket **S203**, and the third sprocket **S204** if needed and/or desired.

As seen in FIGS. **11** and **12**, the bicycle sprocket assembly **210** comprises the first intervening member **22** and a second intervening member **226**. The second intervening member **226** is provided radially outwardly from the first intervening member **22** with respect to the rotational center axis **A**. The first intervening member **22** and the second intervening member **226** are spaced apart from each other in a radial direction with respect to the rotational center axis **A**. While the second intervening member **226** includes a plurality of separate parts in the illustrated embodiment, the second intervening member **226** can be integrally provided as a single unitary member if needed and/or desired. Furthermore, while the first intervening member **22** is a separate member from the second intervening member **226** in the illustrated embodiment, the first intervening member **22** can be integrally provided with the second intervening member **226** if needed and/or desired.

As seen in FIGS. **10** and **12**, the second intervening member **226** has an elongated shape extending along the first reference plane **P1** (FIG. **10**) perpendicular to the rotational center axis **A**. The second intervening member **226** has an elongated shape extending along the side surface **28** perpendicular to the rotational center axis **A**.

As seen in FIGS. **11** and **12**, the second intervening member **226** includes a first elongated portion **234** at least partly extending along the first inner periphery **32**. In the illustrated embodiment, the first elongated portion **234** entirely extends along the first inner periphery **32** and surrounds the first opening **30**. The second intervening member **226** includes first elongated portions **234**. The first elongated portions **234** entirely extend along the first inner peripheries **32**, respectively. A total number of each of the first elongated portions **234** is not limited to the illustrated embodiment. The second intervening member **226** extends from the second sprocket **S202** in the axial direction **D2**.

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As seen in FIG. **10**, the second intervening member **226** is positioned between the first sprocket **S202** and the second sprocket **S203** in the axial direction **D2**. The second intervening member **226** is attached to at least one of the first sprocket **S202** and the second sprocket **S203**. The second intervening member **226** is attached to at least one of the first sprocket **S202** and the second sprocket **S203** by adhesive. The second intervening member **226** is integral with one of the first sprocket **S202** and the second sprocket **S203** as a single unitary member.

In the illustrated embodiment, the second intervening member **226** is integral with the first sprocket **S202** as a single unitary member and is a separate member from the second sprocket **S203**. The second intervening member **226** is attached to the second sprocket **S203** by adhesive. However, the second intervening member **226** can be a separate member from the first sprocket **S202** if needed and/or desired. In such an embodiment, the second intervening member **226** is attached to the first sprocket **S202** and the second sprocket **S203**. Furthermore, the second intervening member **226** can be attached to at least one of the first sprocket **S202** and the second sprocket **S203** by diffusion bonding if needed and/or desired. In such an embodiment, the second intervening member **226** and the at least one of the first sprocket body **12** and the second sprocket body **38** are at least partly made of a metallic material.

Since the second sprocket **S203** and the third sprocket **S204** has substantially the same structures as those of the first sprocket **S202**, they will not be described and/or illustrated in detail here for the sake of brevity. Other sprockets can have substantially the same structures as those of the first sprocket **S202** if needed and/or desired.

With the bicycle sprocket assembly **210**, it is possible to obtain substantially the same advantageous effect as that of the bicycle sprocket assembly **10** in accordance with the first embodiment.

Third Embodiment

A bicycle sprocket assembly **310** in accordance with a third embodiment will be described below referring to FIGS. **13** to **19**. The bicycle sprocket assembly **310** has the same configuration as the bicycle sprocket assembly **10** except for the second intervening member. Thus, elements having substantially the same function as those in the above embodiments will be numbered the same here, and will not be described and/or illustrated again in detail here for the sake of brevity.

As seen in FIG. **13**, the bicycle sprocket assembly **310** is configured to engage with the bicycle chain **C**. In the illustrated embodiment, the bicycle sprocket assembly **310** comprises five bicycle sprockets **S301** to **S305** and other smaller sprockets. The other smaller sprockets are omitted from the bicycle sprocket assembly **310** as illustrated in FIG. **13**. The bicycle sprocket assembly **310** has the rotational center axis **A**. The bicycle sprockets **S301** to **S305** are arranged in the axial direction **D2** parallel to the rotational center axis **A**.

