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Watarai

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- (54) **BICYCLE SPROCKET**
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F16H 55/30 (2006.01)
B62M 9/10 (2006.01)
- (52) **U.S. Cl.**
CPC **F16H 55/30** (2013.01); **B62M 9/10** (2013.01)
- (58) **Field of Classification Search**
CPC F16H 55/30; B62M 9/10
See application file for complete search history.

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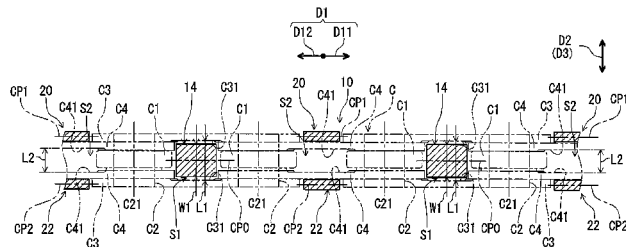
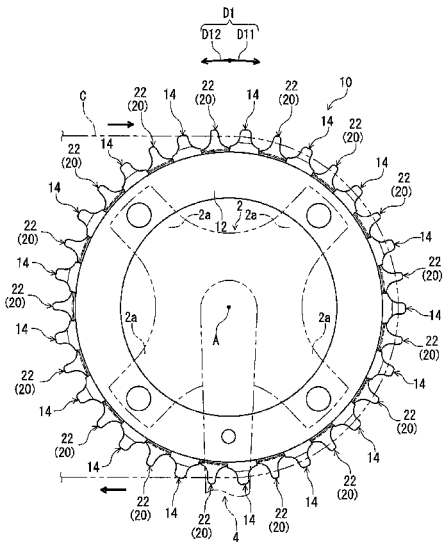
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(57) **ABSTRACT**

A bicycle sprocket has a rotational center axis. The bicycle sprocket comprises a sprocket body, a plurality of sprocket teeth, and at least one chain-supporting portion. The plurality of sprocket teeth are circumferentially arranged on an outer periphery of the sprocket body. The at least one chain-supporting portion is configured to contact one of inner link plates of a bicycle chain without engaging with the bicycle chain at inner link spaces each defined between a pair of inner link plates that face each other in an axial direction parallel to the rotational center axis. The at least one chain-supporting portion is offset from the sprocket teeth in the axial direction.

