



US010059400B2

(12) **United States Patent**  
**Tokuyama et al.**

(10) **Patent No.:** **US 10,059,400 B2**

(45) **Date of Patent:** **Aug. 28, 2018**

(54) **MULTIPLE BICYCLE SPROCKET ASSEMBLY**

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 331 days.

(21) Appl. No.: **14/943,303**

(22) Filed: **Nov. 17, 2015**

(65) **Prior Publication Data**

US 2016/0167737 A1 Jun. 16, 2016

(30) **Foreign Application Priority Data**

Dec. 15, 2014 (DE) ..... 10 2014 018 568  
Jul. 1, 2015 (DE) ..... 10 2015 008 454

(51) **Int. Cl.**  
**B62M 9/10** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **B62M 9/10** (2013.01)

(58) **Field of Classification Search**  
CPC ..... B62M 9/10; B62M 9/12; B62M 9/1242; F16H 55/30; F16H 9/24; F16H 2009/245  
See application file for complete search history.

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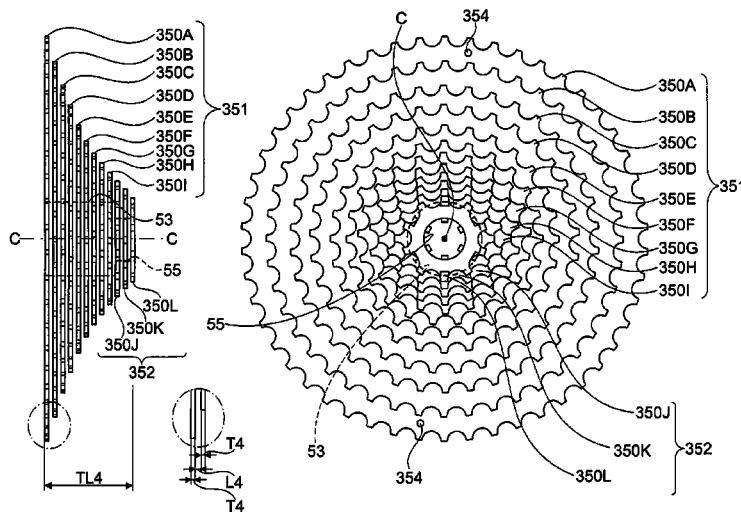
\* cited by examiner

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(57) **ABSTRACT**

A multiple bicycle sprocket assembly is basically provided that is capable of creating a gear ratio in a wide range. The multiple bicycle sprocket assembly includes a first sprocket and a second sprocket. The first sprocket includes a first tooth number that is less than or equal to ten. The second sprocket includes a second tooth number that is more than or equal to forty-four.