The bicycle sprocket assembly **310** comprises a first sprocket and a second sprocket. In the illustrated embodiment, the bicycle sprocket **S301** is also referred to as the first sprocket **S301**, and the bicycle sprocket **S302** is also referred to as the second sprocket **S302**. The bicycle sprocket assembly **310** further comprises a third sprocket. In the illustrated embodiment, the bicycle sprockets **S303** is also referred to as the third sprocket **S303**. However, other sprockets of the

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bicycle sprocket assembly **310** can be referred to as the first sprocket, the second sprocket, and the third sprocket if needed and/or desired.

As seen in FIGS. **14** and **15**, the bicycle sprocket assembly **310** comprises the first intervening member **22** and a second intervening member **326**. The second intervening member **326** is provided radially outwardly from the first intervening member **22** with respect to the rotational center axis **A**. The first intervening member **22** and the second intervening member **326** are spaced apart from each other in a radial direction with respect to the rotational center axis **A**.

As seen in FIGS. **15** and **16**, the second intervening member **326** has an elongated shape extending along the first reference plane **P1** (FIG. **16**) perpendicular to the rotational center axis **A**. The second intervening member **326** has an elongated shape extending along the side surface **28** perpendicular to the rotational center axis **A**.

As seen in FIGS. **14** and **15**, the first intervening member **22** has an annular shape and is disposed to be coaxial with respect to the rotational center axis **A** of the bicycle sprocket assembly **310**. The second intervening member **326** has an annular shape and is disposed to be coaxial with respect to the rotational center axis **A** of the bicycle sprocket assembly **310**. While the first intervening member **22** is a separate member from the second intervening member **326** in the illustrated embodiment, the first intervening member **22** can be integrally provided with the second intervening member **326** if needed and/or desired.

As seen in FIG. **16**, the first intervening member **22** is positioned between the first sprocket **S301** and the second sprocket **S302** in the axial direction **D2** parallel to the rotational center axis **A**. The second intervening member **326** is positioned between the first sprocket **S301** and the second sprocket **S302** in the axial direction **D2**. The first sprocket **S301** is adjacent to the second sprocket **S302** without another sprocket intervening between the first sprocket **S301** and the second sprocket **S302** in the axial direction **D2**. The second sprocket **S302** is adjacent to the third sprocket **S303** without another sprocket intervening between the second sprocket **S302** and the third sprocket **S303** in the axial direction **D2**. The second sprocket **S302** is positioned between the first sprocket **S301** and the third sprocket **S303** in the axial direction **D2**.

The second intervening member **326** is attached to at least one of the first sprocket **S301** and the second sprocket **S302**. The second intervening member **326** is attached to at least one of the first sprocket **S301** and the second sprocket **S302** by adhesive. In the illustrated embodiment, the second intervening member **326** is a separate member from the first sprocket **S301** and the second sprocket **S302**. The second intervening member **326** is attached to the first sprocket **S301** and the second sprocket **S302**. However, the second intervening member **326** can be integral with at least one of the first sprocket **S301** and the second sprocket **S302** as a single unitary member if needed and/or desired.

As seen in FIGS. **15** and **16**, the first sprocket body **12** includes an attachment groove **327**. The second intervening member **326** is provided in the attachment groove **327**. The first sprocket body **12** includes attachment holes **329** provided in the attachment groove **327**. The second intervening member **326** includes an annular body **326a** and protrusions **326b** protruding from the annular body **326a** in the axial direction **D2**. The protrusions **326b** are provided to mate with the attachment holes **329** respectively.

As seen in FIGS. **17** and **18**, the bicycle sprocket assembly **310** further comprises the third intervening member **48** and a fourth intervening member **352**. The fourth intervening

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member **352** is provided radially outwardly from the third intervening member **48** with respect to the rotational center axis **A**. The third intervening member **48** and the fourth intervening member **352** are spaced apart from each other in the radial direction with respect to the rotational center axis **A**.