21 Claims, 13 Drawing Sheets



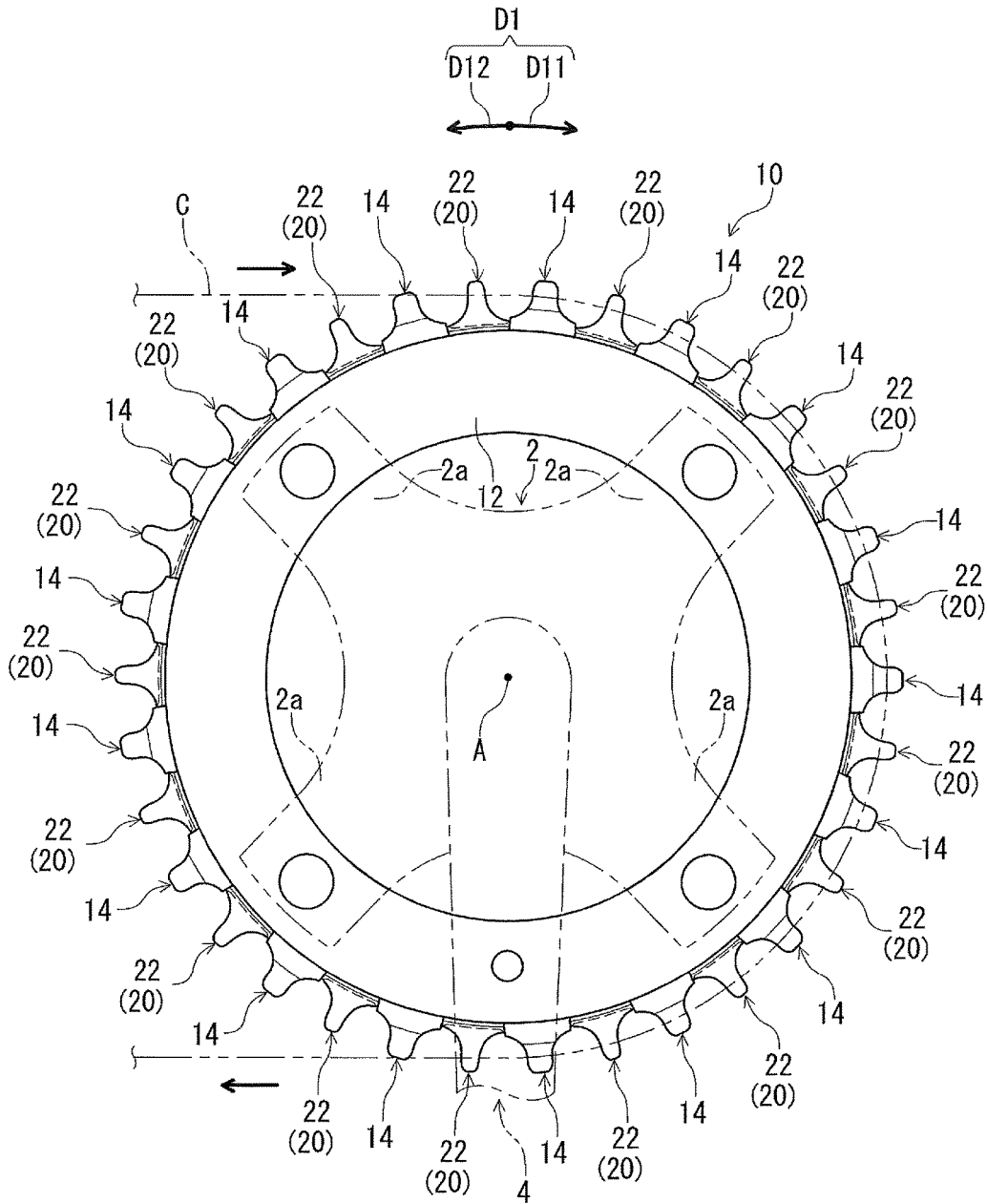


FIG. 1

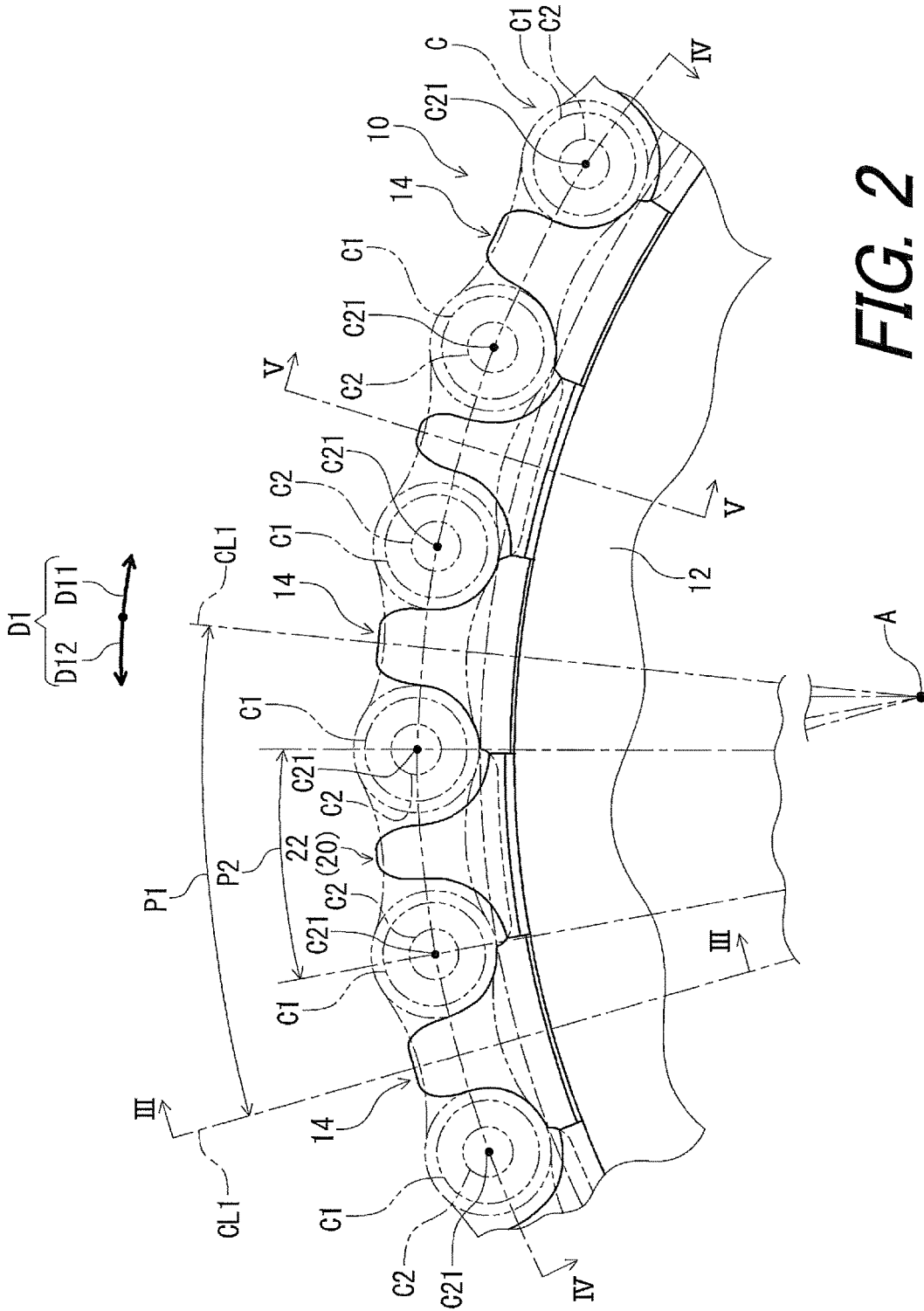


FIG. 2

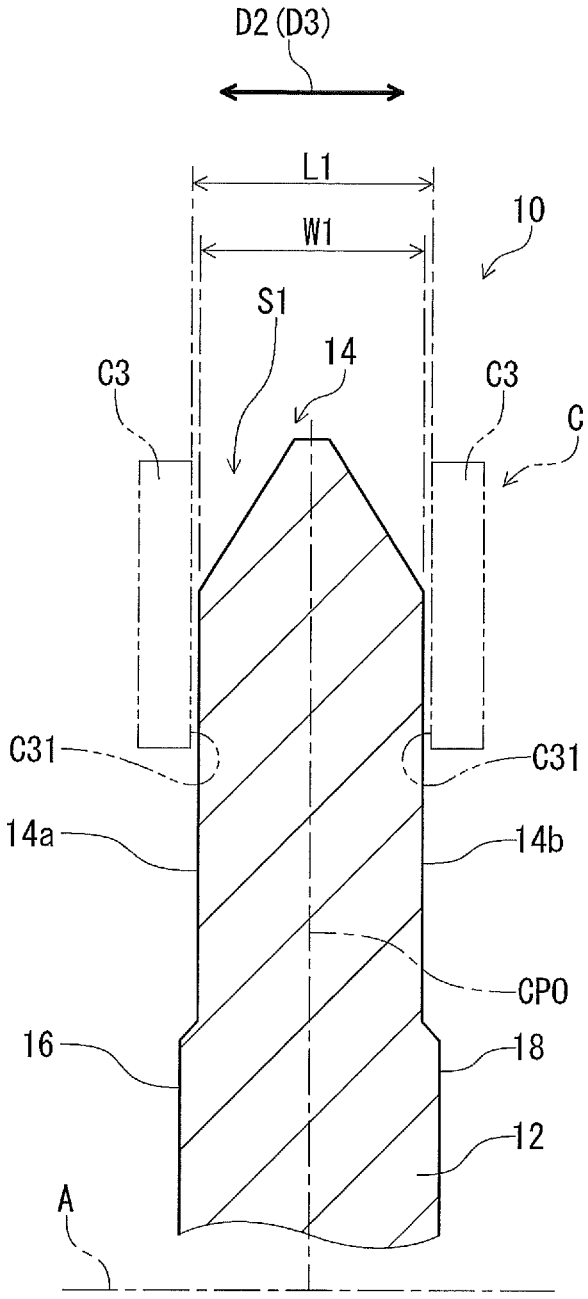


FIG. 3

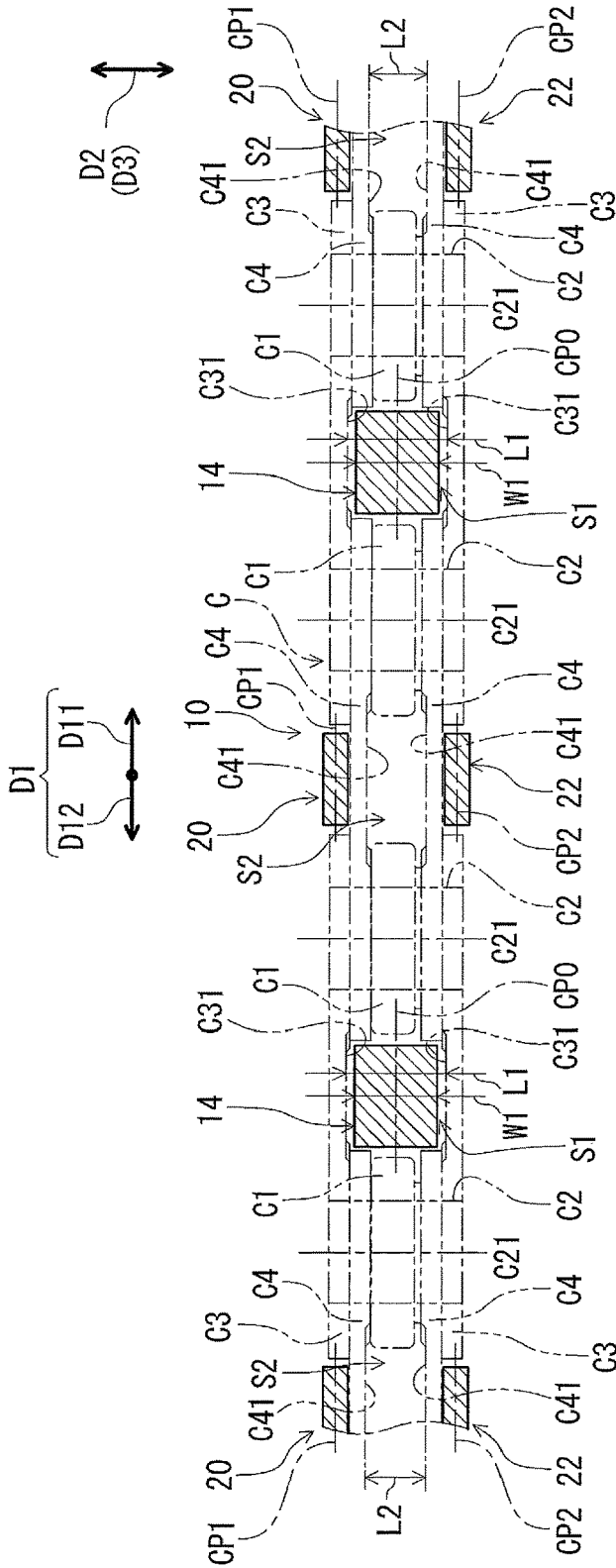


FIG. 4

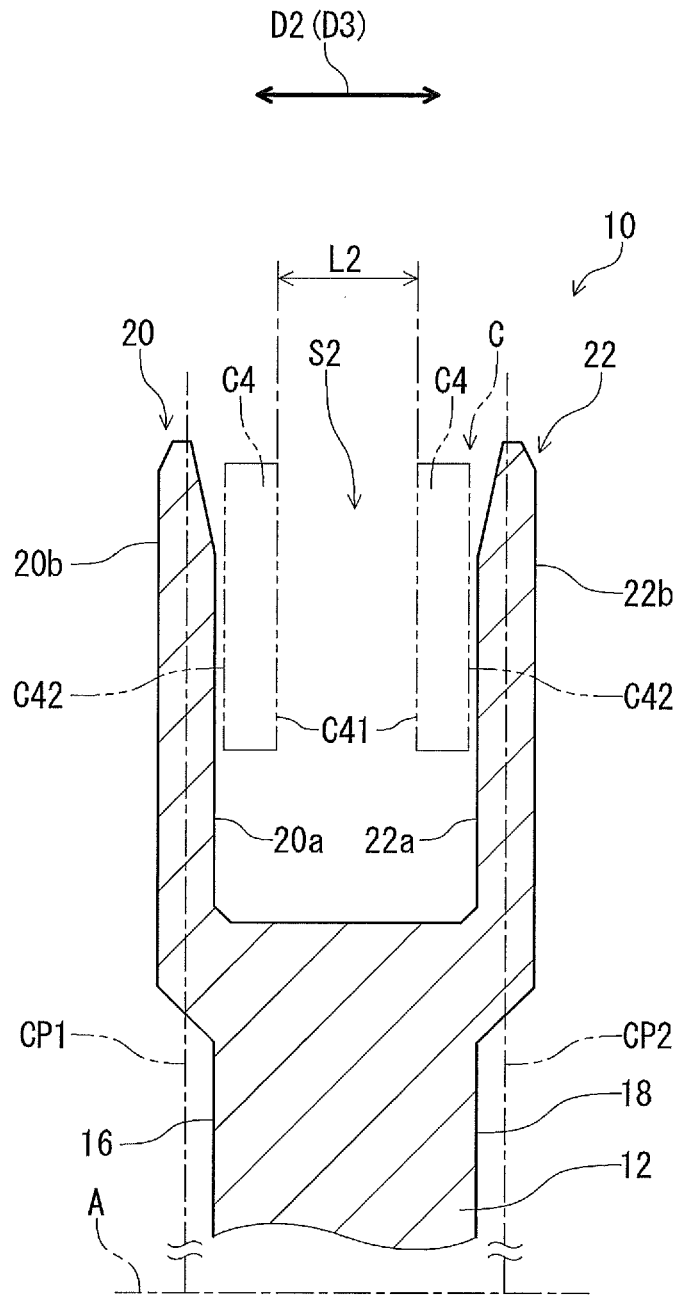
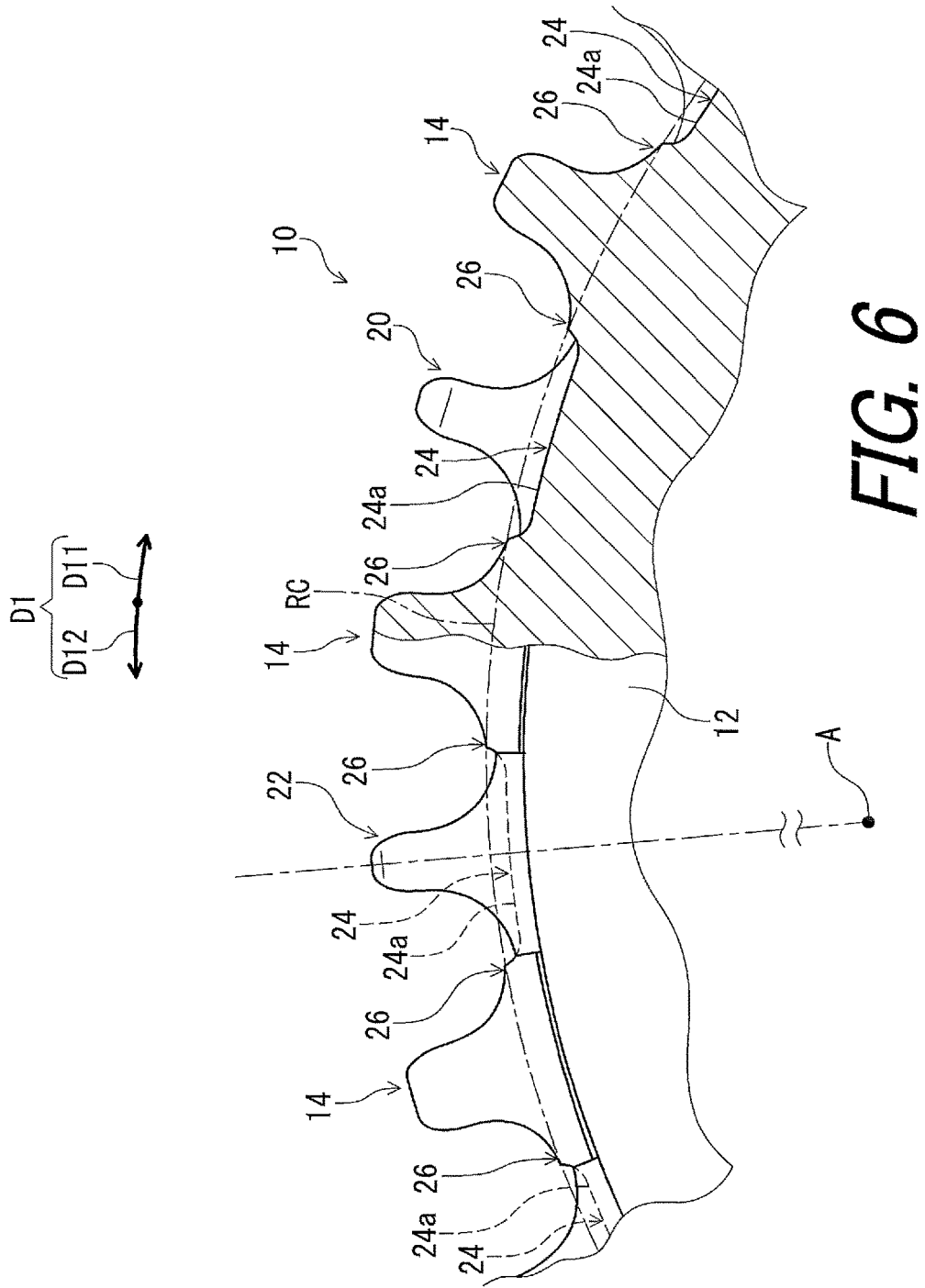