**2 Claims, 9 Drawing Sheets**



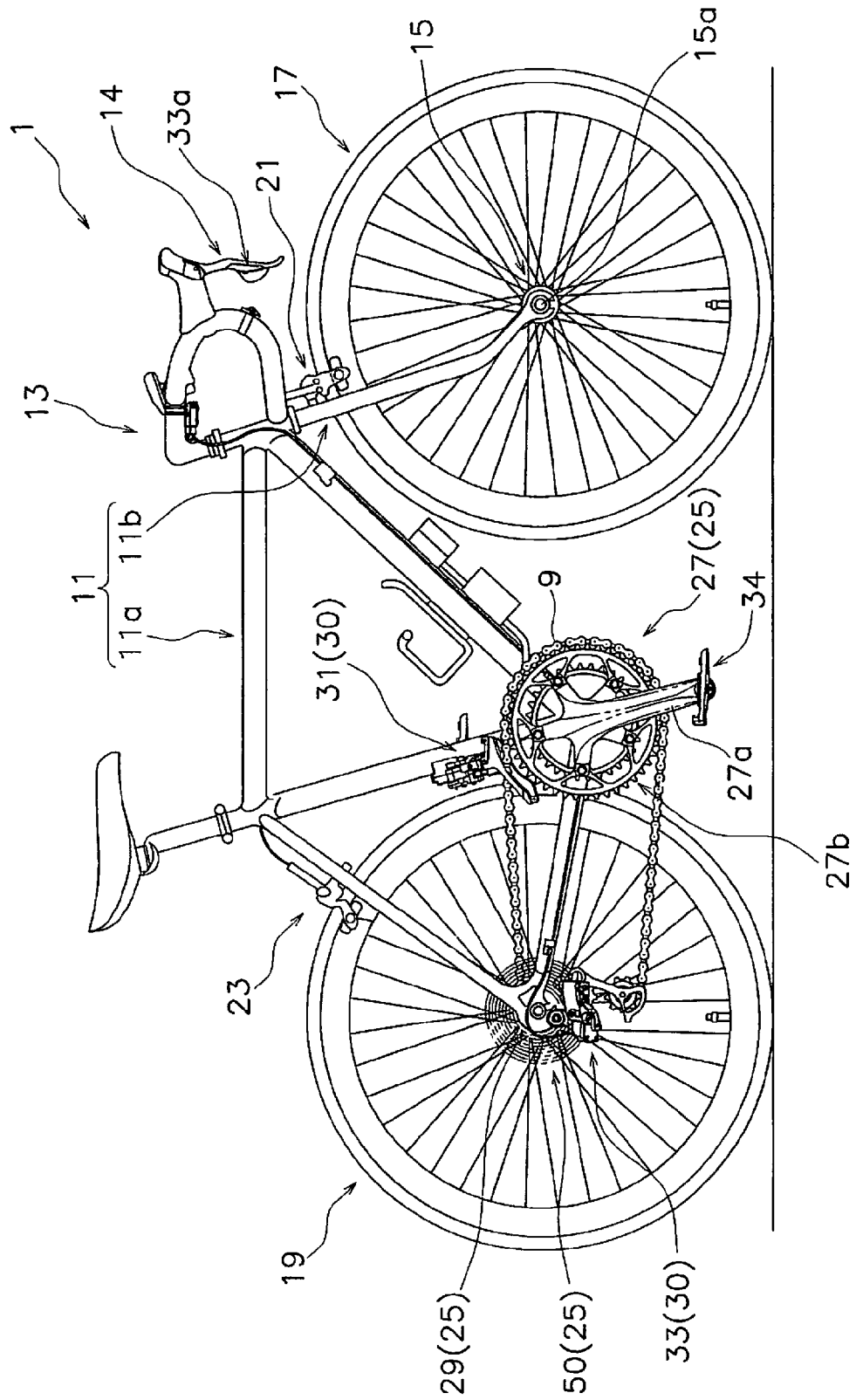


FIG. 1

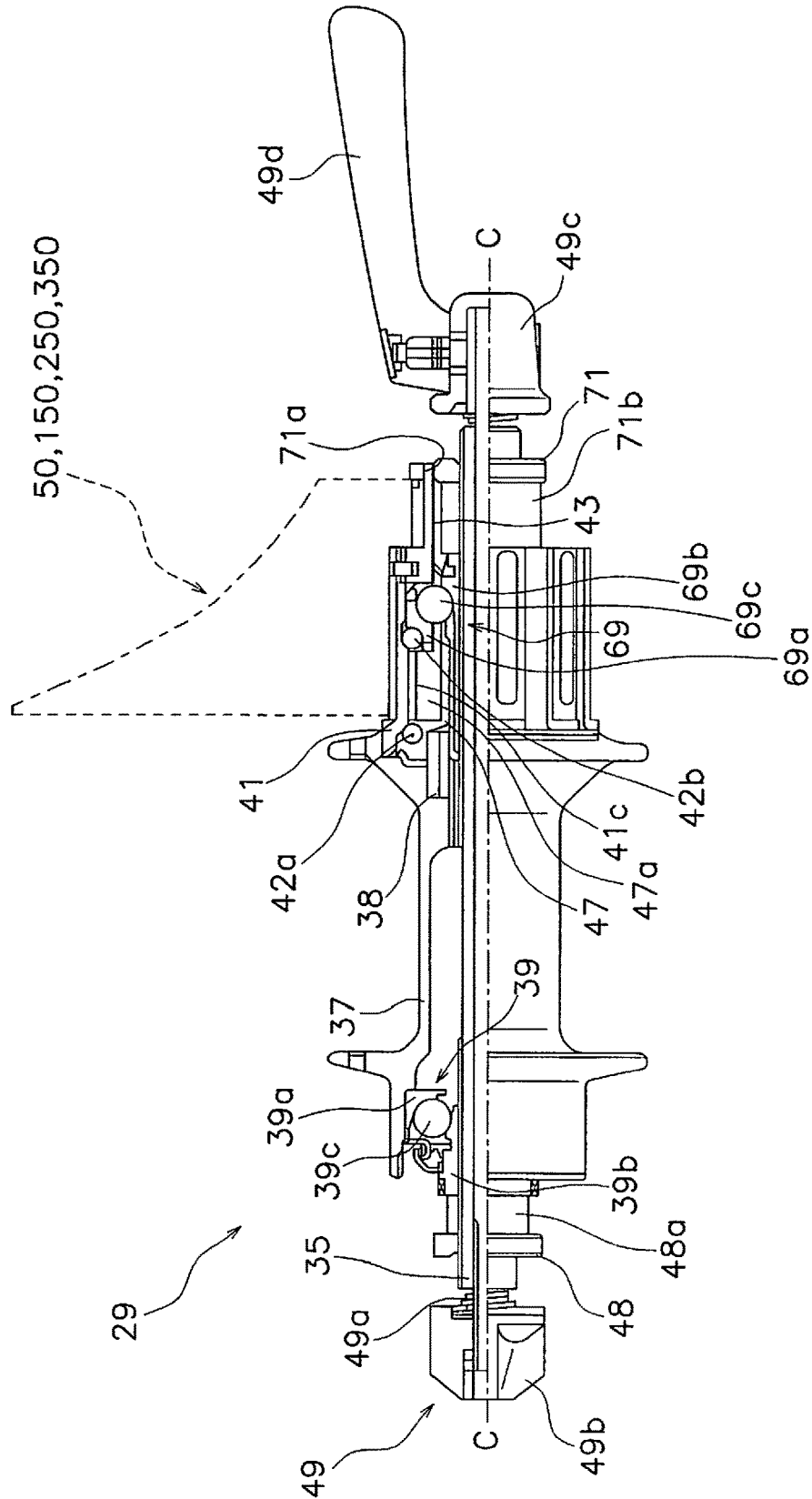


FIG. 2

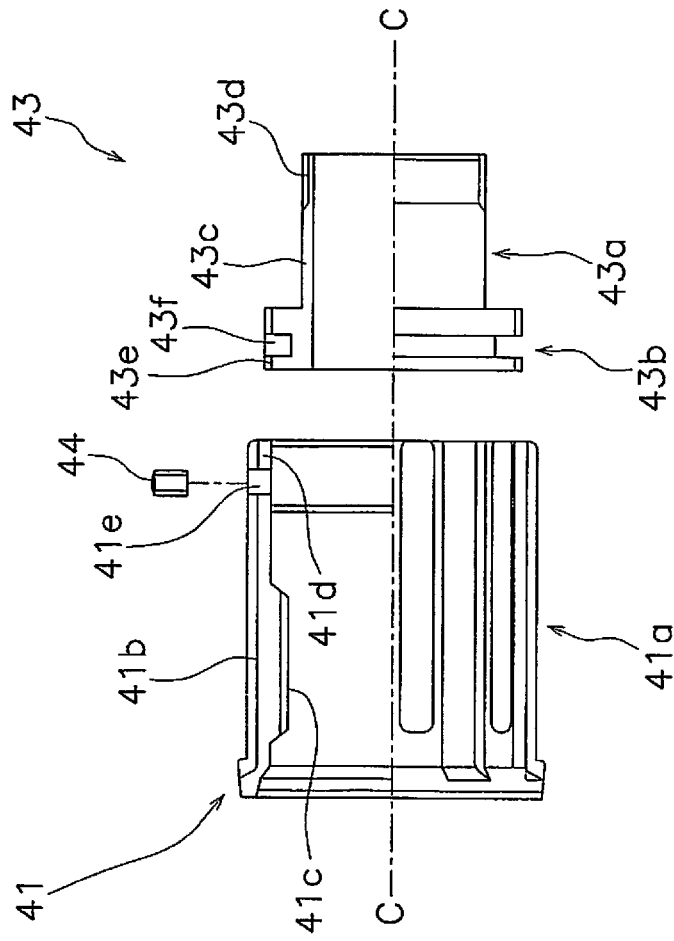


FIG. 3

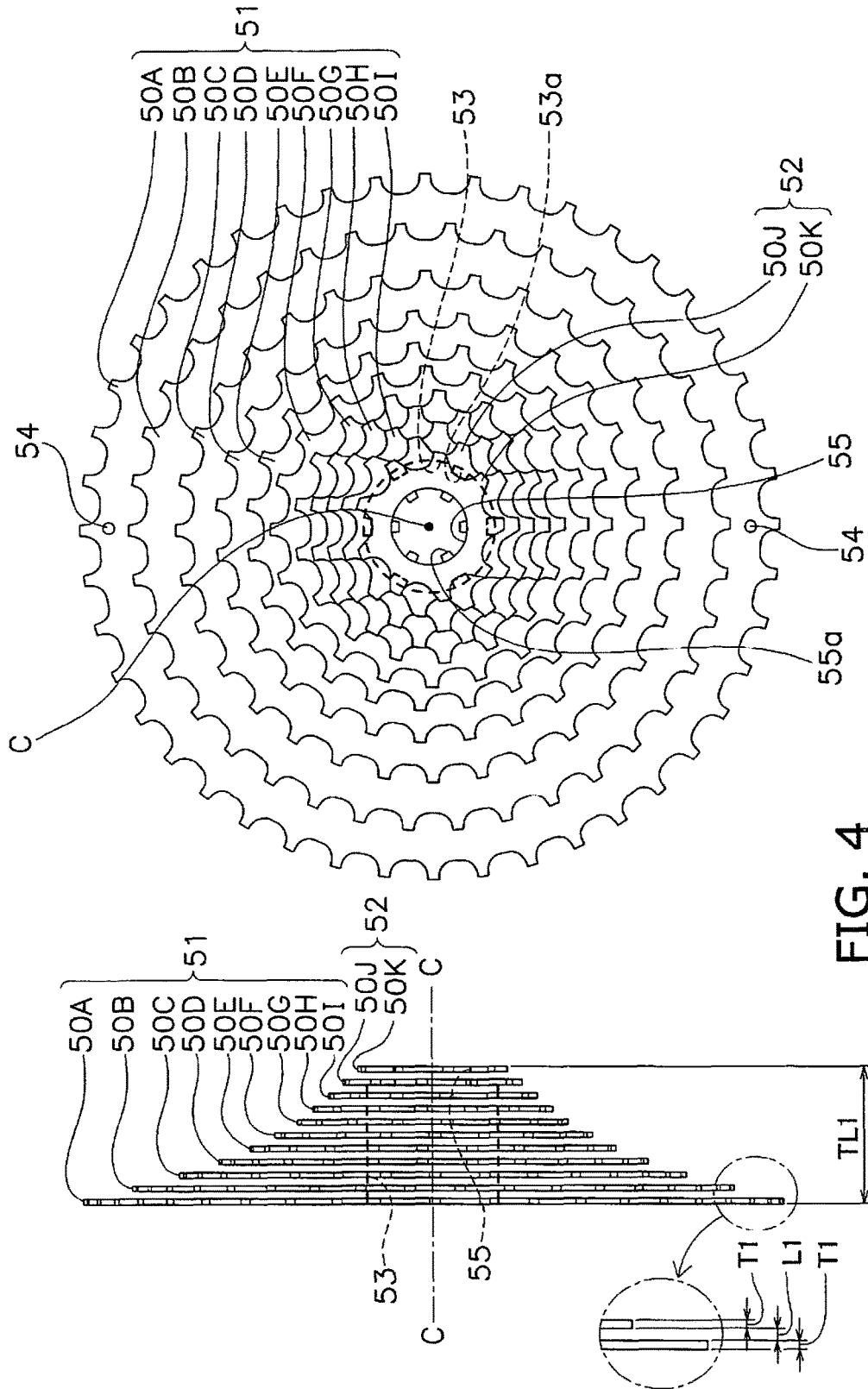


FIG. 4

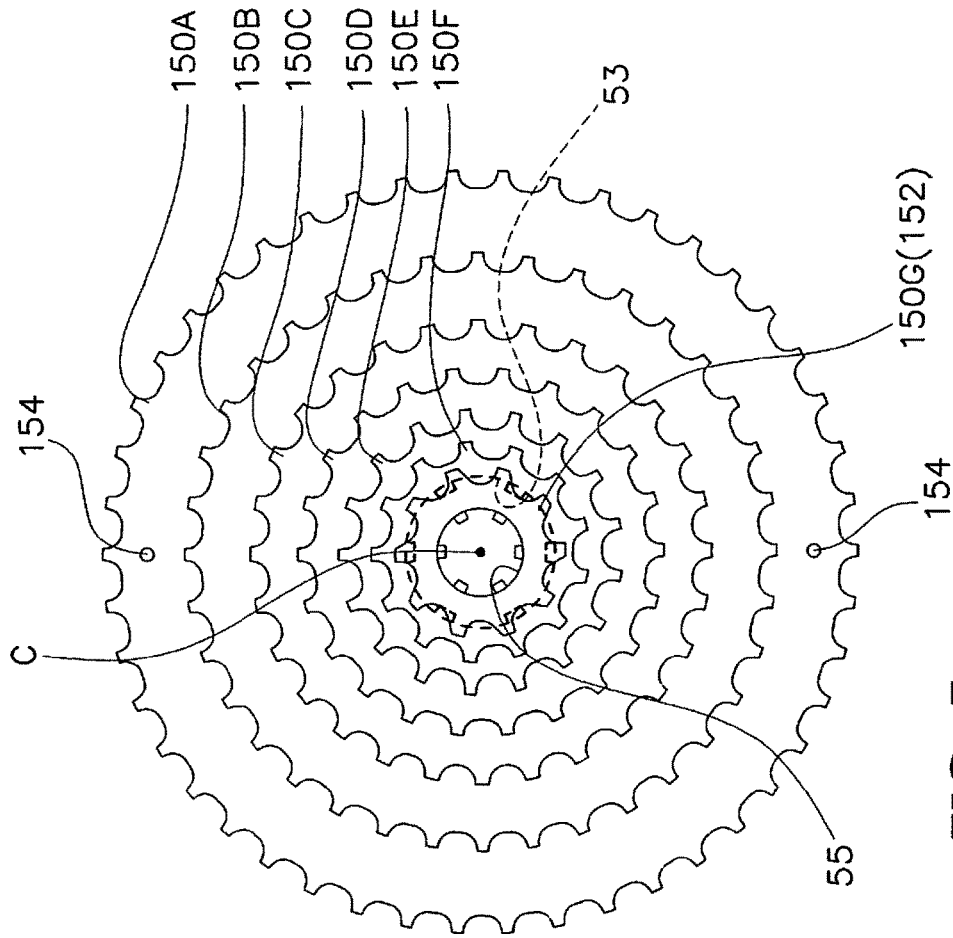
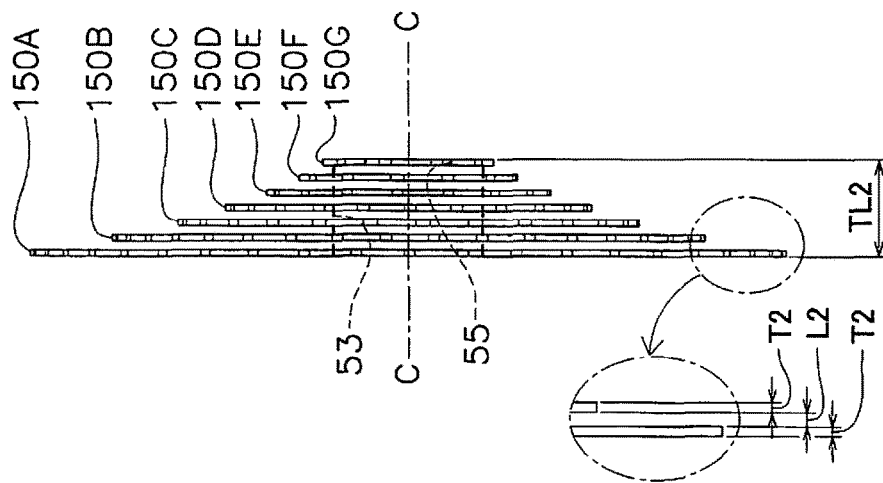


FIG. 5



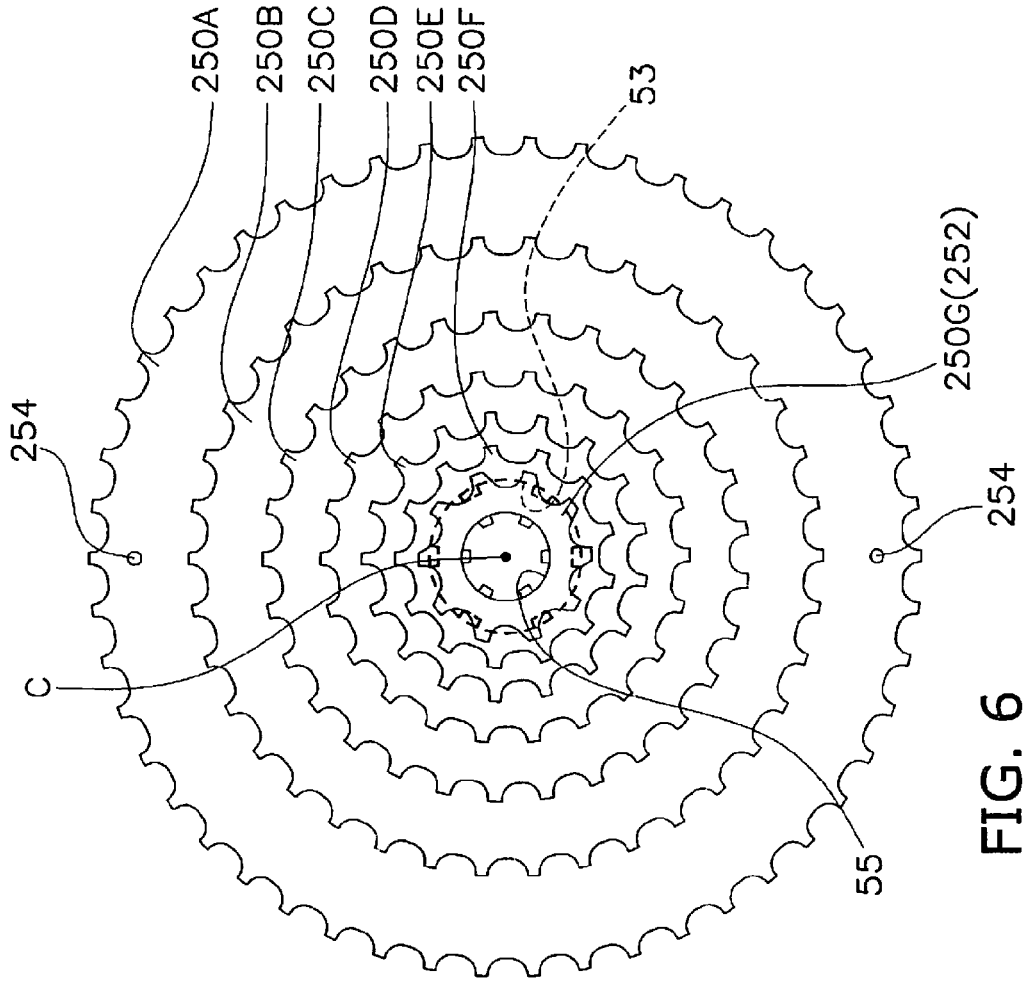
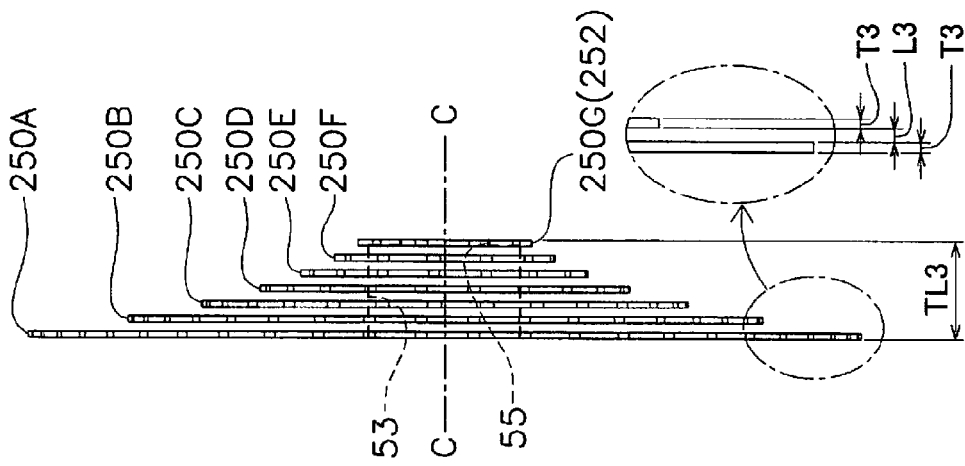