As seen in FIGS. **16** and **18**, the fourth intervening member **352** has an elongated shape extending along the second reference plane **P2** (FIG. **16**) perpendicular to the rotational center axis **A**. The fourth intervening member **352** has an elongated shape extending along the side surface **54** perpendicular to the rotational center axis **A**.

As seen in FIG. **16**, the third intervening member **48** is positioned between the second sprocket **S302** and the third sprocket **S303** in the axial direction **D2**. The fourth intervening member **352** is positioned between the second sprocket **S302** and the third sprocket **S303** in the axial direction **D2**. In the illustrated embodiment, the fourth intervening member **352** is positioned radially inwardly from the second intervening member **326** with respect to the rotational center axis **A**. The second intervening member **326** has an inner diameter larger than an outer diameter of the fourth intervening member **352**. However, the fourth intervening member **352** can be positioned at the radial position equal to the second intervening member **326** or positioned radially outwardly from the second intervening member **326** with respect to the rotational center axis **A** if needed and/or desired.

In the illustrated embodiment, the third intervening member **48** is a separate member from the second sprocket **S302** and the third sprocket **S303**. For example, the third intervening member **48** is attached to at least one of the second sprocket **S302** and the third sprocket **S303** by adhesive. However, the third intervening member **48** can be integrally provided with at least one of the second sprocket **S302** and the third sprocket **S303** if needed and/or desired. In the illustrated embodiment, the third intervening member **48** is attached to the second sprocket **S302** and the third sprocket **S303** by adhesive. However, the third intervening member **48** can be attached to at least one of the second sprocket **S302** and the third sprocket **S303** by other structures.

As seen in FIG. **16**, the fourth intervening member **352** is attached to at least one of the second sprocket **S302** and the third sprocket **S303**. The fourth intervening member **352** is attached to at least one of the second sprocket **S302** and the third sprocket **S303** by adhesive. The fourth intervening member **352** is attached to the second sprocket **S302** and the third sprocket **S303**. In the illustrated embodiment, the fourth intervening member **352** is a separate member from the second sprocket **S302** and the third sprocket **S303**. However, the fourth intervening member **352** can be integral with at least one of the second sprocket **S302** and the third sprocket **S303** if needed and/or desired.

As seen in FIGS. **16** and **18**, while the third intervening member **48** is a separate member from the fourth intervening member **352** in the illustrated embodiment, the third intervening member **48** can be integrally provided with the fourth intervening member **352** if needed and/or desired.

As seen in FIGS. **16** and **18**, the second sprocket body **38** includes an attachment groove **353**. The fourth intervening member **352** is provided in the attachment groove **353**. As seen in FIG. **19**, the second sprocket body **38** includes an additional attachment groove **355**. The additional attachment groove **355** is provided on an additional side surface **357** opposite to the side surface **54** (FIG. **18**) in the axial

direction D2. As seen FIG. 16, the second intervening member 326 is provided in the additional attachment groove 355.

Since the third sprocket S303 and/or other sprockets has substantially the same structures as those of the second sprocket S302, they will not be described and/or illustrated in detail here for the sake of brevity.

With the bicycle sprocket assembly 310, it is possible to obtain substantially the same advantageous effect as that of the bicycle sprocket assembly 10 in accordance with the first embodiment.

Fourth Embodiment

A bicycle sprocket assembly 410 in accordance with a fourth embodiment will be described below referring to FIGS. 20 to 26. The bicycle sprocket assembly 410 has the same configuration as the bicycle sprocket assembly 10 except for sprocket bodies and intervening members. Thus, elements having substantially the same function as those in the above embodiments will be numbered the same here, and will not be described and/or illustrated again in detail here for the sake of brevity.

As seen in FIG. 20, the bicycle sprocket assembly 410 is a bicycle rear sprocket assembly configured to engage with the bicycle chain C. The bicycle sprocket assembly 410 is also referred to as a bicycle rear sprocket assembly 410. In the illustrated embodiment, the bicycle rear sprocket assembly 410 comprises five bicycle sprockets S401 to S405. The bicycle rear sprocket assembly 410 has the rotational center axis A. The bicycle sprockets S401 to S405 are arranged in the axial direction D2 parallel to the rotational center axis A.