FIG. 5



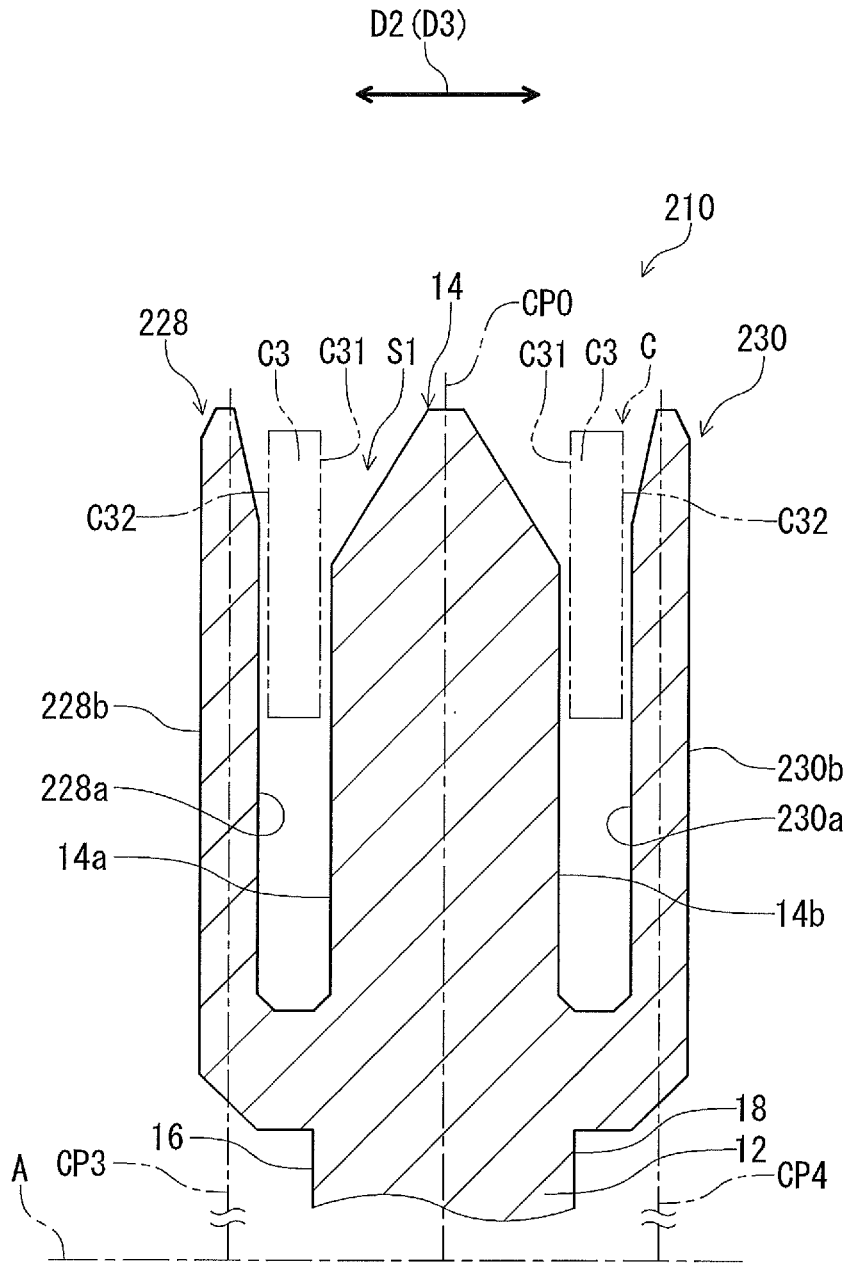


FIG. 7

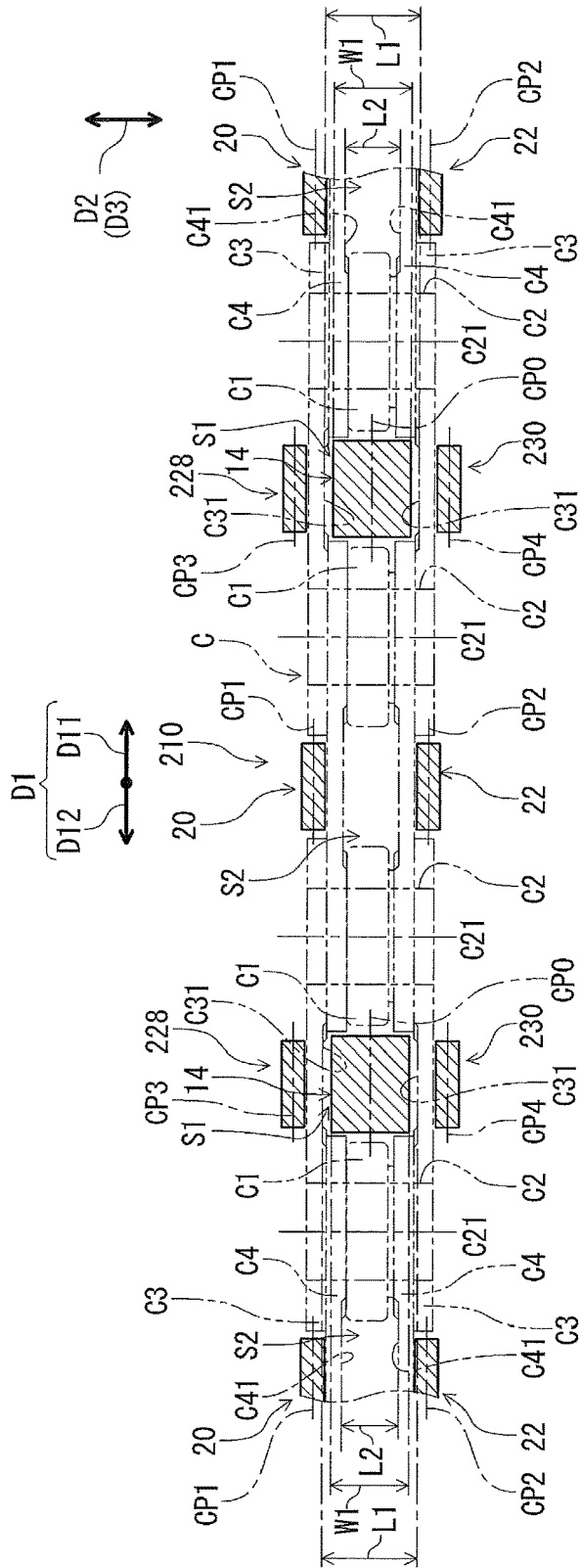


FIG. 8

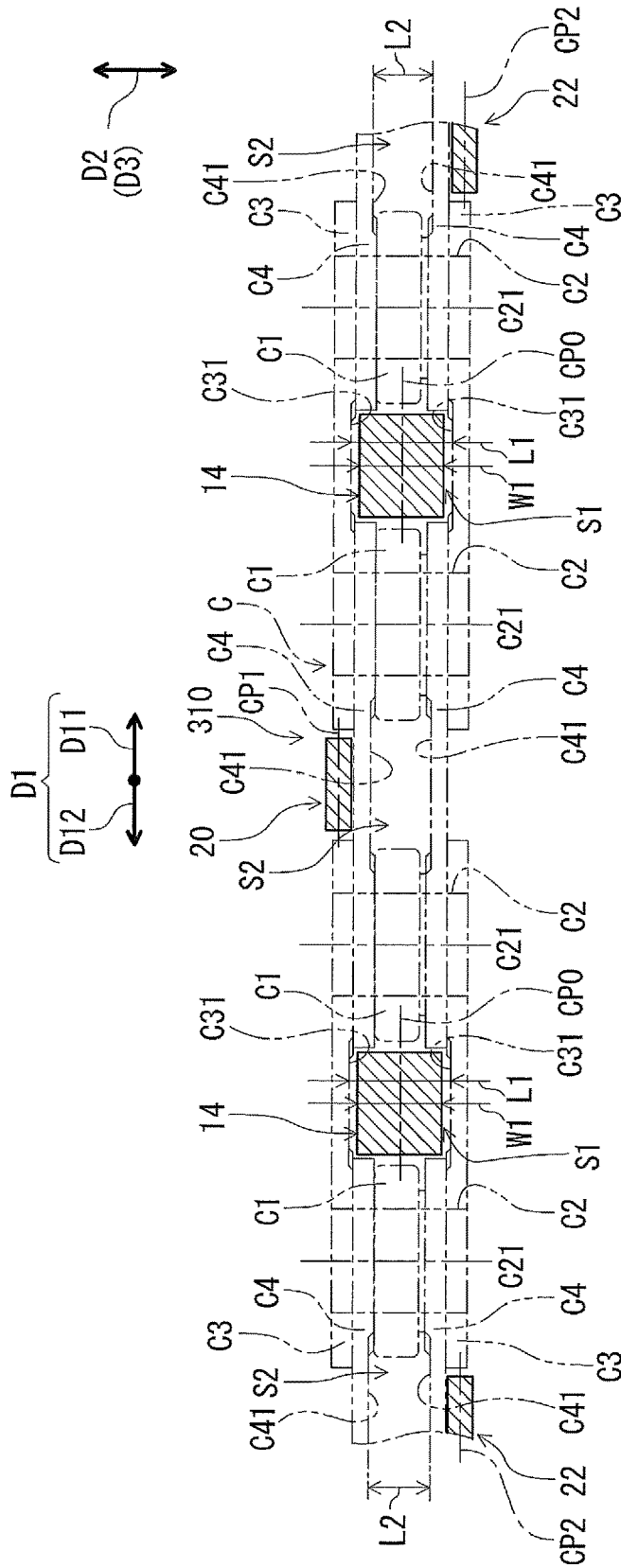


FIG. 9

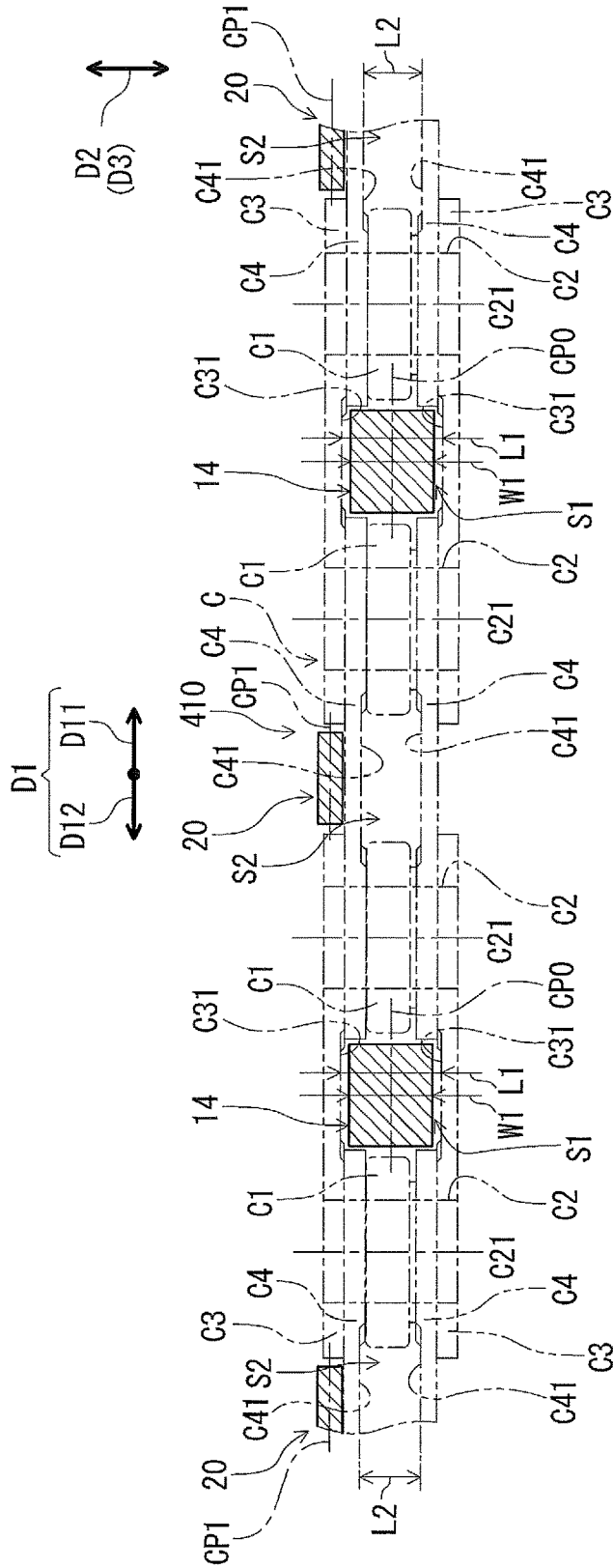


FIG. 10

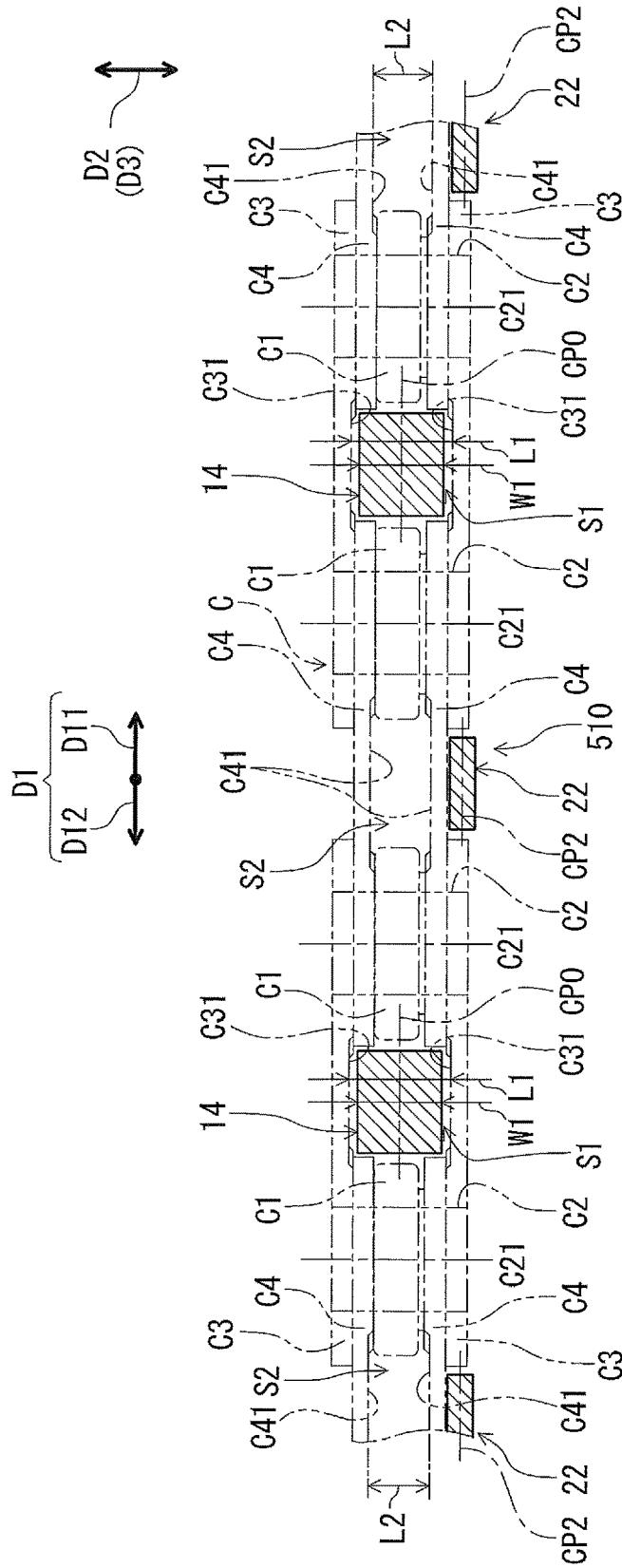


FIG. 11

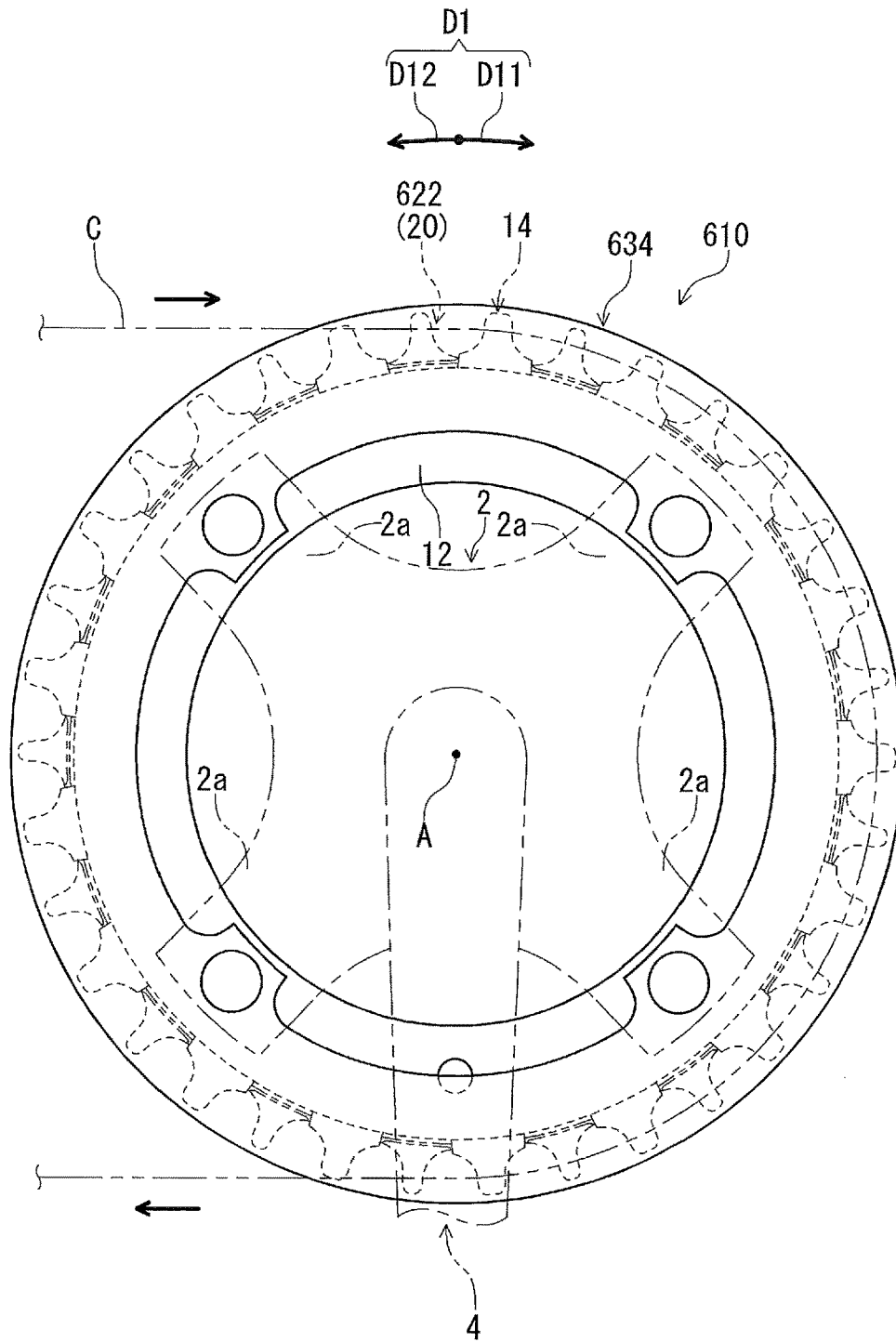


FIG. 12

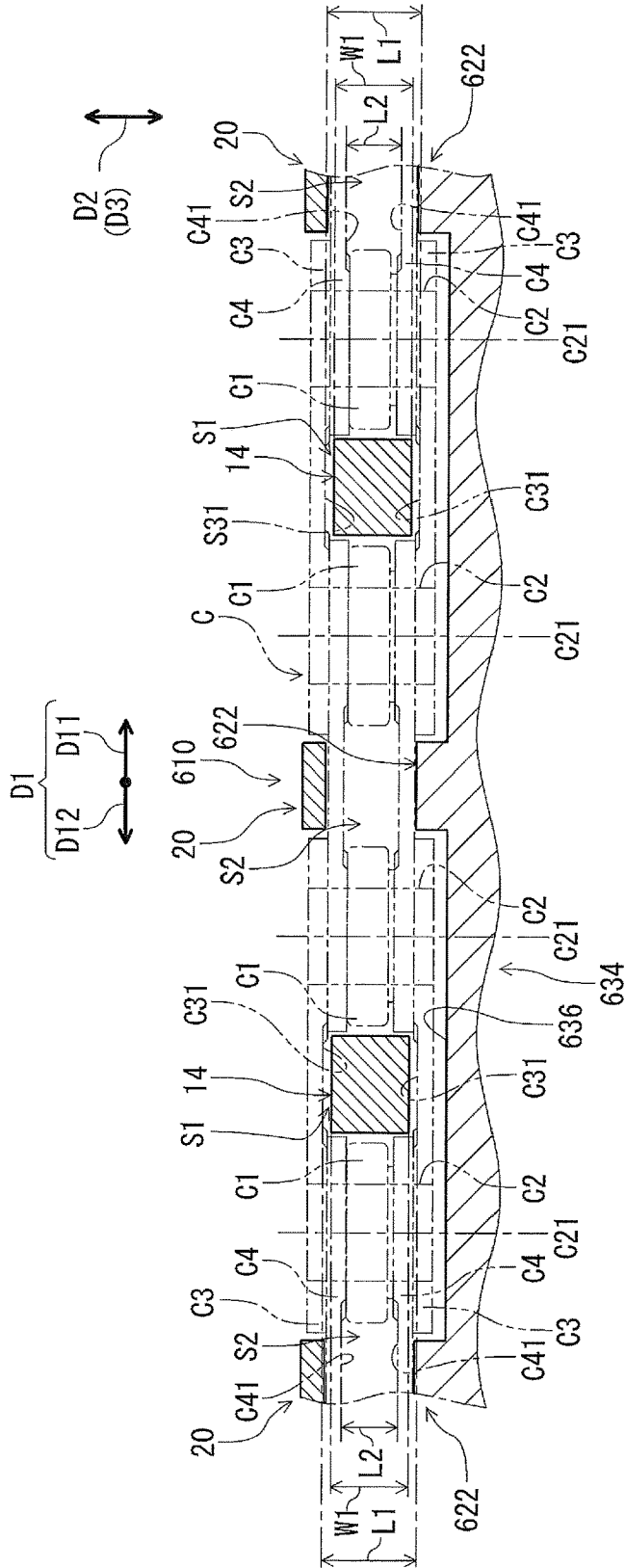


FIG. 13

BICYCLE SPROCKET

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a bicycle sprocket.

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 component that has been recently redesigned is a bicycle sprocket.

Most bicycles have a drive train that uses the bicycle sprocket to transmit the pedaling action from the rider to a bicycle wheel through a bicycle chain. A front sprocket and a rear sprocket have been known as the bicycle sprocket. The bicycle sprocket generally includes a plurality of teeth to engage with the bicycle chain.

SUMMARY OF THE INVENTION

In accordance with a first aspect of the present invention, a bicycle sprocket has a rotational center axis. The bicycle sprocket comprises a sprocket body, a plurality of sprocket teeth, and at least one chain-supporting portion. The plurality of sprocket teeth are circumferentially arranged on an outer periphery of the sprocket body. The at least one chain-supporting portion is configured to contact one of inner link plates of a bicycle chain without engaging with the bicycle chain at inner link spaces each defined between a pair of inner link plates that face each other in an axial direction parallel to the rotational center axis. The at least one chain-supporting portion is offset from the sprocket teeth in the axial direction.

In accordance with a second aspect of the present invention, the bicycle sprocket according to the first aspect is configured so that the at least one chain-supporting portion includes a plurality of chain-supporting portions each configured to contact one of the inner link plates of the bicycle chain without engaging with the bicycle chain at the inner link spaces each defined between the pair of inner link plates that face each other in the axial direction.

In accordance with a third aspect of the present invention, the bicycle sprocket according to the first aspect is configured so that the bicycle sprocket has a first axial side and a second axial side opposite to the first axial side. The at least one chain-supporting portion is positioned closer to one of the first axial side and the second axial side than the other of the first axial side and the second axial side in the axial direction.

In accordance with a fourth aspect of the present invention, the bicycle sprocket according to the first aspect is configured so that the bicycle sprocket has a first axial side and a second axial side opposite to the first axial side. The at least one chain-supporting portion includes a first chain-supporting portion and a second chain-supporting portion which are each configured to contact one of the inner link plates of the bicycle chain without engaging with the bicycle chain at the inner link spaces each defined between the pair of inner link plates that face each other in the axial direction. The first chain-supporting portion is positioned closer to the first axial side than the second axial side in the axial

direction. The second chain-supporting portion is positioned closer to the second axial side than the first axial side in the axial direction.