FIG. 6



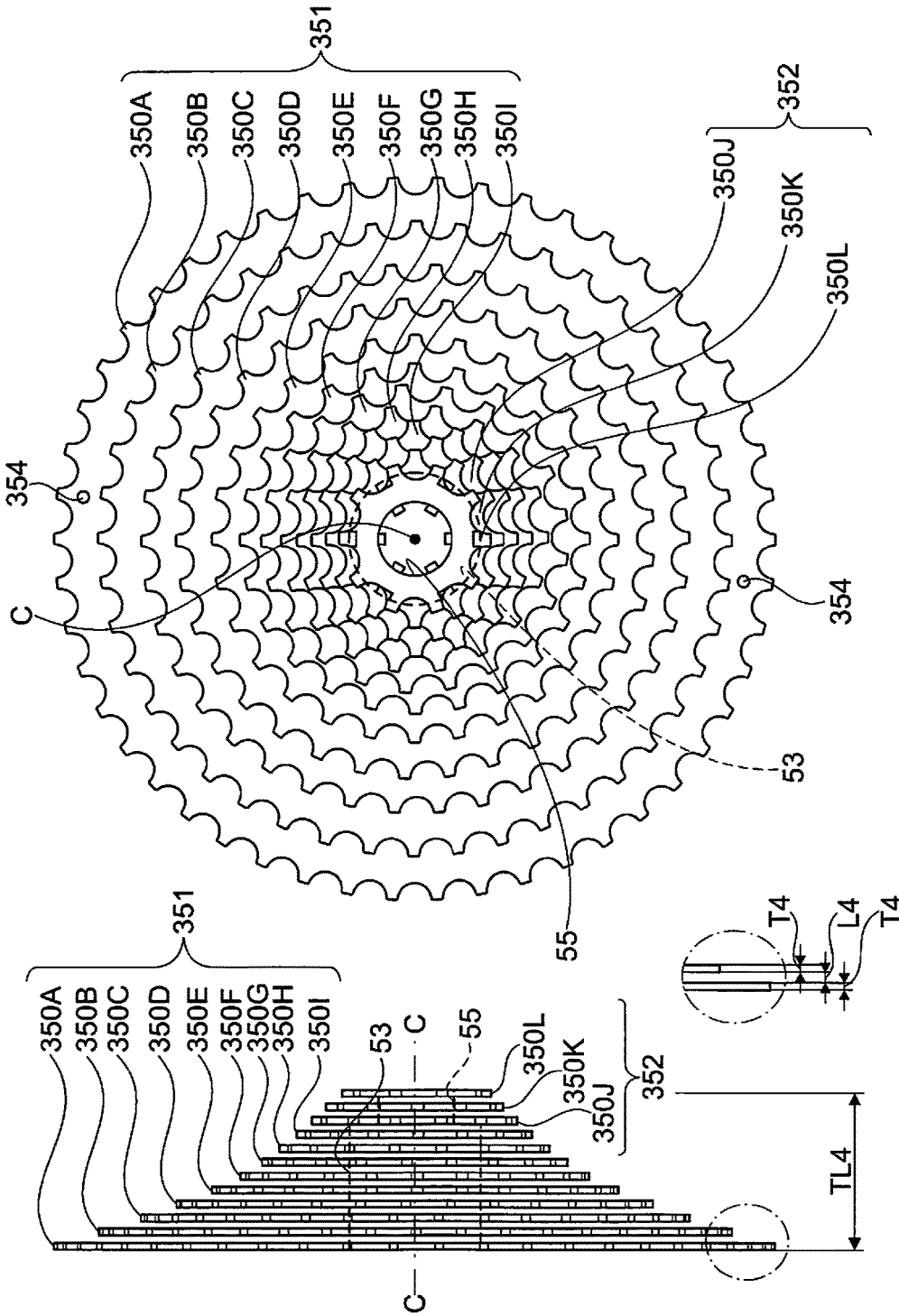


Fig. 7



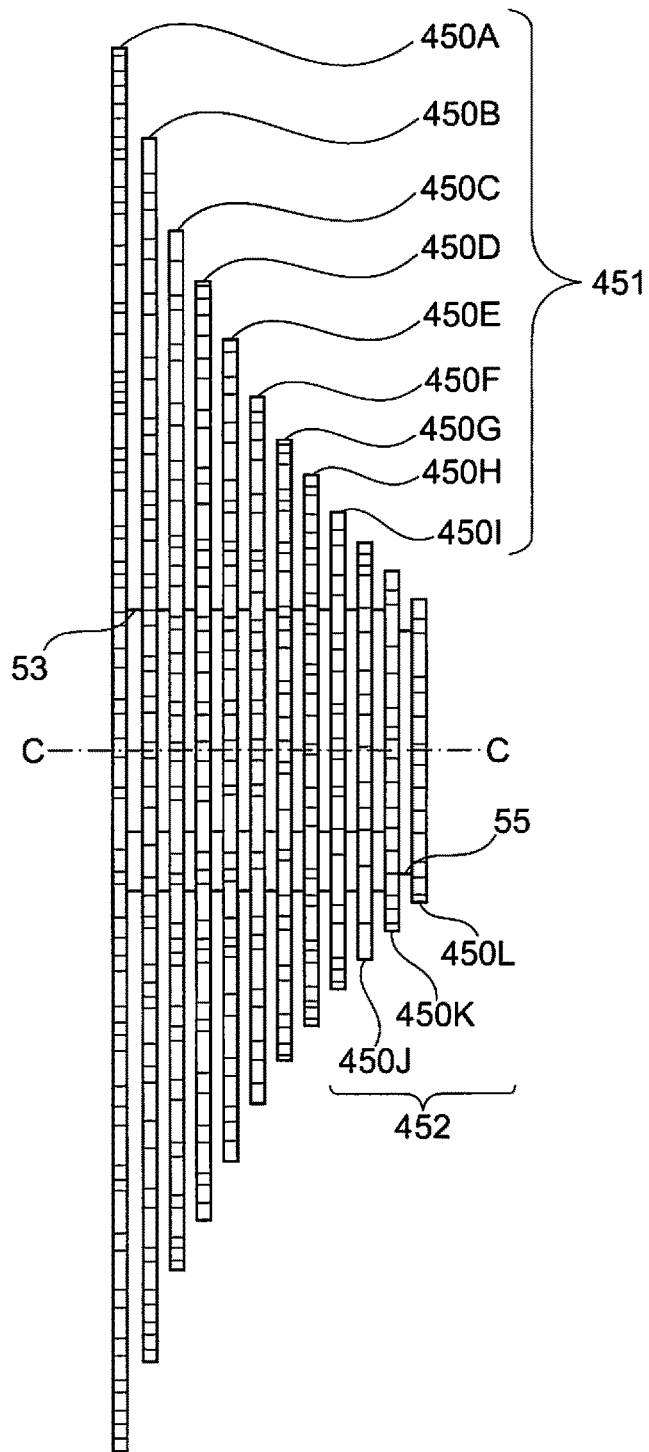


Fig. 8

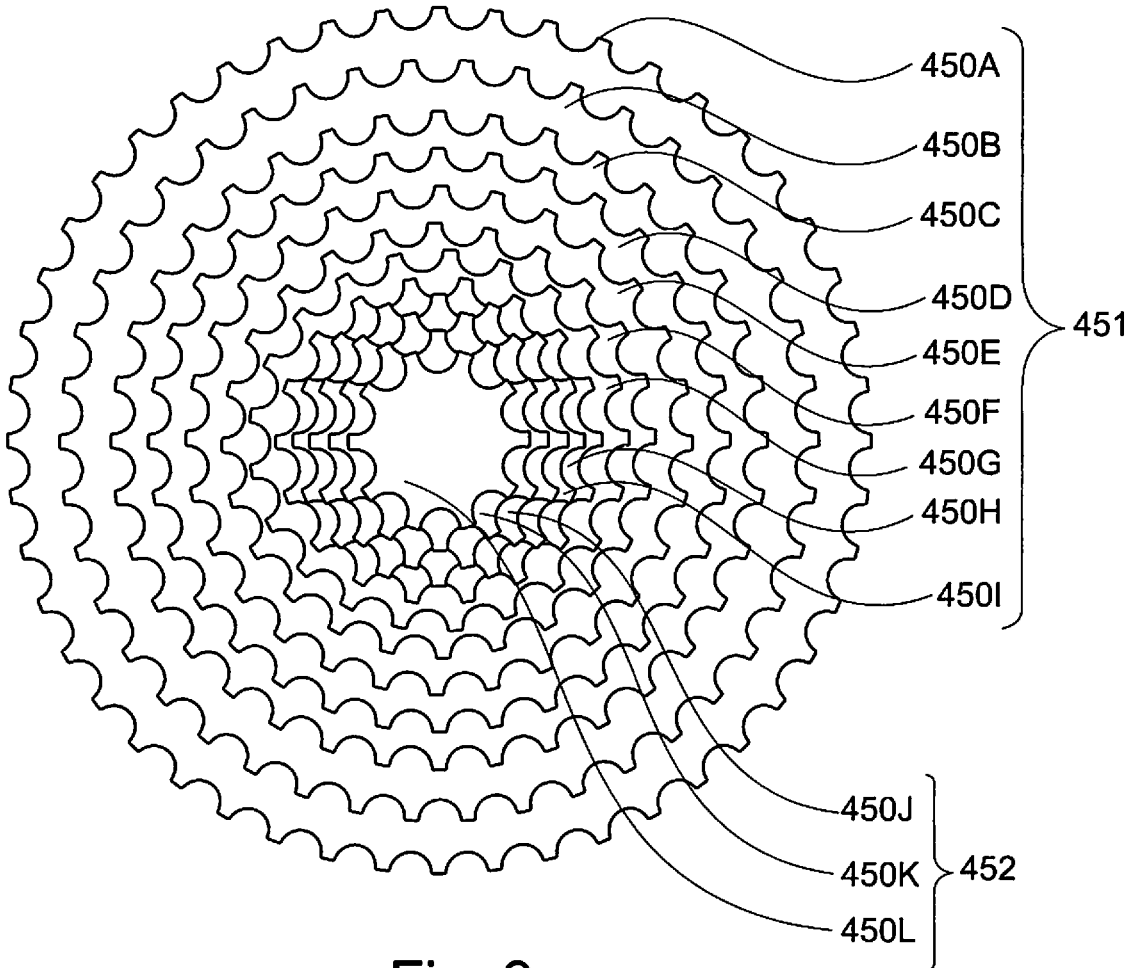


Fig. 9

## MULTIPLE BICYCLE SPROCKET ASSEMBLY

### CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to German Patent Application No. DE102014018568.0, filed on Dec. 15, 2014 and German Patent Application No. DE102015008454.2, filed on Jul. 1, 2015. The entire disclosures of German Patent Application Nos. DE102014018568.0 and DE102015008454.2 are hereby incorporated herein by reference.

### BACKGROUND

#### Field of the Invention

This invention generally relates to a multiple bicycle sprocket assembly. More specifically, the present invention relates to a multiple bicycle sprocket assembly having a rotational central axis and configured to be mounted on a bicycle hub assembly.

#### Background Information

A plurality of rear sprockets are attached to a bicycle rear hub assembly (see EP1342657A2). The respective rear sprockets have different numbers of teeth. A combination of the numbers of teeth of the respective rear sprockets, that is, a tooth combination of the rear sprockets is set according to a characteristic of a course, for example.

In the case in which a rider attaches importance to riding at a high speed in a course having many flat roads or the like, generally, a sprocket having a small number of teeth is used for the rear sprocket on a top side. On the other hand, in the case in which the rider attaches importance to comfortable riding in a course having many uphill or the like, a sprocket having a large number of teeth is used for the rear sprocket on a low side.

In the conventional rear sprocket, it is possible to constitute a gear ratio which attaches importance to a speed, but it is difficult to constitute the gear ratio at which pedal stepping is very light. On the other hand, in the conventional rear sprocket, it is possible to constitute the gear ratio at which the pedal stepping is very light, but it is difficult to constitute the gear ratio which attaches importance to the speed. In other words, the conventional rear sprocket does not have such a configuration as to simultaneously satisfy both of the gear ratio which attaches importance to the speed and the gear ratio at which the pedal stepping is light.

In consideration of the problem, it is an object of the present invention to provide a multiple bicycle sprocket assembly capable of constituting a gear ratio in a wide range.

### SUMMARY

Generally, the present disclosure is directed to various features of a multiple bicycle sprocket assembly.

A multiple bicycle sprocket assembly according to the present invention has a rotational central axis and is configured to be mounted on a bicycle hub assembly. The multiple bicycle sprocket assembly comprises a first sprocket and a second sprocket. The first sprocket has a first tooth number that is less than or equal to ten. The second sprocket has a second tooth number that is more than or equal to forty-four.