The bicycle rear sprocket assembly 410 comprises a first sprocket and a second sprocket. In the illustrated embodiment, the bicycle sprocket S401 is also referred to as the first sprocket S401, and the bicycle sprocket S402 is also referred to as the second sprocket S402. Other sprockets can be referred to as the first sprocket and the second sprocket if needed and/or desired.

As seen in FIG. 21, the first sprocket S401 includes a first sprocket body 412 and a first chain-engagement structure 414. The first chain-engagement structure 414 is configured to engage with the bicycle chain C. The first chain-engagement structure 414 of the first sprocket S401 includes a first annular member 418 and a plurality of first teeth 420. The plurality of first teeth 420 are circumferentially arranged on an outer periphery of the first annular member 418.

The first sprocket body 412 is made of a non-metallic material. For example, the first sprocket body 412 is made of a resin material. The first chain-engagement structure 414 is made of a metallic material. The first annular member 418 is at least partly embedded in the first sprocket body 412. In the illustrated embodiment, the first annular member 418 is at least partly embedded in the first sprocket body 412 by integral molding. The first chain-engagement structure 414 is partly embedded in the first sprocket body 412 by integral molding such as insert molding. However, the first chain-engagement structure 414 can be attached to the first sprocket body 412 by adhesive if needed and/or desired.

As seen in FIG. 22, the second sprocket S402 includes a second sprocket body 438 and a second chain-engagement structure 440. The second chain-engagement structure 440 is configured to engage with the bicycle chain C. The second chain-engagement structure 440 of the second sprocket S402 includes a second annular member 444 and a plurality of

second teeth 446. The plurality of second teeth 446 are circumferentially arranged on an outer periphery of the second annular member 444.

The second sprocket body 438 is made of a non-metallic material. For example, the second sprocket body 438 is made of a resin material. The second sprocket body 438 is attached to the first sprocket body 412. In the illustrated embodiment, as seen in FIG. 23, the second sprocket body 438 is directly attached to the first sprocket body 412. However, the second sprocket body 438 can be attached to the first sprocket body 412 via an intervening member such as the first intervening member and the second intervening member in accordance with the above embodiments if needed and/or desired.

The second chain-engagement structure 440 is made of a metallic material. The second annular member 444 is at least partly embedded in the second sprocket body 438. In the illustrated embodiment, the second annular member 444 is at least partly embedded in the second sprocket body 438 by integral molding. The second chain-engagement structure 440 is partly embedded in the second sprocket body 438 by integral molding such as insert molding. However, the second chain-engagement structure 440 can be attached to the second sprocket body 438 by adhesive if needed and/or desired.

As seen in FIG. 23, the first sprocket body 412 and the second sprocket body 438 provide a base portion 460 having a truncated conical shape. In the illustrated embodiment, each of the bicycle sprockets S403 to S405 includes sprocket bodies 462, 464 and 466. The first sprocket body 412, the second sprocket body 438, and the sprocket bodies 462, 464 and 466 of the bicycle sprockets S401 to S405 provide the base portion 460 having a tapered inner peripheral surface 468.

As seen in FIG. 24, the first sprocket body 412 is attached to the second sprocket body 438 by adhesive. In the illustrated embodiment, the first sprocket body 412 is attached to the second sprocket body 438 through a concavo-convex structure for the purpose of better torque transmission. More specifically, the first sprocket body 412 includes a first axial surface 470 and a first radial surface 472. The first axial surface 470 has an annular shape and faces in the axial direction D2. The first radial surface 472 has an annular shape and radially inwardly faces relative to the rotational center axis A. The second sprocket body 438 includes a second axial surface 474 and a second radial surface 476. The second axial surface 474 has an annular shape and faces in the axial direction D2. The second radial surface 476 has an annular shape and radially outwardly faces relative to the rotational center axis A. The first axial surface 470 is attached to the second axial surface 474 by adhesive. The first radial surface 472 is attached to the second radial surface 476 by adhesive. For example, the concavo-convex structure may comprise a protrusion formed on one of the first axial surface 470 and the second axial surface 474, and a recess formed on the other of the first axial surface 470 and the second axial surface 474. Similarly, the concavo-convex structure may also comprise a protrusion formed on one of the first radial surface 472 and the second radial surface 476, and a recess formed on the other of the first radial surface 472 and the second radial surface 476. However, the concavo-convex structure can be omitted from the bicycle rear sprocket assembly 410 if needed and/or desired.