In accordance with a fifth aspect of the present invention, the bicycle sprocket according to the fourth aspect is configured so that the first chain-supporting portion is aligned with the second chain-supporting portion in the axial direction.

In accordance with a sixth aspect of the present invention, the bicycle sprocket according to the first aspect further comprises at least one additional chain-supporting portion configured to contact one of outer link plates of the bicycle chain without engaging with the bicycle chain at outer link spaces each defined between a pair of outer link plates that face each other in the axial direction. The at least one additional chain-supporting portion is offset from the sprocket teeth in the axial direction.

In accordance with a seventh aspect of the present invention, the bicycle sprocket according to the sixth aspect is configured so that the at least one additional chain-supporting portion includes a plurality of additional chain-supporting portions each configured to contact one of the outer link plates of the bicycle chain without engaging with the bicycle chain at the outer link spaces each defined between the pair of outer link plates that face each other in the axial direction.

In accordance with an eighth aspect of the present invention, the bicycle sprocket according to the sixth aspect is configured so that the bicycle sprocket has a first axial side and a second axial side opposite to the first axial side. The at least one additional chain-supporting portion is positioned closer to one of the first axial side and the second axial side than the other of the first axial side and the second axial side in the axial direction.

In accordance with a ninth aspect of the present invention, the bicycle sprocket according to the sixth aspect is configured so that the bicycle sprocket has a first axial side and a second axial side opposite to the first axial side. The at least one additional chain-supporting portion includes a first additional chain-supporting portion and a second additional chain-supporting portion which are each configured to contact one of the outer link plates of the bicycle chain without engaging with the bicycle chain at the outer link spaces each defined between the pair of outer link plates that face each other in the axial direction. The first additional chain-supporting portion is positioned closer to the first axial side than the second axial side in the axial direction. The second additional chain-supporting portion is positioned closer to the second axial side than the first axial side in the axial direction.

In accordance with a tenth aspect of the present invention, the bicycle sprocket according to the ninth aspect is configured so that the first additional chain-supporting portion is aligned with the second additional chain-supporting portion in the axial direction.

In accordance with an eleventh aspect of the present invention, the bicycle sprocket according to the first aspect is configured so that each of the plurality of sprocket teeth has a chain-engaging axial width that is larger than an axial width of the inner link spaces each defined between the pair of inner link plates of the bicycle chain and that is equal to or smaller than an axial width of the outer link spaces each defined between the pair of outer link plates of the bicycle chain.

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 an elevational view of a bicycle sprocket in accordance with a first embodiment;