In the multiple bicycle sprocket assembly, the first tooth number of the first sprocket is less than or equal to ten. The second tooth number of the second sprocket is more than or

equal to forty-four. In the multiple bicycle sprocket assembly, consequently, it is possible to constitute a gear ratio in a wider range as compared with the conventional configuration.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The first tooth number is ten that is the smallest tooth number. The second tooth number is forty-six that is the largest tooth number. In this preferred multiple bicycle sprocket assembly, consequently, it is possible to constitute a gear ratio in a wider range.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The first tooth number is less than or equal to nine. In this preferred multiple bicycle sprocket assembly, consequently, it is possible to constitute a gear ratio in a wider range.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The first tooth number is nine that is the smallest tooth number. The second tooth number is forty-four that is the largest tooth number. In this preferred multiple bicycle sprocket assembly, consequently, it is possible to constitute a gear ratio in a wider range.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The first tooth number is ten that is the smallest tooth number. The second tooth number is one among forty-six, forty-eight and fifty that is the largest tooth number. In this preferred multiple bicycle sprocket assembly, consequently, it is possible to constitute a gear ratio in a wider range.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The multiple bicycle sprocket assembly further comprises at least five additional sprockets. The at least five additional sprockets are positioned between the first sprocket and the second sprocket in an axial direction parallel to the rotational central axis. With this structure, it is possible to constitute a gear ratio in a wide range, and furthermore, to smoothly change the gear ratio between the first sprocket and the second sprocket.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The multiple bicycle sprocket assembly further comprises five additional sprockets. The five additional sprockets are positioned between the first sprocket and the second sprocket in an axial direction parallel to the rotational central axis. The total sprocket number is seven. With this structure, it is possible to constitute a gear ratio in a wide range while still achieving a low profile design of the multiple sprocket assembly in the axial direction with respect to the rotational central axis, and furthermore, to smoothly change the gear ratio between the first sprocket and the second sprocket.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The multiple bicycle sprocket assembly further comprises at least eight additional sprockets. The at least eight additional sprockets are positioned between the first sprocket and the second sprocket in an axial direction parallel to the rotational central axis. With this structure, it is possible to constitute a gear ratio in a wide range, and furthermore, to smoothly change the gear ratio between the first sprocket and the second sprocket.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The multiple bicycle sprocket assembly further comprises nine additional sprockets. The nine additional sprockets are positioned between the first sprocket and the second sprocket in an axial

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direction parallel to the rotational central axis. The total sprocket number is eleven. With this structure, it is possible to constitute a gear ratio in a wider range, and furthermore, to change the gear ratio more smoothly between the first sprocket and the second sprocket.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The multiple bicycle sprocket assembly further comprises at least ten additional sprockets. The at least ten additional sprockets are positioned between the first sprocket and the second sprocket in an axial direction parallel to the rotational central axis. With this structure, it is possible to constitute a gear ratio in a wide range, and furthermore, to smoothly change the gear ratio between the first sprocket and the second sprocket.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The multiple bicycle sprocket assembly further comprises ten additional sprockets. The ten additional sprockets are positioned between the first sprocket and the second sprocket in an axial direction parallel to the rotational central axis. The total sprocket number is twelve. With this structure, it is possible to constitute a gear ratio in a wider range, and furthermore, to change the gear ratio more smoothly between the first sprocket and the second sprocket.

In one embodiment the multiple bicycle sprocket assembly may comprise first to twelfth sprockets. In such an embodiment the multiple bicycle sprocket assembly of the present invention may be configured as follows: The first sprocket has a first tooth number that is ten. The second sprocket has a second tooth number that is fifty. The third sprocket has a third tooth number that is twelve. The third sprocket is positioned between the first sprocket and the second sprocket in an axial direction parallel to the rotational central axis. The fourth sprocket has a fourth tooth number that is forty-four. The fourth sprocket is positioned between the second sprocket and the third sprocket in the axial direction. The fifth sprocket has a fifth tooth number that is fourteen. The fifth sprocket is positioned between the third sprocket and the fourth sprocket in the axial direction. The sixth sprocket has a sixth tooth number that is thirty-eight. The sixth sprocket is positioned between the fourth sprocket and the fifth sprocket in the axial direction. The seventh sprocket has a seventh tooth number that is sixteen. The seventh sprocket is positioned between the fifth sprocket and the sixth sprocket in the axial direction. The eighth sprocket has an eighth tooth number that is thirty-three. The eighth sprocket is positioned between the sixth sprocket and the seventh sprocket in the axial direction. The ninth sprocket has a ninth tooth number that is eighteen. The ninth sprocket is positioned between the seventh sprocket and the eighth sprocket in the axial direction. The tenth sprocket has a tenth tooth number that is twenty-eight. The tenth sprocket is positioned between the eighth sprocket and the ninth sprocket in the axial direction. The eleventh sprocket has an eleventh tooth number that is twenty-one. The tenth sprocket is positioned between the ninth sprocket and the tenth sprocket in the axial direction. The twelfth sprocket has a twelfth tooth number that is twenty-four. The twelfth sprocket is positioned between the tenth sprocket and the eleventh sprocket in the axial direction. The total sprocket number is twelve.

In another embodiment where the multiple bicycle sprocket assembly comprises first to twelfth sprockets the multiple bicycle sprocket assembly of the present invention may be configured as follows. The first sprocket has a first tooth number that is ten. The second sprocket has a second

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tooth number that is forty-eight. The third sprocket has a third tooth number that is twelve. The third sprocket is positioned between the first sprocket and the second sprocket in an axial direction parallel to the rotational central axis. The fourth sprocket has a fourth tooth number that is forty-two. The fourth sprocket is positioned between the second sprocket and the third sprocket in the axial direction. The fifth sprocket has a fifth tooth number that is fourteen. The fifth sprocket is positioned between the third sprocket and the fourth sprocket in the axial direction. The sixth sprocket has a sixth tooth number that is thirty-six. The sixth sprocket is positioned between the fourth sprocket and the fifth sprocket in the axial direction. The seventh sprocket having a seventh tooth number that is sixteen. The seventh sprocket is positioned between the fifth sprocket and the sixth sprocket in the axial direction. The eighth sprocket has an eighth tooth number that is thirty-two. The eighth sprocket is positioned between the sixth sprocket and the seventh sprocket in the axial direction. The ninth sprocket has a ninth tooth number that is eighteen. The ninth sprocket is positioned between the seventh sprocket and the eighth sprocket in the axial direction. The tenth sprocket has a tenth tooth number that is twenty-eight. The tenth sprocket is positioned between the eighth sprocket and the ninth sprocket in the axial direction. The eleventh sprocket has an eleventh tooth number that is twenty-one. The eleventh sprocket is positioned between the ninth sprocket and the tenth sprocket in the axial direction. The twelfth sprocket has a twelfth tooth number that is twenty-four. The twelfth sprocket is positioned between the tenth sprocket and the eleventh sprocket in the axial direction. The total sprocket number is twelve.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The axial length of each space between axially adjacent sprockets is 2.18 mm.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The axial length of each space between axially adjacent sprockets is 2.2 mm when the bicycle is to be equipped with a thick tire.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The axial thickness of each of the first sprocket, the second sprocket and the additional sprockets is 1.6 mm.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The total axial length between the first sprocket and the second sprocket is 24.28 mm when the total sprocket number is seven.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The total axial length between the first sprocket and the second sprocket is 39.4 mm when the total sprocket number is eleven.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The total axial length between the first sprocket and the second sprocket is 43.4 mm when the total sprocket number is twelve.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The second sprocket includes at least one shift assist projection. Consequently, it is possible to smoothly move a chain from a smaller adjacent sprocket to the second sprocket.

The multiple bicycle sprocket assembly of the present invention may be configured as follows. The first sprocket is configured to be mounted to the bicycle hub assembly via a mounting adapter. Even if the number of the sprockets is increased, consequently, the sprockets can easily be attached to the hub assembly.

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In the multiple bicycle sprocket assembly according to the present invention, it is possible to constitute a gear ratio in a wider range. In the multiple bicycle sprocket assembly according to the present invention, moreover, it is possible to change the gear ratio more smoothly between the first sprocket and the second sprocket.

Also other objects, features, aspects and advantages of the disclosed a multiple bicycle sprocket assembly will become apparent to those skilled in the art from the following detailed description, which, taken in conjunction with the annexed drawings, discloses selected illustrative embodiments of the multiple bicycle sprocket assembly.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the attached drawings which form a part of this original disclosure:

FIG. 1 is a side elevational view of a bicycle that is equipped with a multiple bicycle sprocket assembly in accordance with first to fifth illustrated embodiments;

FIG. 2 is a detailed view of a rear hub assembly according to the first to the fifth embodiments;

FIG. 3 is an exploded view of a first tubular member and a second tubular member on the rear hub assembly according to the first to the fifth embodiments;

FIG. 4 is a front view and a side view of a rear sprocket assembly according to the first embodiment;

FIG. 5 is a front view and a side view of a rear sprocket assembly according to the second embodiment;

FIG. 6 is a front view and a side view of a rear sprocket assembly according to the third embodiment;

FIG. 7 is a front view and a side view of a rear sprocket assembly according to the fourth embodiment;

FIG. 8 is a front view of a rear sprocket assembly according to the fifth embodiment; and

FIG. 9 is a side view of a rear sprocket assembly according to the fifth embodiment.

#### DETAILED DESCRIPTION OF EMBODIMENTS

Selected embodiments will now be explained with reference to the drawings. It will be apparent to those skilled in the bicycle field from this disclosure that the following descriptions of the embodiments are provided for illustration only and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

##### First Embodiment

Referring initially to FIG. 1, a bicycle 1 is illustrated that is configured in accordance with a first embodiment. The bicycle 1 mainly includes a frame 11, a handle 13, a front hub assembly 15, a rear hub assembly 29, front and rear wheels 17, 19, front and rear brake devices 21, 23, a gear change portion 30, and a driving portion 25.

The frame 11 has a frame body 11a and a front fork 11b. The front fork 11b is rotatably attached to the frame body 11a. The handle 13 is fixed to the front fork 11b.

The front hub assembly 15 is supported on the front fork 11b. The front hub assembly 15 mainly has a front hub shaft 15a and a front hub shell (not shown). Both ends of the front hub shaft 15a are held on the front fork 11b. The front hub shell is provided rotatably with respect to the front hub shaft 15a. The front wheel 17 (e.g. spokes) is attached to the front hub shell.

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The front and rear wheels 17, 19 are rotatably attached to the front fork 11b and a rear portion of the frame 11 through the front hub assembly 15 and the rear hub assembly 29, respectively.

The front and rear brake devices 21, 23 are operated by manipulation of a brake lever 14. Since the front and rear brake devices 21, 23 have the same configuration as those in the conventional configuration, description will be omitted.

The gear change portion 30 is attached to the frame 11. The gear change portion 30 includes a front derailleur 31 and a rear derailleur 33. The front derailleur 31 moves a bicycle chain 9 from a front sprocket to an adjacent front sprocket by a shift operation of a shift lever (not shown) attaching to, e.g. the left side of the handle 13. The front derailleur 31 is attached to a seat tube of the frame 11 in the illustrated embodiment. The rear derailleur 33 moves the bicycle chain 9 from a rear sprocket to an adjacent rear sprocket by a shift operation of a shift lever 33a attaching to, e.g. the right side of the handle 13. The rear derailleur 33 is attached to a connecting portion of a chain stay and a seat stay of the frame 11.

The driving portion 25 mainly has a crank assembly 27, a rear hub assembly 29 and a rear sprocket assembly 50 (an example of a multiple bicycle sprocket assembly).

The crank assembly 27 includes a crank shaft (not shown), a right crank arm 27a and a left crank arm (not shown). The crank shaft is rotatably supported on a lower portion of the frame 11, for example, on a bottom bracket hanger portion. Base ends of the right crank arm 27a and the left crank arm are attached unrotatably to both ends of the crank shaft, respectively. A pedal 34 is attached to distal end of the right crank arm 27a and distal end of the left crank arm. A front sprocket assembly 27b having the same configuration as that in the conventional configuration is attached to the right crank arm 27a so as to be integrally rotatable. The front sprocket assembly 27b has at least one front sprocket. For example, the front sprocket assembly 27b has two front sprockets in the illustrated embodiment.

As shown in FIGS. 1 and 2, the rear hub assembly 29 is supported on the rear part of the frame 11. The rear hub assembly 29 has a rear hub shaft 35, a rear hub shell 37, a first tubular member 41 and a second tubular member 43 (an example of a mounting adapter).

The rear hub shaft 35 is held on the rear part of the frame 11 with a conventional wheel securing mechanism 49. The wheel securing mechanism 49 is the same as the conventional mechanism. The wheel securing mechanism 49 has a draw bar 49a, a stationary nut 49b and a movable nut 49c, for example. The draw bar 49a is extended along the rear hub shaft 35. The stationary nut 49b is screwed at one of ends of the draw bar 49a. The movable nut 49c is disposed on the other end of the draw bar 49a. The movable nut 49c is movable in an axial direction by a conventional cam mechanism. The stationary nut 49b and the movable nut 49c clamp the rear hub shaft 35 to the frame 11 when a lever 49d is operated.