As seen in FIGS. 23 and 25, the bicycle rear sprocket assembly 410 further comprises a tubular member 478 positioned coaxially with the rotational center axis A. The tubular member 478 has a hub engagement profile 480

configured to engage with the bicycle hub assembly 2 (FIG. 23). In the illustrated embodiment, the tubular member 478 is secured to the base portion 460. The tubular member 478 is integrally provided with the base portion 460 as a single unitary member. The tubular member 478 is integrally provided with the sprocket body 466 of the bicycle sprocket S405. However, the tubular member 478 can be a separate member from the base portion 460 if needed and/or desired.

As seen in FIGS. 23 and 25, the bicycle rear sprocket assembly 410 further comprises an internal space 482 provided between the base portion 460 and the tubular member 478 in a radial direction with respect to the rotational center axis A. In the illustrated embodiment, the tubular member 478 is spaced apart from the tapered inner peripheral surface 468 of the base portion 460 in the radial direction with respect to the rotational center axis A. The internal space 482 is provided between the tapered inner peripheral surface 468 and an outer peripheral surface of the tubular member 478.

With the bicycle rear sprocket assembly 410, the first sprocket body 412 is made of a non-metallic material. The second sprocket body 438 is made of a non-metallic material and is attached to the first sprocket body 412. In other words, the base portion 460 is made of a non-metallic material. Accordingly, it is possible to save weight of the bicycle rear sprocket assembly 410.

As seen in FIG. 26, the first sprocket body 412 and the second sprocket body 438 can be integral with each other as a single unitary member if needed and/or desired. In such an embodiment, the first chain-engagement structure 414 and the second chain-engagement structure 440 are at least partly embedded in the first sprocket body 412 and the second sprocket body 438 by integral molding such as insert molding. While the base portion 460 is integrally provided as a single unitary member in the illustrated embodiment, at least part of the base portion 460 can be a separate member from other part of the base member 460.

It will be apparent to those skilled in the bicycle field from the present disclosure that the constructions of the above embodiments can be at least partly combined with each other.

In the present application, the term “attached” or “attaching”, as used herein, can encompass configurations in which an element is directly attached to the other element by affixing the element directly to the other element; configurations in which the element is indirectly attached to the other element via the intermediate member(s); and configurations in which one element is integral with another element, i.e. one element is essentially part of the other element. This concept also applies to words of similar meaning, for example, “joined”, “connected”, “coupled”, “mounted”, “bonded”, “fixed” and their derivatives.

The term “comprising” and its derivatives, as used herein, are intended to be open ended terms that specify the presence of the stated features, elements, components, groups, integers, and/or steps, but do not exclude the presence of other unstated features, elements, components, groups, integers and/or steps. This concept also applies to words of similar meaning, for example, the terms “have”, “include” and their derivatives.

The terms “member”, “section”, “portion”, “part”, “element”, “body” and “structure” when used in the singular can have the dual meaning of a single part or a plurality of parts.

The ordinal numbers such as “first” and “second” recited in the present application are merely identifiers, but do not have any other meanings, for example, a particular order and the like. Moreover, for example, the term “first element”

itself does not imply an existence of “second element”, and the term “second element” itself does not imply an existence of “first element.”

The term “pair of”, as used herein, can encompass the configuration in which the pair of elements have different shapes or structures from each other in addition to the configuration in which the pair of elements have the same shapes or structures as each other.