FIG. 2 is a partial enlarged elevational view of the bicycle sprocket illustrated in FIG. 1;

FIG. 3 is a cross-sectional view of the bicycle sprocket taken along line III-III of FIG. 2;

FIG. 4 is a cross-sectional view of the bicycle sprocket taken along line IV-IV of FIG. 2;

FIG. 5 is a cross-sectional view of the bicycle sprocket taken along line V-V of FIG. 2;

FIG. 6 is a partial enlarged elevational view of the bicycle sprocket illustrated in FIG. 1;

FIG. 7 is a cross-sectional view of a bicycle sprocket in accordance with a second embodiment;

FIG. 8 is a cross-sectional view of the bicycle sprocket illustrated in FIG. 7;

FIG. 9 is a cross-sectional view of a bicycle sprocket in accordance with a third embodiment;

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

FIG. 11 is a cross-sectional view of a bicycle sprocket in accordance with a fifth embodiment;

FIG. 12 is an elevational view of a bicycle sprocket in accordance with a sixth embodiment; and

FIG. 13 is a cross-sectional view of the bicycle sprocket illustrated in FIG. 12.

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 10 in accordance with a first embodiment is configured to engage with a bicycle chain C. The bicycle sprocket 10 has a rotational center axis A and is rotatable about the rotational center axis A. In the illustrated embodiment, the bicycle sprocket 10 is a front sprocket configured to be provided on a gear crank (right crank) of a bicycle (not shown). Structures of the bicycle sprocket 10 can, however, be applied to a rear sprocket.

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 the bicycle with facing a handlebar (not shown). Accordingly, these terms, as utilized to describe the bicycle sprocket 10, should be interpreted relative to the bicycle equipped with the bicycle sprocket 10 as used in an upright riding position on a horizontal surface.

The bicycle sprocket 10 comprises a sprocket body 12. In the illustrated embodiment, the sprocket body 12 has an annular shape and is configured to be fastened to crank connecting arms 2a of a sprocket mounting member 2 by bolts (not shown). The sprocket mounting member 2 is fastened on a crank arm 4 to be rotatable integrally with the crank arm 4 about the rotational center axis A. The sprocket mounting member 2 can also be integrally provided with the

crank arm 4 as a single unitary member. The bicycle sprocket 10 is configured to be rotatable integrally with the sprocket mounting member 2 and the crank arm 4 about the rotational center axis A.

The bicycle sprocket 10 is configured to be rotated about the rotational center axis A in a rotational driving direction D11 during the pedaling. The rotational driving direction D11 is defined along a circumferential direction D1 of the bicycle sprocket 10. A direction D12 is defined along the circumferential direction D1. The direction D12 is opposite to the rotational driving direction D11.

As seen in FIG. 1, the bicycle sprocket 10 comprises a plurality of sprocket teeth 14. The plurality of sprocket teeth 14 are circumferentially arranged on an outer periphery of the sprocket body 12. The sprocket teeth 14 are spaced apart from each other in the circumferential direction D1. The sprocket teeth 14 radially outwardly protrude from the sprocket body 12. The sprocket teeth 14 have the same shape as each other in the illustrated embodiment. Some of the sprocket teeth 14 may have different shapes from the other of the sprocket teeth 14.

