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(54) A MULTI-SPEED FREEWHEEL FOR A BICYCLE

(71) We SHIMANO INDUSTRIAL COMPANY LIMITED, a Corporation organized and existing under the laws of Japan, of 77, 3-cho, Oimatsu-cho, Sakai-shi, Osaka, Japan,

do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a multi-speed freewheel capable of being mounted on a wheel hub of a bicycle.

One known type of multi-speed freewheel capable of being mounted on the hub of a bicycle comprises a cylindrical inner member which can be fixed to a bicycle wheel hub, an outer member mounted upon the inner member by means of a unidirectional transmission assembly such that when the outer member is rotated in one direction relative to the inner member, the transmission assembly will transmit torque from the outer member to the inner, but that when the outer member is rotated in the opposed direction relative to the inner member, the transmission assembly will allow the outer member to rotate freely about the inner member, and a plurality of sprockets mounted on the outer member and spaced at regular intervals.

One known five-speed freewheel of this type is shown in Figure 13 of the accompanying drawings. The outer member 92 of this freewheel has a first cylindrical portion of large diameter and a second cylindrical portion of smaller diameter. The three largest-diameter sprockets 91*a*, 91*b* and 91*c* have central apertures provided with splines and are mounted on the first portion of the outer member 92; the splines on the sprockets mesh with corresponding splines on this portion of the outer member 92. On the other hand, the two smallest-diameter sprockets 91*d* and 91*e* are provided with screw-threaded central apertures and the threads in these apertures are engaged with a corresponding thread on the second portion of the outer member 92. The engagement between the threads on the two smallest sprockets and the thread on the outer member 92 causes the sprocket 91*d* to hold the three largest-diameter sprockets fixedly in position, the proper spacing between these three sprockets being maintained by spacers 94.

Once the sprockets have been mounted thus on the outer member, it is difficult to remove them therefrom, and the sprockets have to be fixed to the outer member before the outer member is fixed around the inner member and thus secured to the bicycle hub. If one attempts to attach spokes to the flanges conventionally provided for this purpose on the hub after the sprockets are in position, the presence of the largest sprocket 91*a* adjacent the flange on one side of the hub renders it very difficult to insert the spokes into position. Whilst it is possible to design freewheels similar to that shown in Figure 13 of the accompanying drawings in such a manner that the freewheel can be installed after the spokes have been fitted to the hub, it is often desired to employ a freewheel of the so-called "unit" type, in which the inner member is integral with the hub, and in such a case the freewheel has to be assembled before the spokes are fitted. In any case, whether or not the inner member is integral with the hub, it is sometimes necessary to replace a damaged sprocket, or to fit differently-sized sprockets, and whilst it is not impossible to remove sprockets from the freewheel while it is in position on the wheel, the operation does tend to be very difficult and normally requires the use of a special tool. In addition, it will be appreciated that not all the sprockets of the type shown in Figure 13 are interchangable, some being splined and others being threaded and the two groups having differently-sized central apertures. This lack of interchangeability also prevents the order of the sprockets being changed, if this should be desired, for example to accomodate a different type of derailleur for effecting gear changes between the various sprockets.

The present invention seeks to provide a multi-speed freewheel for a bicycle, which freewheel will permit the sprockets to be easily mounted on or removed from the outer member, thereby allowing sprockets to be

changed readily whilst the freewheel is mounted on a bicycle wheel hub.

According to the invention a multi-speed freewheel for a bicycle comprises an inner member capable of being fixedly mounted on or of forming part of a bicycle wheel hub, an outer member mounted on and rotatable around the inner member, an unidirectional transmission mechanism connecting the inner and outer members and arranged to transmit torque from the outer member to the inner member in one direction of rotation of the outer member and to allow the outer member to rotate freely about the inner member in the opposite direction of rotation of the outer member, a sprocket assembly fitted over the outer member as an axially removable unit, said sprocket assembly comprising a plurality of sprockets detachably clamped together as a unit formed with a bore through which the outer member fits, the surface of the bore being formed with spaced configurations engaged with complementary configurations on the outer surface of the outer member such that the sprocket assembly cannot rotate relatively to the outer member but can slide axially thereon, and disengageable retaining means for preventing axial movement of the sprocket assembly on the outer member.

In the multi-speed freewheel of the invention, very desirably the inner and outer members are both substantially cylindrical in form.

The retaining means is conveniently a snap ring.

Preferred embodiments of the invention will now be described, though by way of illustration only, with reference to the accompanying drawings, in which:

Figure 1 is a part cut-away front elevation of a multi-speed freewheel of the invention and of the bicycle hub on which it is mounted;

Figure 2 is a section along the line II—II in Figure 1;

Figure 3 is an enlarged view showing part of the multi-speed freewheel shown in Figure 1;

Figure 4 is a part cut-away front elevation of the outer member of the multi-speed freewheel shown in Figures 1 to 3;

Figure 5 is a section along the line V—V in Figure 4;

Figure 6 is a partially sectional view of the sprocket carrier of the multi-speed freewheel shown in Figures 1 to 5;

Figure 7 is a section along the line VII—VII in Figure 6;

Figure 8 is a side elevation of one of the spacers of the multi-speed freewheel shown in Figures 1 to 7;

Figure 9 is a side elevation of one of the sprockets of the multi-speed freewheel shown in Figures 1 to 8;

Figure 10 is a part cut-away front elevation of a second multi-speed freewheel of the invention and of the bicycle hub on which it is mounted;

Figure 11 is a section along the line XI—XI in Figure 10;

Figure 12 is an enlarged view showing part of the multi-speed freewheel shown in Figures 10 and 11; and

Figure 13 is, as already stated, a partially sectional view of a prior art multi-speed freewheel.