The rear hub shell 37 is supported rotatably with respect to the rear hub shaft 35. The rear wheel 19 (e.g. spokes) is attached to the rear hub shell 37.

The rear hub shell 37 is rotatable around a shaft center C (an example of a rotational central axis) of the rear hub shaft 35. One of ends (a left side in FIG. 2) of the rear hub shell 37 is rotatably supported on the rear hub shaft 35 through a bearing assembly 39. An outer race 39a of the bearing assembly 39 is fixed to an inner peripheral surface at one of the ends of the rear hub shell 37. An inner race 39b of the bearing assembly 39 is fixed to the rear hub shaft 35 by a

lock nut **48** and spacer **48a**. Ball bearings **39c** are disposed between the outer race **39a** of the bearing assembly **39** and the inner race **39b** of the bearing assembly **39**.

On the other hand, the other end (a right side in FIG. 2) of the rear hub shell **37** is unrotatably supported on an inner member **47** disposed on an inner peripheral side of the first tubular member **41** (described later) by a spline structure **38**. The spline structure **38** comprises splines on an inner peripheral surface at the other end of the rear hub shell **37** and splines on an outer peripheral surface at one of ends (the left side in FIG. 2) of the inner member **47**.

The inner member **47** is rotatable around the shaft center C of the rear hub shaft **35**. For example, the other end (the right side in FIG. 2) of the inner member **47** is rotatably supported on the rear hub shaft **35** through the bearing assembly **69**. An outer race **69a** of the bearing assembly **69** is fixed to an outer peripheral surface at the other end of the inner member **47**. An inner race **69b** of the bearing assembly **69** is fixed to the rear hub shaft **35** by a lock nut **71** and a spacer **71b**. Ball bearings **69c** are disposed between the outer race **69a** of the bearing assembly and the inner race **69b** of the bearing assembly. Thus, the other end of the rear hub shell **37** and the inner member **47** are rotatably supported on the rear hub shaft **35** through the bearing assembly **69**. Ratchet pawls **47a** are formed on the outer peripheral portion of the inner member **47**.

The first tubular member **41** is rotatable around the shaft center C of the rear hub shaft **35** as shown in FIG. 3. The first tubular member **41** has a first body portion **41a**, a plurality of first splines **41b**, a plurality of ratchet teeth **41c** and a first female screw portion **41d**. The first body portion **41a** is formed in a tubular shape. The first splines **41b** are formed integrally with the outer peripheral portion of the first body portion **41a**. A rear sprocket assembly **50** (a first rear sprocket assembly **51**; described later) is mounted to the first splines **41b**.

The ratchet teeth **41c** are formed integrally with the inner peripheral portion of the first body portion **41a**. The ratchet teeth **41c** are engaged with the ratchet pawls **47a** of the inner member **47**. A one-way clutch used conventionally is configured by the engagement of the ratchet teeth **41c** and the ratchet pawls **47a**.

The first female screw portion **41d** is formed on an inner peripheral surface at the end of the first body portion **41a**, for example, an inner peripheral surface at the end of the second tubular member **43** side. A second male screw portion **43e** (described later) of the second tubular member **43** is screwed with the first female screw portion **41d**. Moreover, a screw hole portion **41e** is formed at the end where the first female screw portion **41d** is formed on the first body portion **41a**. The screw hole portion **41e** penetrates from the outer peripheral surface toward the inner peripheral surface.

The first body portion **41a** is rotatably supported on the inner member **47** through ball bearings **42a**, **42b**. For example, the ball bearings **42a**, **42b** are disposed on both sides of the ratchet teeth **41c** in a direction along the rotation axis of the first body portion **41a**. The ball bearings **42a** are disposed between the inner peripheral surface of the first body portion **41a** and one end side (the left side in FIG. 2) of the outer peripheral portion of the inner member **47**. Moreover, the ball bearings **42b** are disposed between the inner peripheral surface of the first body portion **41a** and an outer race **69a** of the bearing assembly **69**.

The second tubular member **43** is rotatable around the shaft center C of the rear hub shaft **35**. The second tubular member **43** has a second body portion **43a**, a coupling portion **43b**, a plurality of second splines **43c**, and a first

male screw portion **43d**. The second body portion **43a** is formed in a tubular shape. The outside diameter of the second body portion **43a** is smaller than the outside diameter of the first body portion **41a**. The coupling portion **43b** is coupled to the first tubular member **41** (the first body portion **41a**). The coupling portion **43b** is formed in a flange shape and is provided integrally with one of the ends (the left side in FIG. 2) of the second body portion **43a**. The second male screw portion **43e** is formed on the outer peripheral portion of the coupling portion **43b**. Moreover, a groove portion **43f** extended in a circumferential direction is formed on the outer peripheral portion of the coupling portion **43b**.

The second male screw portion **43e** is screwed into the first female screw portion **41d** of the first tubular member **41** (the first body portion **41a**). In this condition, a clamping member such as a screw member **44** is screwed into the screw hole portion **41e** of the first tubular member **41** (the first body portion **41a**) and is engaged with the groove portion **43f**. Thus, the first tubular member **41** and the second tubular member **43** are coupled to each other.

The second splines **43c** are formed integrally with the outer peripheral portion of the second body portion **43a**. A rear sprocket assembly **50** (a second rear sprocket assembly **52**; described later) is attached to the second splines **43c**.

The first male screw portion **43d** is formed on the outer peripheral surface (the right side in FIG. 2) at the other end of the second body portion **43a**. A second female screw portion **71a** of a lock nut **71** is screwed to the first male screw portion **43d**. For example, the second female screw portion **71a** of the lock nut **71** is screwed to the first male screw portion **43d** of the second tubular member **43** in a state in which the rear sprocket assembly **50** is mounted to the rear hub assembly **29** (the first tubular member **41** and the second tubular member **43**).

The rear sprocket assembly **50** is configured to be mounted on the rear hub assembly **29**. The rear sprocket assembly **50** has a rotational central axis. The rotational central axis corresponds to the rear hub shaft **35** or the shaft center C of the rear hub shaft **35**.

The rear sprocket assembly **50** is mounted to the first tubular member **41** and the second tubular member **43**. The rear sprocket assembly **50** has a plurality of rear sprockets **50A-50K**.

As shown in FIG. 4, the rear sprocket assembly **50** has a first rear sprocket assembly **51** and a second rear sprocket assembly **52**.

The first rear sprocket assembly **51** is mounted to the first tubular member **41** (the first body portion **41a**). The first rear sprocket assembly **51** has first to ninth rear sprockets **50A-50I**. The first to ninth rear sprockets **50A-50I** are arranged on the outer peripheral portion of the first tubular member **41** in an axial direction parallel to the shaft center C of the rear hub shaft **35**. The first rear sprocket **50A** is disposed on the outer peripheral portion of the first tubular member **41** on a side of the rear hub shell **37**. A spacer (not shown) is disposed between two sprockets which are adjacent to each other in the first to ninth rear sprockets **50A-50I**. Instead of such a spacer, some of the first to ninth rear sprockets **50A-50I** may be fixed to a sprocket support member (not shown) such that the sprockets fixed to the sprocket support member are mounted to the first tubular member **41** through the sprocket support member.

More specifically, first hole portions **53** are formed on the respective inner peripheral portions of the first to ninth rear sprockets **50A-50I**. A plurality of third splines **53a** are formed on each of the first hole portions **53**. The third splines **53a** are engaged with the first splines **41b** (see FIG. 3) on the

first tubular member **41**, respectively. Thus, the first to ninth rear sprockets **50A-50I** are engaged with the first tubular member **41** so that the first to ninth rear sprockets **50A-50I** are arranged on the outer peripheral portion of the first tubular member **41**.

The second rear sprocket assembly **52** is attached to the second tubular member **43** (the second body portion **43a**). The second rear sprocket assembly **52** has tenth and eleventh rear sprockets **50J, 50K**. The tenth and eleventh rear sprockets **50J, 50K** are arranged on the outer peripheral portion of the second tubular member **43** in the axial direction parallel to the shaft center **C** of the rear hub shaft **35**. The tenth rear sprocket **50J** is disposed on the outer peripheral portion of the second tubular member **43** so as to be adjacent to the ninth rear sprocket **50I** in the axial direction. The eleventh rear sprocket **50K** is disposed on the outer peripheral portion of the second tubular member **43** so as to be adjacent to the tenth rear sprocket **50J** at the most distant position from the first rear sprocket **50A** in the axial direction. A spacer (not shown) is disposed between the two sprockets which are adjacent to each other in the tenth and eleventh rear sprockets **50J, 50K**.

More specifically, a second hole portion **55** is formed on the respective inner peripheral portions of the tenth and eleventh rear sprockets **50J, 50K**. A plurality of fourth splines **55a** are formed on the second hole portion **55**. The fourth splines **55a** are engaged with the second splines **43c** of the second tubular member **43**, respectively. Thus, the tenth and eleventh rear sprockets **50J, 50K** are engaged with the second tubular member **43** so that the tenth and eleventh rear sprockets **50J, 50K** are arranged on the outer peripheral portion of the second tubular member **43**.

As described above, the first rear sprocket assembly **51** is attached to the first tubular member **41** (the first body portion **41a**). Moreover, the second rear sprocket assembly **52** is attached to the second tubular member **43** (the second body portion **43a**). In this condition, the lock nut **71** (the second female screw portion **71a**; see FIG. 2) is screwed with the second tubular member **43** (the first male screw portion **43d**) so that the rear sprocket assembly **50** (the first rear sprocket assembly **51** and the second rear sprocket assembly **52**) is fixed to the rear hub assembly **29**.

The first rear sprocket **50A** is an example of a second sprocket. The second to tenth rear sprockets **50B-50J** are an example of at least five additional sprockets, at least eight additional sprockets, and nine additional sprockets. The eleventh rear sprocket **50K** is an example of a first sprocket.

Layouts of the first to eleventh rear sprockets **50A-50K** will be described below in detail. The first to eleventh rear sprockets **50A-50K** are arranged on the first tubular member **41** and the second tubular member **43** in alphabetical order.

Specifically, the second to tenth rear sprockets **50B-50J** are positioned between the first rear sprocket **50A** and the eleventh rear sprocket **50K** in the axial direction parallel to the shaft center **C** of the rear hub shaft **35**. The second rear sprocket **50B** is positioned between the first rear sprocket **50A** and the third rear sprocket **50C** in the axial direction. The third rear sprocket **50C** is positioned between the second rear sprocket **50B** and the fourth rear sprocket **50D** in the axial direction. The fourth rear sprocket **50D** is positioned between the third rear sprocket **50C** and the fifth rear sprocket **50E** in the axial direction. The fifth rear sprocket **50E** is positioned between the fourth rear sprocket **50D** and the sixth rear sprocket **50F** in the axial direction.

The sixth rear sprocket **50F** is positioned between the fifth rear sprocket **50E** and the seventh rear sprocket **50G** in the axial direction. The seventh rear sprocket **50G** is positioned

between the sixth rear sprocket **50F** and the eighth rear sprocket **50H** in the axial direction. The eighth rear sprocket **50H** is positioned between the seventh rear sprocket **50G** and the ninth rear sprocket **50I** in the axial direction. The ninth rear sprocket **50I** is positioned between the eighth rear sprocket **50H** and the tenth rear sprocket **50J** in the axial direction. The tenth rear sprocket **50J** is positioned between the ninth rear sprocket **50I** and the eleventh rear sprocket **50K** in the axial direction.

In other words, the second rear sprocket **50B** is positioned between the first rear sprocket **50A** and the tenth rear sprocket **50J** in the axial direction. The third rear sprocket **50C** is positioned between the second rear sprocket **50B** and the ninth rear sprocket **50I** in the axial direction. The fourth rear sprocket **50D** is positioned between the third rear sprocket **50C** and the eighth rear sprocket **50H** in the axial direction. The fifth rear sprocket **50E** is positioned between the fourth rear sprocket **50D** and the seventh rear sprocket **50G** in the axial direction.

The sixth rear sprocket **50F** is positioned between the fifth rear sprocket **50E** and the seventh rear sprocket **50G** in the axial direction. The seventh rear sprocket **50G** is positioned between the fourth rear sprocket **50D** and the eighth rear sprocket **50H** in the axial direction. The eighth rear sprocket **50H** is positioned between the third rear sprocket **50C** and the ninth rear sprocket **50I** in the axial direction. The ninth rear sprocket **50I** is positioned between the second rear sprocket **50B** and the tenth rear sprocket **50J** in the axial direction. The tenth rear sprocket **50J** is positioned between the first rear sprocket **50A** and the eleventh rear sprocket **50K** in the axial direction.