In the illustrated embodiment, the sprocket teeth 14 and the sprocket body 12 comprise a metallic material such as iron or titanium. The sprocket teeth 14 are integrally provided with the sprocket body 12 as a single unitary member. The sprocket teeth 14 can, however, be separately provided from the sprocket body 12. In the case of the sprocket teeth 14 being separately provided from the sprocket body 12, the sprocket body 12 can be made of a non-metallic material such as a fiber-reinforced composite material.

As seen in FIG. 2, each of the sprocket teeth 14 is configured to engage with the bicycle chain C to transmit a rotational force between the bicycle sprocket 10 and the bicycle chain C. A tooth pitch P1 defined between adjacent two of the sprocket teeth 14 is twice as long as a roller pitch P2 defined between adjacent two of rollers C1 of the bicycle chain C. Each of the tooth pitch P1 and the roller pitch P2 is defined as an angular range about the rotational center axis A. The tooth pitch P1 is defined between circumferential center lines CL1 of adjacent two of the sprocket teeth 14. The roller pitch P2 is defined between center axes C21 of adjacent two of pins C2.

As seen in FIG. 3, the sprocket teeth 14 is configured to engage with the bicycle chain C at outer link spaces S1 each defined between a pair of outer link plates C3 that face each other in an axial direction D2 parallel to the rotational center axis A. The sprocket teeth 14 is configured not to engage with the bicycle chain C at inner link spaces S2 each defined between a pair of inner link plates C4 that face each other in the axial direction D2.

As seen in FIG. 4, each of the plurality of sprocket teeth 14 has a chain-engaging axial width W1 that is larger than an axial width of the inner link spaces S2 each defined between the pair of inner link plates C4 of the bicycle chain C and that is equal to or smaller than an axial width of the outer link spaces S1 each defined between the pair of outer link plates C3 of the bicycle chain C.

As seen in FIG. 3, each of the sprocket teeth 14 has a first chain-engaging surface 14a and a second chain-engaging surface 14b. The first chain-engaging surface 14a and the second chain-engaging surface 14b face in the axial direction D2. The first chain-engaging surface 14a and the second chain-engaging surface 14b are contactable with opposed inner surfaces C31 of the outer link plates C3, respectively. For example, the chain-engaging axial width W1 is a maxi-

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mum axial width defined between the first chain-engaging surface **14a** and the second chain-engaging surface **14b** in the axial direction **D2**.

As seen in FIG. 4, the chain-engaging axial width **W1** is smaller than an outer-link axial distance **L1** defined between the opposed inner surfaces **C31** of the outer link plates **C3**. The chain-engaging axial width **W1** is larger than an inner-link axial distance **L2** defined between opposed inner surfaces **C41** of the inner link plates **C4**.

The outer-link axial distance **L1** is defined between the opposed inner surfaces **C31** of the outer link plates **C3** in a direction **D3** parallel to the center axes **C21** of the pins **C2**. The inner-link axial distance **L2** is defined between the opposed inner surfaces **C41** of the inner link plates **C4** in the direction **D3** parallel to the center axes **C21** of the pins **C2**. In a state where the bicycle chain **C** engages with the sprocket teeth **14**, the axial direction **D2** coincides with the direction **D3** defined with respect to the bicycle chain **C**.

As seen in FIG. 4, the sprocket teeth **14** are aligned in the circumferential direction **D1**. More specifically, each of the sprocket teeth **14** has a reference axial center plane **CP0** defined at a center position of each of the sprocket teeth **14** in the axial direction **D2**. The reference axial center planes **CP0** of the sprocket teeth **14** are disposed at the same position in the axial direction **D2**.

As seen in FIG. 3, the reference axial center plane **CP0** is defined at a center position between the first chain-engaging surface **14a** and the second chain-engaging surface **14b** in the axial direction **D2**. The reference axial center plane **CP0** is perpendicular to the rotational center axis **A**. While each of the sprocket teeth **14** has a symmetrical shape with respect to the reference axial center plane **CP0**, each of the sprocket teeth **14** can have an asymmetrical shape with respect to the reference axial center plane **CP0**.

As seen in FIG. 3, the bicycle sprocket **10** has a first axial side **16** and a second axial side **18** opposite to the first axial side **16**. In the illustrated embodiment, the first axial side **16** and the second axial side **18** are provided on the sprocket body **12**. In the illustrated embodiment, the reference axial center plane **CP0** is disposed at a center position between the first axial side **16** and the second axial side **18** in the axial direction **D2**.

As seen in FIG. 1, the bicycle sprocket **10** comprises at least one chain-supporting portion **20** and/or **22**. The at least one chain-supporting portion **20** and/or **22** is provided on and protrudes from the outer periphery of the sprocket body **12**. As seen in FIGS. 4 and 5, the at least one chain-supporting portion **20** and/or **22** is configured to contact one of the inner link plates **C4** of the bicycle chain **C** without engaging with the bicycle chain **C** at the inner link spaces **S2** each defined between the pair of inner link plates **C4** that face each other in the axial direction **D2** parallel to the rotational center axis **A**.

In the illustrated embodiment, as seen in FIG. 4, the at least one chain-supporting portion **20** and/or **22** includes a plurality of chain-supporting portions **20** and **22** each configured to contact one of the inner link plates **C4** of the bicycle chain **C** without engaging with the bicycle chain **C** at the inner link spaces **S2** each defined between the pair of inner link plates **C4** that face each other in the axial direction **D2**. The at least one chain-supporting portion **20** and/or **22** includes a first chain-supporting portion **20** and a second chain-supporting portion **22**.

In the illustrated embodiment, the chain-supporting portions **20** and **22** include a plurality of first chain-supporting portions **20** and a plurality of second chain-supporting portions **22**. The first chain-supporting portion **20** and the

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second chain-supporting portion **22** are each configured to contact one of the inner link plates **C4** of the bicycle chain **C** without engaging with the bicycle chain **C** at the inner link spaces **S2** each defined between the pair of inner link plates **C4** that face each other in the axial direction **D2**.

As seen in FIG. 4, the at least one chain-supporting portion **20** and/or **22** is offset from the sprocket teeth **14** in the axial direction **D2**. In the illustrated embodiment, each of the first chain-supporting portions **20** is offset from the sprocket teeth **14** in the axial direction **D2**. Each of the second chain-supporting portions **22** is offset from the sprocket teeth **14** in the axial direction **D2**. More specifically, each of the first chain-supporting portions **20** and each of the second chain-supporting portions **22** are offset from the reference axial center planes **CP0** of the sprocket teeth **14** in the axial direction **D2**. The reference axial center planes **CP0** of the sprocket teeth **14** are disposed between the first chain-supporting portions **20** and the second chain-supporting portions **22** in the axial direction **D2**.

The first chain-supporting portion **20** is preferably aligned with the second chain-supporting portion **22** in the axial direction **D2**. The first chain-supporting portion **20** is arranged to face the second chain-supporting portion **22** in the axial direction **D2**. The first chain-supporting portion **20** is disposed at a circumferential position same as a circumferential position of the second chain-supporting portion **22** in the circumferential direction **D1**. The pair of inner link plates **C4** are partially disposed between the first chain-supporting portion **20** and the second chain-supporting portion **22** which face each other in the axial direction **D2** in a state where the bicycle chain **C** at least partially engages with the sprocket teeth **14**.

As seen in FIG. 4, the first chain-supporting portions **20** are aligned with each other in the circumferential direction **D1**. The second chain-supporting portions **22** are aligned with each other in the circumferential direction **D1**. Each of the first chain-supporting portions **20** has a first axial center plane **CP1** defined at a center position of each of the first chain-supporting portions **20** in the axial direction **D2**. The first axial center planes **CP1** are disposed at the same position in the axial direction **D2**. Each of the second chain-supporting portions **22** has a second axial center plane **CP2** defined at a center position of each of the second chain-supporting portions **22** in the axial direction **D2**. The second axial center planes **CP2** are disposed at the same position in the axial direction **D2**.

As seen in FIG. 5, the at least one chain-supporting portion **20** and/or **22** is positioned closer to one of the first axial side **16** and the second axial side **18** than the other of the first axial side **16** and the second axial side **18** in the axial direction **D2**. In the illustrated embodiment, the first chain-supporting portion **20** is positioned closer to the first axial side **16** than the second axial side **18** in the axial direction **D2**. The second chain-supporting portion **22** is positioned closer to the second axial side **18** than the first axial side **16** in the axial direction **D2**.

Each of the first chain-supporting portions **20** has a first support surface **20a** and a first outer surface **20b**. Each of the first support surface **20a** and the first outer surface **20b** faces in the axial direction **D2**. The first support surface **20a** is contactable with an outer surface **C42** of one of the inner link plates **C4**.

Each of the second chain-supporting portions **22** has a second support surface **22a** and a second outer surface **22b**. Each of the second support surface **22a** and the second outer surface **22b** faces in the axial direction **D2**. The second support surface **22a** is arranged to face the first support

surface **20a** in the axial direction **D2**. The second support surface **22a** is contactable with an outer surface **C42** of one of the inner link plates **C4**.

The first axial center plane **CP1** is defined at a center position between the first support surface **20a** and the first outer surface **20b** in the axial direction **D2**. The first axial center plane **CP1** is perpendicular to the rotational center axis **A**. While each of the first chain-supporting portions **20** has an asymmetrical shape with respect to the first axial center plane **CP1**, each of the first chain-supporting portions **20** can have a symmetrical shape with respect to the first axial center plane **CP1**.

The second axial center plane **CP2** is defined at a center position between the second support surface **22a** and the second outer surface **22b** in the axial direction **D2**. The second axial center plane **CP2** is perpendicular to the rotational center axis **A**. While each of the second chain-supporting portions **22** has an asymmetrical shape with respect to the second axial center plane **CP2**, each of the second chain-supporting portions **22** can have a symmetrical shape with respect to the second axial center plane **CP2**.

As seen in FIG. 6, each of the first chain-supporting portions **20** is provided between adjacent two of the sprocket teeth **14** when viewed from the axial direction **D2** (a direction perpendicular to a paper surface of FIG. 6). Each of the second chain-supporting portions **22** is provided between adjacent two of the sprocket teeth **14** when viewed from the axial direction **D2** (the direction perpendicular to the paper surface of FIG. 6).