Finally, terms of degree such as “substantially”, “about” and “approximately” as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

What is claimed is:

1. A bicycle rear sprocket assembly having a rotational center axis, the bicycle rear sprocket assembly comprising: a first sprocket including
 - a first sprocket body made of a non-metallic material, and
 - a first chain-engagement structure made of a metallic material and configured to engage with a bicycle chain; and
- a second sprocket including
 - a second sprocket body made of a non-metallic material and attached to the first sprocket body, and
 - a second chain-engagement structure made of a metallic material and configured to engage with the bicycle chain, wherein
 the first chain-engagement structure includes a first annular member at least partly embedded in an outermost periphery of the first sprocket body in a radial direction with respect to the rotational center axis.
2. The bicycle rear sprocket assembly according to claim 1, wherein
 - the first chain-engagement structure of the first sprocket includes
 - a plurality of first teeth circumferentially arranged on an outer periphery of the first annular member,
 - the second chain-engagement structure of the second sprocket includes
 - a second annular member, and
 - a plurality of second teeth circumferentially arranged on an outer periphery of the second annular member, and
 - the second annular member is at least partly embedded in the second sprocket body.
3. The bicycle rear sprocket assembly according to claim 2, wherein
 - the first annular member is at least partly embedded in the first sprocket body by integral molding, and
 - the second annular member is at least partly embedded in the second sprocket body by integral molding.
4. The bicycle rear sprocket assembly according to claim 1, wherein
 - the first sprocket body is attached to the second sprocket body by adhesive.
5. The bicycle rear sprocket assembly according to claim 1, further comprising:
 - a tubular member positioned coaxially with the rotational center axis, wherein
 - the tubular member has a hub engagement profile configured to engage with a bicycle hub assembly.

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- 6. The bicycle rear sprocket assembly according to claim 5, further comprising:
 an internal space provided between the base portion and the tubular member in a radial direction with respect to the rotational center axis. 5
- 7. The bicycle rear sprocket assembly according to claim 1, wherein
 the first sprocket body and the second sprocket body are integral with each other as a single unitary member. 10
- 8. The bicycle rear sprocket assembly according to claim 1, wherein
 the second sprocket body is directly attached to the first sprocket body. 15
- 9. The bicycle rear sprocket assembly according to claim 1, wherein
 the second sprocket body is attached to the first sprocket body via an intervening member. 20
- 10. The bicycle rear sprocket assembly according to claim 9, wherein
 the intervening member is made of a metallic material. 25
- 11. The bicycle rear sprocket assembly according to claim 9, wherein
 the intervening member has a hub engagement profile configured to engage with a bicycle hub assembly. 30
- 12. The bicycle rear sprocket assembly according to claim 1, wherein
 the first sprocket body has a first hub engagement profile configured to engage with a bicycle hub assembly.
- 13. The bicycle rear sprocket assembly according to claim 12, wherein
 the second sprocket body has a second hub engagement profile configured to engage with the bicycle hub assembly.

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- 14. A bicycle rear sprocket assembly having a rotational center axis, the bicycle rear sprocket assembly comprising:
 a first sprocket including
 a first sprocket body made of a non-metallic material, and
 a first chain-engagement structure made of a metallic material and configured to engage with a bicycle chain; and
 a second sprocket including
 a second sprocket body made of a non-metallic material and attached to the first sprocket body, and
 a second chain-engagement structure made of a metallic material and configured to engage with the bicycle chain, wherein
 the first sprocket body and the second sprocket body provide a base portion having a truncated conical shape.
- 15. A bicycle rear sprocket assembly having a rotational center axis, the bicycle rear sprocket assembly comprising:
 a first sprocket including
 a first sprocket body made of a non-metallic material, and
 a first chain-engagement structure made of a metallic material and configured to engage with a bicycle chain; and
 a second sprocket including
 a second sprocket body made of a non-metallic material and attached to the first sprocket body, and
 a second chain-engagement structure made of a metallic material and configured to engage with the bicycle chain, wherein
 the first sprocket body is attached to the second sprocket body through a concavo-convex structure.

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