Finally, the configuration and the tooth combination of the first to eleventh rear sprocket **50A-50K** will be described in detail. A root circle diameter of the first rear sprocket **50A** is the largest in the first to eleventh rear sprocket **50A-50K**. Root circle diameters of the second to tenth sprockets **50B-50J** are gradually reduced in order of the second to tenth sprockets **50B-50J**. A root circle diameter of the eleventh sprocket is the smallest in the first to eleventh rear sprocket **50A-50K**.

The first rear sprocket **50A** preferably includes at least one shift assist projection **54**. The shift assist projection **54** catches the chain prior to sprocket teeth of the first sprocket **50A** when the rear derailleur **33** moves the chain from the second rear sprocket **50B** to the first rear sprocket **50A**. For example, the first rear sprocket **50A** includes two shift assist projections **54**. The two shift assist projections **54** are provided on the outer peripheral portion of the first rear sprocket **50A** on the side of the second rear sprocket **50B**. The two shift assist projections **54** are disposed at a predetermined interval around the rear hub shaft **35** (in a circumferential direction).

The axial thickness **T1** of each of the first to the eleventh rear sprockets **50A-50K** is 1.6 mm. The axial length **L1** of each space between the axially adjacent rear sprockets is 2.18 mm. The total axial length **TL1** between the first rear sprocket **50A** and the eleventh rear sprocket **50K** is 39.4 mm. The total axial length **TL1** represents a distance between a surface of the first rear sprocket **50A** on an opposite side of the second rear sprocket **50B** and a surface of the eleventh rear sprocket **50K** on an opposite side to the tenth rear sprocket **50J**.

The first rear sprocket **50A** has a first tooth number (an example of a second tooth number). The first tooth number is more than or equal to forty-four. In the embodiment, for example, the first tooth number is forty-four that is the largest tooth number.

The second rear sprocket **50B** has a second tooth number. The second tooth number is thirty eight. The third rear sprocket **50C** has a third tooth number. The third tooth number is thirty two. The fourth rear sprocket **50D** has a fourth tooth number. The fourth tooth number is twenty seven. The fifth rear sprocket **50E** has a fifth tooth number. The fifth tooth number is twenty three. The sixth rear sprocket **50F** has a sixth tooth number. The sixth tooth number is twenty. The seventh rear sprocket **50G** has a seventh tooth number. The seventh tooth number is seventeen. The eighth rear sprocket **50H** has an eighth tooth number. The eighth tooth number is fifteen. The ninth rear sprocket **50I** has a ninth tooth number. The ninth tooth number is thirteen. The tenth rear sprocket **50J** has a tenth tooth number. The tenth tooth number is eleven.

The eleventh rear sprocket **50K** has an eleventh tooth number (an example of a first tooth number). The eleventh tooth number is less than or equal to ten. Specifically, the eleventh tooth number is less than or equal to nine. In the embodiment, for example, the eleventh tooth number is nine that is the smallest tooth number.

#### Second Embodiment

A configuration of a bicycle employing a second embodiment according to the present invention is substantially identical to that of the first embodiment except for a configuration of a rear sprocket assembly **150**. For this reason, in the second embodiment, the rear sprocket assembly **150** will be described in detail and explanation of the other configuration will be omitted. The configurations omitted herein conform to the configuration according to the first embodiment. The same configurations as those in the first embodiment have the same reference numerals.

As shown in FIGS. **2** and **5**, the rear sprocket assembly **150** is configured to be mounted on the rear hub assembly **29**. The rear sprocket assembly **150** has a rotational central axis. The rotational central axis corresponds to the rear hub shaft **35** or the shaft center **C** of the rear hub shaft **35**.

The rear sprocket assembly **150** is attached to the first tubular member **41** (the first body portion **41a**) and the second tubular member **43** (the second body portion **43a**). The rear sprocket assembly **150** has a plurality of rear sprockets **150A-150G**.

The first to sixth rear sprockets **150A-150F** are disposed on the outer peripheral portion of the first tubular member **41** in an axial direction parallel to the shaft center **C** of the rear hub shaft **35**. The first rear sprocket **150A** is disposed on the outer peripheral portion of the first tubular member **41** at the rear hub shell **37** side. The first to sixth rear sprockets **150A-150F** are arranged on the outer peripheral portion of the first tubular member **41** by the same spline coupling as that in the first embodiment.

The seventh rear sprockets **150G** are disposed on the outer peripheral portion of the second tubular member **43** in an axial direction parallel to the shaft center **C** of the rear hub shaft **35**. The seventh rear sprocket **150G** is disposed on the outer peripheral portion of the second tubular member **43** so as to be adjacent to the sixth rear sprocket **150F** at the most distant position from the first rear sprocket **150A** in the axial direction. The seventh rear sprocket **150G** is arranged on the outer peripheral portion of the second tubular member **43** by the same spline coupling as that in the first embodiment.

The first rear sprocket **150A** is an example of a second sprocket. The second to sixth rear sprockets **150F** are an example of five additional sprockets. The seventh rear sprocket **150G** is an example of a first sprocket.

In the second embodiment, the first tubular member **41** is formed so as to be shorter than that of the first embodiment in the axial direction. The second tubular member **43** is formed so as to be shorter than that of the first embodiment in the axial direction. Total number of the first to sixth rear sprockets **150A-150F** is smaller than total number of the first to ninth rear sprockets **50A-50I** in the first embodiment. Also, number of the seventh rear sprocket **150G** is smaller than number of the tenth and eleventh rear sprockets **50J, 50K** in the first embodiment.

Layouts of the first to seventh rear sprockets **150A-150G** will be described below in detail. The first to seventh rear sprockets **150A-150G** are arranged on the first tubular member **41** in alphabetical order.

Specifically, the second to sixth rear sprockets **150B-150F** are positioned between the first rear sprocket **150A** and the seventh rear sprocket **150G** in the axial direction parallel to the shaft center **C** of the rear hub shaft **35**.

The second rear sprocket **150B** is positioned between the first rear sprocket **150A** and the third rear sprocket **150C** in the axial direction. The third rear sprocket **150C** is positioned between the second rear sprocket **150B** and the fourth rear sprocket **150D** in the axial direction. The fourth rear sprocket **150D** is positioned between the third rear sprocket **150C** and the fifth rear sprocket **150E** in the axial direction. The fifth rear sprocket **150E** is positioned between the fourth rear sprocket **150D** and the sixth rear sprocket **150F** in the axial direction. The sixth rear sprocket **150F** is positioned between the fifth rear sprocket **150E** and the seventh rear sprocket **150G** in the axial direction.

In other words, the sixth rear sprocket **150F** is positioned between the first rear sprocket **150A** and the seventh rear sprocket **150G** in the axial direction. The second rear sprocket **150B** is positioned between the first rear sprocket **150A** and the sixth rear sprocket **150F** in the axial direction. The fifth rear sprocket **150E** is positioned between the second rear sprocket **150B** and the sixth rear sprocket **150F** in the axial direction. The third rear sprocket **150C** is positioned between the second rear sprocket **150B** and the fifth rear sprocket **150E** in the axial direction. The fourth rear sprocket **150D** is positioned between the third rear sprocket **150C** and the fifth rear sprocket **150E** in the axial direction.

Finally, a configuration and a tooth combination of the first to seventh rear sprockets **150A-150G** will be described in detail. A root circle diameter of the first rear sprocket **150A** is the largest in the first to seventh rear sprockets **150A-150G**. Root circle diameters of the second to sixth sprockets **150B-150F** are gradually reduced in order of the second to sixth sprockets **150B-150F**. A root circle diameter of the seventh sprocket **150G** is the smallest in the first to seventh rear sprockets **150A-150G**.

The first rear sprocket **150A** preferably includes at least one shift assist projection **154**. For example, the first rear sprocket **150A** includes two shift assist projections **154**. The two shift assist projections **154** are provided on the outer peripheral portion of the first rear sprocket **150A**. The two shift assist projections **154** are disposed at a predetermined interval around the rear hub shaft **35** (in a circumferential direction).

The axial thickness **T2** of each of the first to the seventh rear sprockets **150A-150G** is 1.6 mm. The axial length **L2** of each space between the axially adjacent rear sprockets is 2.18 mm. The total axial length **TL2** between the first rear sprocket **150A** and the seventh rear sprocket **150G** is 24.28 mm. The total axial length **TL2** represents a distance between a surface of the first rear sprocket **150A** on an



opposite side to the second rear sprocket **150B** and a surface of the seventh rear sprocket **150G** on an opposite side to the sixth rear sprocket **150F**.

The first rear sprocket **150A** has a first tooth number (an example of a second tooth number). The first tooth number is more than or equal to forty-four. In the embodiment, for example, the first tooth number is forty-six that is the largest tooth number.

The second rear sprocket **150B** has a second tooth number. The second tooth number is thirty six. The third rear sprocket **150C** has a third tooth number. The third tooth number is twenty eight. The fourth rear sprocket **150D** has a fourth tooth number. The fourth tooth number is twenty two. The fifth rear sprocket **150E** has a fifth tooth number. The fifth tooth number is seventeen. The sixth rear sprocket **150F** has a sixth tooth number. The sixth tooth number is thirteen.

The seventh rear sprocket **150G** has a seventh tooth number (an example of a first tooth number). The seventh tooth number is less than or equal to ten. In the embodiment, for example, the seventh tooth number is ten that is the smallest tooth number.

#### Third Embodiment

A configuration of a bicycle employing a third embodiment according to the present invention is substantially identical to that of the first embodiment except for a configuration of a rear sprocket assembly **250**. Moreover, the configuration of the rear sprocket assembly **250** is substantially identical to that of the second embodiment except for configuration of rear sprockets **250A-250G**.

For this reason, in the third embodiment, layouts of the rear sprockets **250A-250G** will be described in detail and explanation of the other configuration will be omitted. The configurations omitted herein conform to the configuration according to the first and second embodiments. The same configurations as those in the first and second embodiments have the same reference numerals.

As shown in FIG. 2 and FIG. 6, the rear sprocket assembly **250** is attached to the first tubular member **41** (the first body portion **41a**) and the second tubular member **43** (the second body portion **43a**). The rear sprocket assembly **250** has a plurality of rear sprockets **250A-250G**.

The first to sixth rear sprockets **150A-150F** are disposed on the outer peripheral portion of the first tubular member **41** in the same manner as the second embodiment. The seventh rear sprocket **150G** is disposed on the outer peripheral portion of the second tubular member **43** in the same manner as the second embodiment.

The first to seventh rear sprockets **150A-150G** is arranged respectively on the outer peripheral portions of the first and second tubular member **41**, **43** by the same spline coupling as that in the first embodiment.

A root circle diameter of the first rear sprocket **250A** is the largest in the first to seventh rear sprockets **250A-250G**. Root circle diameters of the second to sixth sprockets **250B-250F** are gradually reduced in order of the second to sixth sprockets **250B-250F**. A root circle diameter of the seventh rear sprocket **250G** is the smallest in the first to seventh rear sprockets **250A-250G**.

The first rear sprocket **250A** preferably includes at least one shift assist projection **254**. For example, the first rear sprocket **250A** includes two shift assist projections **254**. The two shift assist projections **254** are provided on the outer peripheral portion of the first rear sprocket **250A**. The two

shift assist projections **254** are disposed at a predetermined interval around the rear hub shaft **35** (in a circumferential direction).

The axial thickness **T3** of each of the first to the seventh rear sprockets **250A-250G** is 1.6 mm. The axial length **L3** of each space between the axially adjacent rear sprockets is 2.18 mm. The total axial length **TL3** between the first rear sprocket **250A** and the eleventh rear sprocket **250K** is 24.28 mm. The total axial length **TL3** represents a distance between a surface of the first rear sprocket **250A** on an opposite side to the second rear sprocket **250B** and a surface of the seventh rear sprocket **250G** on an opposite side to the sixth rear sprocket **250F**.

The first rear sprocket **250A** has a first tooth number (an example of a second tooth number). The first tooth number is more than or equal to forty-four. In the embodiment, for example, the first tooth number is fifty that is the largest tooth number.

The second rear sprocket **250B** has a second tooth number. The second tooth number is thirty eight. The third rear sprocket **250C** has a third tooth number. The third tooth number is twenty nine. The fourth rear sprocket **250D** has a fourth tooth number. The fourth tooth number is twenty two. The fifth rear sprocket **250E** has a fifth tooth number. The fifth tooth number is seventeen. The sixth rear sprocket **250F** has a sixth tooth number. The sixth tooth number is thirteen.

The seventh rear sprocket **250G** has a seventh tooth number (an example of a first tooth number). The seventh tooth number is less than or equal to ten. In the embodiment, for example, the seventh tooth number is ten that is the smallest tooth number.