In the illustrated embodiment, the first chain-supporting portions **20** have the same shape as each other. The second chain-supporting portions **22** have the same shape as each other. Each of the first chain-supporting portions **20** has a shape same as a shape of each of the second chain-supporting portions **22** when viewed from the axial direction **D2** (the direction perpendicular to the paper surface of FIG. 6).

As seen in FIG. 6, the bicycle sprocket **10** includes recesses **24** provided between the sprocket teeth **14** in the circumferential direction **D1**. The sprocket teeth **14** include tooth bottoms **26** defining a root circle **RC** of the bicycle sprocket **10**. The recesses **24** are provided between the tooth bottoms **26** in the circumferential direction **D1** of the bicycle sprocket **10**. Each of the recesses **24** includes a bottom surface **24a** provided radially inward of the root circle **RC**.

In the illustrated embodiment, the bicycle sprocket **10** is free from an additional sprocket tooth configured to engage with the bicycle chain **C** at the inner link spaces **S2** (FIGS. 4 and 5). Each of the recesses **24** is free from such an additional sprocket tooth. Such an additional sprocket tooth can, however, be provided in the recess **24** between adjacent two of the sprocket teeth **14** in the circumferential direction **D1**.

With the bicycle sprocket **10**, the at least one chain-supporting portion **20** and/or **22** is configured to contact one of the inner link plates **C4** of the bicycle chain **C** without engaging with the bicycle chain **C** at the inner link spaces **S2** each defined between the pair of inner link plates **C4** that face each other in the axial direction **D2** parallel to the rotational center axis **A**. The at least one chain-supporting portion **20** and/or **22** is offset from the sprocket teeth **14** in the axial direction **D2**. Accordingly, it is possible to improve function to hold the bicycle chain **C** in the bicycle sprocket **10** in comparison with a sprocket which is free from the at least one chain-supporting portion **20** and/or **22**. Further, because the bicycle chain **C** contacts both of the sprocket teeth **14** and the chain-supporting portion **20** and/or **22**, it is possible to reduce wear of the sprocket teeth **14** due to

contact of a chain with the sprocket teeth **14** in the case of a sprocket being free from the chain-supporting portion **20** and/or **22**.

Second Embodiment

A bicycle sprocket **210** in accordance with a second embodiment will be described below referring to FIGS. 7 and 8. Elements having substantially the same function as those in the first embodiment will be numbered the same here, and will not be described again in detail here for the sake of brevity.

FIG. 7 is a cross-sectional view corresponding to the cross-sectional view of FIG. 3. As seen in FIG. 7, the bicycle sprocket **210** further comprises at least one additional chain-supporting portion **228** and/or **230** configured to contact one of the outer link plates **C3** of the bicycle chain **C** without engaging with the bicycle chain **C** at the outer link spaces **S1** each defined between the pair of outer link plates **C3** that face each other in the axial direction **D2**. In the illustrated embodiment, the at least one additional chain-supporting portion **228** and/or **230** includes a plurality of additional chain-supporting portions **228** and **230** each configured to contact one of the outer link plates **C3** of the bicycle chain **C** without engaging with the bicycle chain **C** at the outer link spaces **S1** each defined between the pair of outer link plates **C3** that face each other in the axial direction **D2**.

The at least one additional chain-supporting portion **228** and/or **230** includes a first additional chain-supporting portion **228** and a second additional chain-supporting portion **230** which are each configured to contact one of the outer link plates **C3** of the bicycle chain **C** without engaging with the bicycle chain **C** at the outer link spaces **S1** each defined between the pair of outer link plates **C3** that face each other in the axial direction **D2**. In the illustrated embodiment, the additional chain-supporting portions **228** and **230** include a plurality of first additional chain-supporting portions **228** and a plurality of second additional chain-supporting portions **230**.

As seen in FIG. 7, the at least one additional chain-supporting portion **228** and/or **230** is positioned closer to one of the first axial side **16** and the second axial side **18** than the other of the first axial side **16** and the second axial side **18** in the axial direction **D2**. In the illustrated embodiment, the first additional chain-supporting portion **228** is positioned closer to the first axial side **16** than the second axial side **18** in the axial direction **D2**. The second additional chain-supporting portion **230** is positioned closer to the second axial side **18** than the first axial side **16** in the axial direction **D2**.

As seen in FIG. 8, the at least one additional chain-supporting portion **228** and/or **230** is offset from the sprocket teeth **14** in the axial direction **D2**. In the illustrated embodiment, each of the first additional chain-supporting portions **228** is offset from the sprocket teeth **14** in the axial direction **D2**. Each of the second additional chain-supporting portions **230** is offset from the sprocket teeth **14** in the axial direction **D2**.

The first additional chain-supporting portion **228** is preferably aligned with the second additional chain-supporting portion **230** in the axial direction **D2**. The sprocket tooth **14** is disposed between the first additional chain-supporting portion **228** and the second additional chain-supporting portion **230** in the axial direction **D2**. The first additional chain-supporting portions **228** are arranged to face the sprocket teeth **14** in the axial direction **D2**. The second

additional chain-supporting portions **230** are arranged to face the sprocket teeth **14** in the axial direction **D2**.

The first additional chain-supporting portion **228** is disposed at a circumferential position same as a circumferential position of the second additional chain-supporting portion **230** in the circumferential direction **D1**. The pair of outer link plates **C3** are partially disposed between the first additional chain-supporting portion **228** and one of the sprocket teeth **14** and between the second additional chain-supporting portion **230** and one of the sprocket teeth **14** in a state where the bicycle chain **C** at least partially engages with the sprocket teeth **14**.

As seen in FIG. 8, the first additional chain-supporting portions **228** are aligned with each other in the circumferential direction **D1**. The second additional chain-supporting portions **230** are aligned with each other in the circumferential direction **D1**. Each of the first additional chain-supporting portions **228** has a third axial center plane **CP3** defined at a center position of each of the first additional chain-supporting portions **228** in the axial direction **D2**. The third axial center planes **CP3** are disposed at the same position in the axial direction **D2**. Each of the second additional chain-supporting portions **230** has a fourth axial center plane **CP4** defined at a center position of each of the second additional chain-supporting portions **230** in the axial direction **D2**. The fourth axial center planes **CP4** are disposed at the same position in the axial direction **D2**.

As seen in FIG. 7, each of the first additional chain-supporting portions **228** has a third support surface **228a** and a third outer surface **228b**. Each of the third support surface **228a** and the third outer surface **228b** faces in the axial direction **D2**. The third support surface **228a** is contactable with an outer surface **C32** of one of the outer link plates **C3**.

Each of the second additional chain-supporting portions **230** has a fourth support surface **230a** and a fourth outer surface **230b**. Each of the fourth support surface **230a** and the fourth outer surface **230b** faces in the axial direction **D2**. The fourth support surface **230a** is arranged to face the third support surface **228a** in the axial direction **D2**. The fourth support surface **230a** is contactable with an outer surface **C32** of one of the outer link plates **C3**.

As seen in FIG. 7, the third axial center plane **CP3** is defined at a center position between the third support surface **228a** and the third outer surface **228b** in the axial direction **D2**. The third axial center plane **CP3** is perpendicular to the rotational center axis **A**. While each of first additional chain-supporting portions **228** has an asymmetrical shape with respect to the third axial center plane **CP3**, each of first additional chain-supporting portions **228** can have a symmetrical shape with respect to the third axial center plane **CP3**.

The fourth axial center plane **CP4** is defined at a center position between the fourth support surface **230a** and the fourth outer surface **230b** in the axial direction **D2**. The fourth axial center plane **CP4** is perpendicular to the rotational center axis **A**. While each of the second additional chain-supporting portions **230** has an asymmetrical shape with respect to the fourth axial center plane **CP4**, each of the second additional chain-supporting portions **230** can have a symmetrical shape with respect to the fourth axial center plane **CP4**.

With the bicycle sprocket **210**, the at least one additional chain-supporting portion **228** and/or **230** is configured to contact one of the outer link plates **C3** of the bicycle chain **C** without engaging with the bicycle chain **C** at the outer link spaces **S1** each defined between the pair of outer link plates **C3** that face each other in the axial direction **D2**. Accord-

ingly, it is possible to obtain holding function of the at least one additional chain-supporting portion **228** and/or **230** in addition to the at least one chain-supporting portion **20** and/or **22** in accordance with the first embodiment.

Third Embodiment

A bicycle sprocket **310** in accordance with a third embodiment will be described below referring to FIG. 9. The bicycle sprocket **310** has the same configuration as the bicycle sprocket **10** except for the arrangement of the at least one chain-supporting portion **20** and/or **22**. Thus, elements having substantially the same function as those in the above embodiments will be numbered the same here, and will not be described again in detail here for the sake of brevity.

In the bicycle sprocket **310**, as seen in FIG. 9, the first chain-supporting portions **20** and the second chain-supporting portions **22** are alternatively arranged in the circumferential direction **D1**. The first chain-supporting portion **20** is not aligned with the second chain-supporting portion **22** in the axial direction **D2**. The first chain-supporting portions **20** are partially omitted from the bicycle sprocket **310**. The second chain-supporting portions **22** are partially omitted from the bicycle sprocket **310**.

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

Fourth Embodiment

A bicycle sprocket **410** in accordance with a fourth embodiment will be described below referring to FIG. 10. The bicycle sprocket **410** has the same configuration as the bicycle sprocket **10** except for the arrangement of the at least one chain-supporting portion **20** and/or **22**. Thus, elements having substantially the same function as those in the above embodiments will be numbered the same here, and will not be described again in detail here for the sake of brevity.

In the bicycle sprocket **410**, as seen in FIG. 10, the second chain-supporting portions **22** are omitted from the bicycle sprocket **410**. While the first chain-supporting portions **20** are circumferentially arranged, the first chain-supporting portions **20** can be partially omitted from the bicycle sprocket **410** if needed and/or desired.

With the bicycle sprocket **410**, it is possible to obtain the advantageous effect same as that of the bicycle sprocket **10** in accordance with the first embodiment with saving weight of the bicycle sprocket **410**.

Fifth Embodiment

A bicycle sprocket **510** in accordance with a fifth embodiment will be described below referring to FIG. 11. The bicycle sprocket **510** has the same configuration as the bicycle sprocket **10** except for the arrangement of the at least one chain-supporting portion **20** and/or **22**. Thus, elements having substantially the same function as those in the above embodiments will be numbered the same here, and will not be described again in detail here for the sake of brevity.

In the bicycle sprocket **510**, as seen in FIG. 11, the first chain-supporting portions **20** can be omitted from the bicycle sprocket **510**. While the second chain-supporting portions **22** are circumferentially arranged, the second chain-supporting portions **22** can be partially omitted from the bicycle sprocket **510** if needed and/or desired.