#### Fourth Embodiment

A configuration of a bicycle employing a fourth embodiment according to the present invention is substantially identical to that of the first embodiment except for a configuration of a rear sprocket assembly **350**. For this reason, in the fourth embodiment, the rear sprocket assembly **350** will be described in detail and explanation of the other configuration will be omitted. The configurations omitted herein conform to the configuration according to the first embodiment. The same configurations as those in the first embodiment have the same reference numerals.

As shown in FIGS. 2 and 7, the rear sprocket assembly **350** is configured to be mounted on the rear hub assembly **29**. The rear sprocket assembly **350** has a rotational central axis. The rotational central axis corresponds to the rear hub shaft **35** or a shaft center **C** of the rear hub shaft **35**.

The rear sprocket assembly **350** is attached to a first tubular member **41** and a second tubular member **43**. The rear sprocket assembly **350** has a plurality of rear sprockets **350A-350L**.

For example, the rear sprocket assembly **350** has a first rear sprocket assembly **351** and a second rear sprocket assembly **352**.

The first rear sprocket assembly **351** is attached to the first tubular member **41** (the first body portion **41a**). The first rear sprocket assembly **351** has first to ninth rear sprockets **350A-350I**. The first to ninth rear sprockets **350A-350I** are arranged on the outer peripheral portion of the first tubular member **41** in an axial direction parallel to the shaft center **C** of the rear hub shaft **35**. The first rear sprocket **350A** is disposed on the outer peripheral portion of the first tubular member **41** at a rear hub shell **37** side. The first to ninth rear sprockets **350A-350I** are arranged on the outer peripheral

portion of the first tubular member **41** by the same spline coupling as that in the first embodiment.

The second rear sprocket assembly **352** is attached to the second tubular member **43** (the second body portion **43a**). The second rear sprocket assembly **352** has tenth to twelfth rear sprockets **350J-350L**. The tenth to twelfth rear sprockets **350J-350L** are arranged on the outer peripheral portion of the second tubular member **43** in the axial direction parallel to the shaft center C of the rear hub shaft **35**. The tenth rear sprocket **350J** is disposed on the outer peripheral portion of the second tubular member **43** so as to be adjacent to the ninth rear sprocket **350I** in the axial direction. The eleventh rear sprocket **350K** is disposed on the outer peripheral portion of the second tubular member **43** so as to be adjacent to the tenth rear sprocket **350J** in the axial direction. The twelfth rear sprocket **350L** is disposed on the outer peripheral portion of the second tubular member **43** so as to be adjacent to the eleventh rear sprocket **350K** at the most distant position from the first rear sprocket **350A** in the axial direction.

The first rear sprocket **350A** is an example of a second sprocket. The second to eleventh rear sprockets **350B-350K** are an example of at least five additional sprockets, and at least eight additional rear sprockets. The twelfth rear sprocket **350L** is an example of a first sprocket.

Layouts of the first to twelfth rear sprockets **350A-350L** will be described below in detail. The first to twelfth rear sprockets **350A-350L** are arranged on the first tubular member **41** and the second tubular member **43** in alphabetical order.

Specifically, the second to eleventh rear sprockets **350B-350K** are positioned between the first rear sprocket **350A** and the twelfth rear sprocket **350L** in the axial direction parallel to the shaft center C of the rear hub shaft **35**. The second rear sprocket **350B** is positioned between the first rear sprocket **350A** and the third rear sprocket **350C** in the axial direction. The third rear sprocket **350C** is positioned between the second rear sprocket **350B** and the fourth rear sprocket **350D** in the axial direction. The fourth rear sprocket **350D** is positioned between the third rear sprocket **350C** and the fifth rear sprocket **350E** in the axial direction. The fifth rear sprocket **350E** is positioned between the fourth rear sprocket **350D** and the sixth rear sprocket **350F** in the axial direction.

The sixth rear sprocket **350F** is positioned between the fifth rear sprocket **350E** and the seventh rear sprocket **350G** in the axial direction. The seventh rear sprocket **350G** is positioned between the sixth rear sprocket **350F** and the eighth rear sprocket **350H** in the axial direction. The eighth rear sprocket **350H** is positioned between the seventh rear sprocket **350G** and the ninth rear sprocket **350I** in the axial direction. The ninth rear sprocket **350I** is positioned between the eighth rear sprocket **350H** and the tenth rear sprocket **350J** in the axial direction. The tenth rear sprocket **350J** is positioned between the ninth rear sprocket **350I** and the eleventh rear sprocket **350K** in the axial direction. The eleventh rear sprocket **350K** is positioned between the tenth rear sprocket **350J** and the twelfth rear sprocket **350L** in the axial direction.

In other words, the second rear sprocket **350B** (an example of a fourth sprocket) is positioned between the first rear sprocket **350A** (an example of a second sprocket) and the eleventh rear sprocket **350K** (an example of a third sprocket) in the axial direction. The third rear sprocket **350C** (an example of a sixth sprocket) is positioned between the second rear sprocket **350B** (an example of a fourth sprocket) and the tenth rear sprocket **350J** (an example of a fifth

sprocket) in the axial direction. The fourth rear sprocket **350D** (an example of an eighth sprocket) is positioned between the third rear sprocket **350C** (an example of a sixth sprocket) and the ninth rear sprocket **350I** (an example of a seventh sprocket) in the axial direction. The fifth rear sprocket **350E** (an example of a tenth sprocket) is positioned between the fourth rear sprocket **350D** (an example of an eighth sprocket) and the eighth rear sprocket **350H** (an example of a ninth sprocket) in the axial direction.

The sixth rear sprocket **350F** (an example of a twelfth sprocket) is positioned between the fifth rear sprocket **350E** (an example of a tenth sprocket) and the seventh rear sprocket **350G** (an example of an eleventh sprocket) in the axial direction. The seventh rear sprocket **350G** (an example of an eleventh sprocket) is positioned between the fifth rear sprocket **350E** (an example of a tenth sprocket) and the eighth rear sprocket **350H** (an example of a ninth sprocket) in the axial direction. The eighth rear sprocket **350H** (an example of a ninth sprocket) is positioned between the fourth rear sprocket **350D** (an example of an eighth sprocket) and the ninth rear sprocket **350I** (an example of a seventh sprocket) in the axial direction. The ninth rear sprocket **350I** (an example of a seventh sprocket) is positioned between the third rear sprocket **350C** (an example of a sixth sprocket) and the tenth rear sprocket **350J** (an example of a fifth sprocket) in the axial direction. The tenth rear sprocket **350J** (an example of a fifth sprocket) is positioned between the second rear sprocket **350B** (an example of a fourth sprocket) and the eleventh rear sprocket **350K** (an example of a third sprocket) in the axial direction. The eleventh rear sprocket **350K** (an example of a third sprocket) is positioned between the first rear sprocket **350A** (an example of a second sprocket) and the twelfth rear sprocket **350L** (an example of a first sprocket) in the axial direction.

Finally, a configuration of the first to twelfth rear sprockets **350A-350L** will be described in detail. A root circle diameter of the first rear sprocket **350A** is the largest in the first to twelfth rear sprockets **350A-350L**. Root circle diameters of the second to eleventh sprockets **350B-350K** are gradually reduced in order of the second to eleventh sprockets **350B-350K**. A root circle diameter of the twelfth sprocket **350L** is the smallest in the first to twelfth rear sprockets **350A-350L**.

The first rear sprocket **350A** preferably includes at least one shift assist projection **354**. For example, the first rear sprocket **350A** includes two shift assist projections **354**. The two shift assist projections **354** are provided on the outer peripheral portion of the first rear sprocket **350A**. The two shift assist projections **354** are disposed at a predetermined interval around the rear hub shaft **35** (in a circumferential direction).

The axial thickness T4 of each of the first to the twelfth rear sprockets **350A-350L** is 1.6 mm. The axial length L4 of each space between the axially adjacent rear sprockets is 2.2 mm. The total axial length TL4 between the first rear sprocket **350A** and the twelfth rear sprocket **350L** is 43.4 mm. The total axial length TL4 represents a distance between a surface of the first rear sprocket **350A** on an opposite side to the second rear sprocket **350B** and a surface of the twelfth rear sprocket **350L** on an opposite side to the eleventh rear sprocket **350K**.

The first rear sprocket **350A** has a first tooth number (an example of a second tooth number). The first tooth number is more than or equal to forty-four. In the embodiment, for example, the first tooth number is fifty that is the largest tooth number.

The second rear sprocket **350B** has a second tooth number. The second tooth number is forty four. The third rear sprocket **350C** has a third tooth number. The third tooth number is thirty eight. The fourth rear sprocket **350D** has a fourth tooth number. The fourth tooth number is thirty three. The fifth rear sprocket **350E** has a fifth tooth number. The fifth tooth number is twenty eight. The sixth rear sprocket **350F** has a sixth tooth number. The sixth tooth number is twenty four. The seventh rear sprocket **350G** has a seventh tooth number. The seventh tooth number is twenty one. The eighth rear sprocket **350H** has an eighth tooth number. The eighth tooth number is eighteen. The ninth rear sprocket **350I** has a ninth tooth number. The ninth tooth number is sixteen. The tenth rear sprocket **350J** has a tenth tooth number. The tenth tooth number is fourteen. The eleventh rear sprocket **350K** has an eleventh tooth number. The eleventh tooth number is twelve.

The twelfth rear sprocket **350L** has a twelfth tooth number (an example of a first tooth number). The twelfth tooth number is less than or equal to ten. In the embodiment, for example, the twelfth tooth number is ten that is the smallest tooth number.

#### Fifth Embodiment

A configuration of a bicycle employing a fifth embodiment according to the present invention is substantially identical to that of the first embodiment except for a configuration of a rear sprocket assembly **450**. For this reason, in the fifth embodiment, the rear sprocket assembly **450** will be described in detail and explanation of the other configuration will be omitted. The configurations omitted herein conform to the configuration according to the first embodiment. The same configurations as those in the first embodiment have the same reference numerals.

As shown in FIGS. **2** and **8**, the rear sprocket assembly **450** is configured to be mounted on the rear hub assembly **29**. The rear sprocket assembly **450** has a rotational central axis. The rotational central axis corresponds to the rear hub shaft **35** or a shaft center C of the rear hub shaft **35**.

The rear sprocket assembly **450** is attached to a first tubular member **41** and a second tubular member **43**. The rear sprocket assembly **450** has a plurality of rear sprockets **450A-450L**.

For example, the rear sprocket assembly **450** has a first rear sprocket assembly **451** and a second rear sprocket assembly **452**.

The first rear sprocket assembly **451** is attached to the first tubular member **41** (the first body portion **41a**). The first rear sprocket assembly **451** has first to ninth rear sprockets **450A-450I**. The first to ninth rear sprockets **450A-450I** are arranged on the outer peripheral portion of the first tubular member **41** in an axial direction parallel to the shaft center C of the rear hub shaft **35**. The first rear sprocket **450A** is disposed on the outer peripheral portion of the first tubular member **41** at a rear hub shell **37** side. The first to ninth rear sprockets **450A-450I** are arranged on the outer peripheral portion of the first tubular member **41** by the same spline coupling as that in the first embodiment.

The second rear sprocket assembly **452** is attached to the second tubular member **43** (the second body portion **43a**). The second rear sprocket assembly **452** has tenth to twelfth rear sprockets **450J-450L**. The tenth to twelfth rear sprockets **450J-450L** are arranged on the outer peripheral portion of the second tubular member **43** in the axial direction parallel to the shaft center C of the rear hub shaft **35**. The tenth rear sprocket **450J** is disposed on the outer peripheral portion of

the second tubular member **43** so as to be adjacent to the ninth rear sprocket **450I** in the axial direction. The eleventh rear sprocket **450K** is disposed on the outer peripheral portion of the second tubular member **43** so as to be adjacent to the tenth rear sprocket **450J** in the axial direction. The twelfth rear sprocket **450L** is disposed on the outer peripheral portion of the second tubular member **43** so as to be adjacent to the eleventh rear sprocket **450K** at the most distant position from the first rear sprocket **450A** in the axial direction.

The first rear sprocket **450A** is an example of a second sprocket. The second to eleventh rear sprockets **450B-450K** are an example of at least five additional sprockets, and at least eight additional rear sprockets. The twelfth rear sprocket **450L** is an example of a first sprocket.

Layouts of the first to twelfth rear sprockets **450A-450L** will be described below in detail. The first to twelfth rear sprockets **450A-450L** are arranged on the first tubular member **41** and the second tubular member **43** in alphabetical order.

Specifically, the second to eleventh rear sprockets **450B-450K** are positioned between the first rear sprocket **450A** and the twelfth rear sprocket **450L** in the axial direction parallel to the shaft center C of the rear hub shaft **35**. The second rear sprocket **450B** is positioned between the first rear sprocket **450A** and the third rear sprocket **450C** in the axial direction. The third rear sprocket **450C** is positioned between the second rear sprocket **450B** and the fourth rear sprocket **450D** in the axial direction. The fourth rear sprocket **450D** is positioned between the third rear sprocket **450C** and the fifth rear sprocket **450E** in the axial direction. The fifth rear sprocket **450E** is positioned between the fourth rear sprocket **450D** and the sixth rear sprocket **450F** in the axial direction.

The sixth rear sprocket **450F** is positioned between the fifth rear sprocket **450E** and the seventh rear sprocket **450G** in the axial direction. The seventh rear sprocket **450G** is positioned between the sixth rear sprocket **450F** and the eighth rear sprocket **450H** in the axial direction. The eighth rear sprocket **450H** is positioned between the seventh rear sprocket **450G** and the ninth rear sprocket **450I** in the axial direction. The ninth rear sprocket **450I** is positioned between the eighth rear sprocket **450H** and the tenth rear sprocket **450J** in the axial direction. The tenth rear sprocket **450J** is positioned between the ninth rear sprocket **450I** and the eleventh rear sprocket **450K** in the axial direction. The eleventh rear sprocket **450K** is positioned between the tenth rear sprocket **450J** and the twelfth rear sprocket **450L** in the axial direction.

In other words, the second rear sprocket **450B** (an example of a fourth sprocket) is positioned between the first rear sprocket **450A** (an example of a second sprocket) and the eleventh rear sprocket **450K** (an example of a third sprocket) in the axial direction. The third rear sprocket **450C** (an example of a sixth sprocket) is positioned between the second rear sprocket **450B** (an example of a fourth sprocket) and the tenth rear sprocket **450J** (an example of a fifth sprocket) in the axial direction. The fourth rear sprocket **450D** (an example of an eighth sprocket) is positioned between the third rear sprocket **450C** (an example of a sixth sprocket) and the ninth rear sprocket **450I** (an example of a seventh sprocket) in the axial direction. The fifth rear sprocket **450E** (an example of a tenth sprocket) is positioned between the fourth rear sprocket **450D** (an example of an eighth sprocket) and the eighth rear sprocket **450H** (an example of a ninth sprocket) in the axial direction.

The sixth rear sprocket **450F** (an example of a twelfth sprocket) is positioned between the fifth rear sprocket **450E** (an example of a tenth sprocket) and the seventh rear sprocket **450G** (an example of an eleventh sprocket) in the axial direction. The seventh rear sprocket **450G** (an example of an eleventh sprocket) is positioned between the fifth rear sprocket **450E** (an example of a tenth sprocket) and the eighth rear sprocket **450H** (an example of a ninth sprocket) in the axial direction. The eighth rear sprocket **450H** (an example of a ninth sprocket) is positioned between the fourth rear sprocket **450D** (an example of an eighth sprocket) and the ninth rear sprocket **450I** (an example of a seventh sprocket) in the axial direction. The ninth rear sprocket **450I** (an example of a seventh sprocket) is positioned between the third rear sprocket **450C** (an example of a sixth sprocket) and the tenth rear sprocket **450J** (an example of a fifth sprocket) in the axial direction. The tenth rear sprocket **450J** (an example of a fifth sprocket) is positioned between the second rear sprocket **450B** (an example of a fourth sprocket) and the eleventh rear sprocket **450K** (an example of a third sprocket) in the axial direction. The eleventh rear sprocket **450K** (an example of a third sprocket) is positioned between the first rear sprocket **450A** (an example of a second sprocket) and the twelfth rear sprocket **450L** (an example of a first sprocket) in the axial direction.

Finally, a configuration of the first to twelfth rear sprockets **450A-450L** will be described in detail. A root circle diameter of the first rear sprocket **450A** is the largest in the first to twelfth rear sprockets **450A-450L**. Root circle diameters of the second to eleventh sprockets **450B-450K** are gradually reduced in order of the second to eleventh sprockets **450B-450K**. A root circle diameter of the twelfth sprocket **450L** is the smallest in the first to twelfth rear sprockets **450A-450L**.

The first rear sprocket **450A** preferably includes at least one shift assist projection (not shown). For example, the first rear sprocket **450A** may include six shift assist projections. The six shift assist projections are provided on the outer peripheral portion of the first rear sprocket **450A**. The six shift assist projections are disposed at a predetermined interval around the rear hub shaft **35** (in a circumferential direction).

The axial thickness **T4** of each of the first to the twelfth rear sprockets **450A-450L** is 1.6 mm. The axial length **L4** of each space between the axially adjacent rear sprockets is 2.2 mm. The total axial length **TL4** between the first rear sprocket **450A** and the twelfth rear sprocket **450L** is 43.4 mm. The total axial length **TL4** represents a distance between a surface of the first rear sprocket **450A** on an opposite side to the second rear sprocket **450B** and a surface of the twelfth rear sprocket **450L** on an opposite side to the eleventh rear sprocket **450K**.

The first rear sprocket **450A** has a first tooth number (an example of a second tooth number). The first tooth number is more than or equal to forty-eight. In the embodiment, for example, the first tooth number is forty-eight that is the largest tooth number.

The second rear sprocket **450B** has a second tooth number. The second tooth number is forty-two. The third rear sprocket **450C** has a third tooth number. The third tooth number is thirty-six. The fourth rear sprocket **450D** has a fourth tooth number. The fourth tooth number is thirty-two. The fifth rear sprocket **450E** has a fifth tooth number. The fifth tooth number is twenty eight. The sixth rear sprocket **450F** has a sixth tooth number. The sixth tooth number is twenty four. The seventh rear sprocket **450G** has a seventh

tooth number. The seventh tooth number is twenty one. The eighth rear sprocket **450H** has an eighth tooth number. The eighth tooth number is eighteen. The ninth rear sprocket **450I** has a ninth tooth number. The ninth tooth number is sixteen. The tenth rear sprocket **450J** has a tenth tooth number. The tenth tooth number is fourteen. The eleventh rear sprocket **450K** has an eleventh tooth number. The eleventh tooth number is twelve.

The twelfth rear sprocket **450L** has a twelfth tooth number (an example of a first tooth number). The twelfth tooth number is less than or equal to ten. In the embodiment, for example, the twelfth tooth number is ten that is the smallest tooth number.

#### Other Embodiments

(a) In the first to fifth embodiments, the description has been given to the example of the case in which the present invention is applied to a bicycle of a road type. Instead of this, the present invention can be applied to a mountain bike and/or a city cycle etc.

(b) In the first to fifth embodiments, the description has been given to the example of the case in which a plurality of rear sprockets is attached to the first tubular member **41** and one, two or three rear sprockets are disposed in the second tubular member **43**. The numbers of the rear sprockets to be disposed in the first tubular member **41** and the second tubular member **43** are not restricted to the first to fourth embodiments but can be set optionally.

(c) In the first to fifth embodiments, the second tubular member **43** is provided separately from the first tubular member **41**. Instead of this, the second tubular member **43** may be formed integrally with the first tubular member **41**.

(d) In the first to fifth embodiments, the description has been given to the example of the case in which the front sprocket assembly **27b** has two front sprockets. The numbers of the front sprockets are not restricted to the first to fourth embodiments but can be set optionally such as one sprocket or three sprockets.

(e) Although the first sprockets **50A**, **150A**, **250A**, **350A** and **450A** illustrated in the first to fifth embodiments include the shift assist projections **54**, **154**, **254** **354** respectively, the shift assist projections can be omitted from the first sprocket in the first, fourth and fifth embodiment since the difference between the first tooth number and the tooth number of the adjacent sprocket is not so large in comparison with the second and third embodiments. The shift assist projections **154** and **254** can also be omitted from the first sprockets **150A** and **250A** according to need.

(f) Although the shift assist projection **54**, **154**, **254** **354** is provided to the first sprocket **50A**, **150A**, **250A**, and **350A** only in the first to fifth embodiments, such a shift assist projection **54**, **154**, **254** **354** can also be provided to the other sprocket according to need.

In understanding the scope of the present invention, 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. The foregoing also applies to words having similar meanings such as the terms, "including", "having" and their derivatives. Also, the terms "part," "section," "portion," "member" or "element" when used in the singular can have the dual meaning of a single part or a plurality of parts unless otherwise stated.

As used herein, the following directional terms “frame facing side”, “non-frame facing side”, “forward”, “rearward”, “front”, “rear”, “up”, “down”, “above”, “below”, “upward”, “downward”, “top”, “bottom”, “side”, “vertical”, “horizontal”, “perpendicular” and “transverse” as well as 5 any other similar directional terms refer to those directions of a bicycle in an upright, riding position and equipped with the multiple bicycle sprocket assembly. Accordingly, these directional terms, as utilized to describe the multiple bicycle sprocket assembly should be interpreted relative to a bicycle in an upright riding position on a horizontal surface and that is equipped with the multiple bicycle sprocket assembly. The terms “left” and “right” are used to indicate the “right” when referencing from the right side as viewed from the rear of the bicycle, and the “left” when referencing from the left side as viewed from the rear of the bicycle.

Also it will be understood that although the terms “first” and “second” may be used herein to describe various components these components should not be limited by these terms. These terms are only used to distinguish one component from another. Thus, for example, a first component discussed above could be termed a second component and vice versa without departing from the teachings of the present invention. The term “attached” or “attaching”, as used herein, encompasses configurations in which an element is directly secured to another element by affixing the element directly to the other element; configurations in which the element is indirectly secured to the other element by affixing the element to the intermediate member(s) which in turn are affixed to the other element; and configurations in which one element is integral with another element, i.e. one element is essentially part of the other element. This definition also applies to words of similar meaning, for example, “joined”, “connected”, “coupled”, “mounted”, “bonded”, “fixed” and their derivatives. Finally, terms of degree such as “substantially”, “about” and “approximately” as used herein mean an amount of deviation of the modified term such that the end result is not significantly changed.

While only selected embodiments have been chosen to illustrate the present invention, it will be apparent to those skilled in the art from this disclosure that various changes and modifications can be made herein without departing from the scope of the invention as defined in the appended claims. For example, unless specifically stated otherwise, the size, shape, location or orientation of the various components can be changed as needed and/or desired so long as the changes do not substantially affect their intended function. Unless specifically stated otherwise, components that are shown directly connected or contacting each other can have intermediate structures disposed between them so long as the changes do not substantially affect their intended function. The functions of one element can be performed by two, and vice versa unless specifically stated otherwise. The structures and functions of one embodiment can be adopted in another embodiment. It is not necessary for all advantages to be present in a particular embodiment at the same time. Every feature which is unique from the prior art, alone or in combination with other features, also should be considered a separate description of further inventions by the applicant,

including the structural and/or functional concepts embodied by such feature(s). Thus, the foregoing descriptions of the embodiments according to the present invention are provided for illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

What is claimed is:

1. A multiple bicycle sprocket assembly having a rotational central axis and configured to be mounted on a bicycle hub assembly, the multiple bicycle sprocket assembly comprising:

a first sprocket having a total first tooth number that is less than or equal to ten;

a second sprocket having a total second tooth number that is more than or equal to forty-four;

a third sprocket having a third tooth number that is twelve, the third sprocket being positioned between the first sprocket and the second sprocket in an axial direction parallel to the rotational central axis;

a fourth sprocket having a fourth tooth number, the fourth sprocket being positioned between the second sprocket and the third sprocket in the axial direction;

a fifth sprocket having a fifth tooth number that is fourteen, the fifth sprocket being positioned between the third sprocket and the fourth sprocket in the axial direction;

a sixth sprocket having a sixth tooth number, the sixth sprocket being positioned between the fourth sprocket and the fifth sprocket in the axial direction;

a seventh sprocket having a seventh tooth number that is sixteen, the seventh sprocket being positioned between the fifth sprocket and the sixth sprocket in the axial direction;

an eighth sprocket having an eighth tooth number, the eighth sprocket being positioned between the sixth sprocket and the seventh sprocket in the axial direction;

a ninth sprocket having a ninth tooth number that is eighteen, the ninth sprocket being positioned between the seventh sprocket and the eighth sprocket in the axial direction;

a tenth sprocket having a tenth tooth number that is twenty-eight, the tenth sprocket being positioned between the eighth sprocket and the ninth sprocket in the axial direction;

an eleventh sprocket having an eleventh tooth number that is twenty-one, the eleventh sprocket being positioned between the ninth sprocket and the tenth sprocket in the axial direction; and

a twelfth sprocket having a twelfth tooth number that is twenty-four, the twelfth sprocket being positioned between the tenth sprocket and the eleventh sprocket in the axial direction,

the total sprocket number being twelve.

2. The multiple bicycle sprocket assembly according to claim 1, wherein

the fourth tooth number is forty-two;

the sixth tooth number is thirty-six; and

the eighth tooth number is thirty-two.

\* \* \* \* \*