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With the bicycle sprocket **510**, it is possible to obtain the advantageous effect same as that of the bicycle sprocket **10** in accordance with the first embodiment with saving weight of the bicycle sprocket **510**.

Sixth Embodiment

A bicycle sprocket **610** in accordance with a sixth embodiment will be described below referring to FIGS. **12** and **13**. The bicycle sprocket **610** has the same configuration as the bicycle sprocket **10** except for the second chain-supporting portions **22**. Thus, elements having substantially the same function as those in the above embodiments will be numbered the same here, and will not be described again in detail here for the sake of brevity.

As seen in FIG. **12**, the bicycle sprocket **610** includes a bash guard **634** configured to be attached to the sprocket body **12** by bolts (not shown). The bash guard **634** has an annular shape and is rotatable together with the sprocket body **12** about the rotational center axis A. The bicycle sprocket **610** comprises second chain-supporting portions **622** instead of the second chain-supporting portions **22**. The second chain-supporting portions **622** have a shape same as a shape of the first chain-supporting portions **20** when viewed from the axial direction **D2** (a direction perpendicular to a paper surface of FIG. **12**).

As seen in FIG. **13**, the second chain-supporting portions **622** are configured to contact one of the inner link plates **C4** of the bicycle chain **C** without engaging with the bicycle chain **C** at the inner link spaces **S2** each defined between the pair of inner link plates **C4** that face each other in the axial direction **D2**. The second chain-supporting portions **622** and the bash guard **634** are made of a resin material or a metallic material. While the second chain-supporting portions **622** are integrally provided with the bash guard **634** in the illustrated embodiment, the second chain-supporting portions **622** can be separately provided from the bash guard **634** if needed and/or desired.

The bash guard **634** includes an axial surface **636** configured to face the sprocket teeth **14** in the axial direction **D2**. The axial surface **636** is configured to face one of the outer link plates **C3** in the axial direction **D2** in a state where the bicycle chain **C** at least partially engages with the bicycle sprocket **610**. Each of the second chain-supporting portions **622** are provided on the axial surface **636**. Each of the second chain-supporting portions **622** protrudes from the axial surface **636**.

With the bicycle sprocket **610**, it is possible to obtain the advantageous effect same as that of the bicycle sprocket **10** in accordance with the first embodiment.

The above embodiments can be at least partially combined with each other if needed and/or desired. In the second embodiment, for example, the first additional chain-supporting portions **228** can be at least partially omitted from the bicycle sprocket **210** as well as the first chain-supporting portions **20** in accordance with the third and fifth embodiments. In the second embodiment, the second additional chain-supporting portions **230** can be at least partially omitted from the bicycle sprocket **210** as well as the second chain-supporting portions **22** in accordance with the third and fourth embodiments. Furthermore, in the sixth embodiment, the second chain-supporting portions **622** can be at least partially omitted from the bicycle sprocket **610** as well as the second chain-supporting portions **22** in accordance with the third and fourth embodiments.

Structures of the bicycle sprockets **10** to **610** in accordance with the first to sixth embodiments can be applied to

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a rear sprocket and/or a sprocket assembly including a plurality of sprockets for changing gears.

In the above embodiments, 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 the other 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”, “fixed” and their derivatives except for the terms “bonded” and “bonding.”

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” or “element” when used in the singular can have the dual meaning of a single part or a plurality of parts.

The ordinal numbers such as the terms “first” or “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 sprocket having a rotational center axis, the bicycle sprocket comprising:

a sprocket body having an annular shape;
a plurality of sprocket teeth circumferentially arranged on an outer periphery of the sprocket body; and

at least one chain-supporting portion configured to contact an axial outer surface of one of a pair of inner link plates of a bicycle chain, the pair of inner link plates have an inner link space not engaging with the at least one chain-supporting portion at the inner link space, the inner link space defined as a gap in an axial direction between the pair of inner link plates that are spaced apart from each other in the axial direction to form the gap, and the inner link plates face each other in the axial direction parallel to the rotational center axis, the at least one chain-supporting portion being offset from the sprocket teeth in the axial direction, wherein

each of the plurality of sprocket teeth has a chain-engaging axial width that is larger than an axial width of the inner link space, and the chain-engaging axial

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width of each of the plurality of sprocket teeth is equal to or smaller than an axial width of an outer link space defined between a pair of outer link plates of the bicycle chain, and

the at least one chain-supporting portion axially extends 5 beyond an outermost axial side of the sprocket body having the annular shape in the axial direction.

2. The bicycle sprocket according to the claim 1, wherein the at least one chain-supporting portion includes a plu- 10 rality of chain-supporting portions each configured to contact one of the pair of inner link plates of the bicycle chain without engaging with the bicycle chain at the inner link space defined between the pair of inner link plates that face each other in the axial direction.

3. The bicycle sprocket according to the claim 1, wherein 15 the bicycle sprocket has a first axial side and a second axial side opposite to the first axial side, and the at least one chain-supporting portion is positioned closer to one of the first axial side and the second axial 20 side than the other of the first axial side and the second axial side in the axial direction.

4. The bicycle sprocket according to the claim 1, wherein the bicycle sprocket has a first axial side and a second 25 axial side opposite to the first axial side, the at least one chain-supporting portion includes a first chain-supporting portion and a second chain-supporting portion, the first chain-supporting portion being configured to contact the axial outer surface of one of the pair of inner link plates of the bicycle chain without 30 engaging with the bicycle chain at the inner link space defined between the pair of inner link plates that face each other in the axial direction, the second chain-supporting portion being configured to contact an additional axial outer surface of another of the pair of inner 35 link plates of the bicycle chain without engaging with the bicycle chain at the inner link space, the first chain-supporting portion is positioned closer to the first axial side than the second axial side in the axial direction, and 40 the second chain-supporting portion is positioned closer to the second axial side than the first axial side in the axial direction.

5. The bicycle sprocket according to the claim 4, wherein the first chain-supporting portion is aligned with the 45 second chain-supporting portion in the axial direction.

6. The bicycle sprocket according to the claim 1, further comprising:

at least one additional chain-supporting portion config- 50 ured to contact one of a pair of outer link plates of the bicycle chain without engaging with the bicycle chain at outer link space defined between the pair of outer link plates that face each other in the axial direction, wherein

the at least one additional chain-supporting portion is 55 offset from the sprocket teeth in the axial direction.

7. The bicycle sprocket according to the claim 6, wherein the at least one additional chain-supporting portion includes a plurality of additional chain-supporting por- 60 tions each configured to contact one of the pair of outer link plates of the bicycle chain without engaging with the bicycle chain at the outer link space defined between the pair of outer link plates that face each other in the axial direction.

8. The bicycle sprocket according to the claim 6, wherein 65 the bicycle sprocket has a first axial side and a second axial side opposite to the first axial side, and

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the at least one additional chain-supporting portion is positioned closer to one of the first axial side and the second axial side than the other of the first axial side and the second axial side in the axial direction.

9. The bicycle sprocket according to the claim 6, wherein the bicycle sprocket has a first axial side and a second axial side opposite to the first axial side, the at least one additional chain-supporting portion includes a first additional chain-supporting portion and a second additional chain-supporting portion which are each configured to contact one of the pair of outer link plates of the bicycle chain without engaging with the bicycle chain at the outer link space defined between the pair of outer link plates that face each other in the axial direction, the first additional chain-supporting portion is positioned closer to the first axial side than the second axial side in the axial direction, and the second additional chain-supporting portion is positioned closer to the second axial side than the first axial side in the axial direction.

10. The bicycle sprocket according to the claim 9, wherein the first additional chain-supporting portion is aligned with the second additional chain-supporting portion in the axial direction.

11. The bicycle sprocket according to the claim 1, wherein at least one of the plurality of sprocket teeth is configured to face an axial inner surface of at least one of the pair of outer link plates of the bicycle chain in the axial direction.

12. The bicycle sprocket according to the claim 1, wherein the at least one chain-supporting portion has a support axial width defined in the axial direction, and the support axial width is smaller than the chain-engaging axial width.

13. The bicycle sprocket according to the claim 1, wherein the plurality of sprocket teeth includes tooth bottoms defining a root circle of the bicycle sprocket, and each of the plurality of sprocket teeth has a radial length defined radially outward from the root circle, the radial length being larger than the chain-engaging axial width.

14. The bicycle sprocket according to the claim 1, wherein the plurality of sprocket teeth includes tooth bottoms defining a root circle of the bicycle sprocket, and the at least one chain-supporting portion has a support axial width defined in the axial direction, and a radial length defined radially outward from the root circle and larger than the support axial width.

15. The bicycle sprocket according to the claim 1, wherein each of the plurality of sprocket teeth has a reference axial center plane defined at a center position of each of the plurality of sprocket teeth in the axial direction, the at least one chain-supporting portion has an axial center plane defined at a center position of the at least one chain-supporting portion in the axial direction, and the axial center plane of the at least one chain-supporting portion is offset from the reference axial center plane in the axial direction.

16. The bicycle sprocket according to the claim 1, wherein each of the plurality of sprocket teeth includes a first chain-engaging surface facing in the axial direction, and a second chain-engaging surface facing in the axial direction, the second chain-engaging surface being opposite to the first chain-engaging surface in the axial direction.

17. The bicycle sprocket according to the claim 16,
wherein
the at least one chain-supporting portion includes a support
surface facing in the axial direction, the support
surface being contactable with one of the pair of inner 5
link plates of the bicycle chain, and
the support surface is offset from the first chain-engaging
surface and the second chain-engaging surface in the
axial direction.

18. The bicycle sprocket according to the claim 16, 10
wherein
the first chain-engaging surface and the second chain-
engaging surface are respectively configured to face the
pair of outer link plates in the axial direction.

19. The bicycle sprocket according to the claim 1, wherein 15
the at least one chain-supporting portion includes a support
surface facing in the axial direction to contact the
axial outer surface of one of the pair of inner link plates.

20. The bicycle sprocket according to the claim 1,
wherein, when the at least one chain-supporting portion 20
contacts the axial outer surface of the one of the pair of
inner link plates, no structure of said bicycle sprocket
engages with the bicycle chain at the inner link space
defined between the one of a pair of inner link plates.

21. The bicycle sprocket according to the claim 1, 25
wherein at least one sprocket tooth of the plurality of
sprocket teeth has a first profile when viewed in the
axial direction;
wherein the at least one chain-supporting portion has a
second profile when viewed in the axial direction; and 30
wherein the first profile is different from the second
profile.

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