The first multi-speed freewheel of the invention shown in Figures 1 to 9 of the accompanying drawings is of the unit type having its inner member 1 forming part of a bicycle rear wheel hub 7. However, the present invention also embraces multi-speed freewheels having inner members which do not form part of bicycle wheel hubs but which can be fixedly mounted thereon. 2 denotes a substantially cylindrical outer member and 4 denotes a sprocket assembly formed as a unit. The members 1 and 2 are coupled by a uni-directional transmission mechanism (described below).

The rear wheel hub 7 comprises a hub shell 71 having a central aperture 71*a* extending axially therethrough. A threaded shaft 75 passes through the aperture 71*a* and is fixed to the rear forks of a bicycle frame (not shown) by nuts 78 and 79. On to each end of the shaft 75 is screwed a ball-holder 76 or 77 provided with a ball race 76*a* or 77*a*.

The hub shell 71 bears two flanges 72 and 73 adjacent its opposed ends, these two flanges being used for attaching spokes to the hub shell 71. Axially outwardly of the flange 73 is provided a ball-holder 74, which bears on its radially-inward surface a ball race 74*a*. The inner member 1 extends axially outwardly of the hub shell 71 adjacent the flange 72 and bears at its axially-outward end a screw thread (best seen in Figure 3). An internally-threaded ball-holder 12 is screwed on to this thread, and bears on its radially-inward surface a ball race 12*b*. A first set of ball bearings 80 are held between this ball race 12*b* and the ball race 76*a* on the ball-holder 76 attached to the shaft 75, whilst a second set of ball bearings 81 are held between the ball race 74*a* on the ball-holder 74 attached to the hub shell 71 and the ball race 77*a* on the ball-holder 77 attached to the shaft 75. Thus, the two sets of ball bearings 80 and 81 render the hub shell 71 and the inner member 1 freely rotatable together about the shaft 75.

The ball-holder 12 is provided on its radially-outward surface with a ball race 12*a*. At its end remote from the ball-holder 12, the inner member 1 is provided with a ball race 11*a*. Between the two ball races 11*a* and 12*a*, several pawls 13 are mounted on the inner member 1, these pawls 13 being

biased radially-outwardly from the inner member 1 by springs (not shown).

The outer member 2, which encircles the inner member 1, bears on its radially-inward face two ball races 21 and 22, and ratchet teeth 23 are disposed between these two ball races. A third set of ball bearings 14 is held between the ball race 11*a* on the inner member 1 and the ball race 21 on the outer member 2, whilst a fourth set of ball bearings 15 is held between the ball race 12*a* on the ball holder 12 and the ball race 22 on the outer member 2: the two sets of ball bearings 14 and 15 render the outer member 2 rotatable about the axis of the inner member 1. Furthermore, the pawls 13 and the ratchet teeth 23 together constitute a unidirectional transmission assembly such that when the outer member is rotated in one direction (clockwise in Figure 2) relative to the inner member, the pawls 13 will engage the ratchet teeth 23 and torque will be transmitted from the outer member to the inner, but when the outer member is rotated in the opposed direction (anticlockwise in Figure 2) relative to the inner member, the pawls 13 will slide freely over the ratchet teeth 23, thus allowing the outer member to rotate freely about the inner member.

On the racially-outward surface of the outer member 2 are formed a plurality of recesses in the form of grooves 24, each of which is of semi-circular cross-section (as best seen in Figures 2 and 5); these grooves 24 run the whole length of the outer member 2 and are parallel to the axis of the shaft 75. It will be seen from Figure 5 that the grooves 24 are symmetrically disposed around the outer member 2. Furthermore, as best seen in Figure 4, the outer member 2 bears at its axially-inward end a radially-outwardly extending flange 25 and at its opposed end a groove 26, which encircles the outer member 2.

As shown in Figures 1, 3, 6 and 7, the sproket assembly A comprises five sprockets 4 spaced at regular axial intervals by spacers 5. The sprockets 4 each have a cental aperture 40 of the same size, which is sufficiently large to enable the sprockets 4 to be slid around the outer member 2, and the apertures 40 of the various sprockets 4 are held in alignment with one another by a sprocket carrier 3. This sprocket carrier 3, as shown in Figure 6, comprises three elongate support strips 31, each of which is integral at one end with an annular member 32 lying in a plane perpendicular to the support strips 31, which are symmetrically disposed around the periphery of the annular member 32. Adjacent the annular member 32, each support strip 31 is provided with a radially-outwardly extending flange 35, whilst at its opposed end each support strip 31 bears on its radially-inward face a recess 33 and on its radially-outward face a radially-outwardly extending flange 34. (It will be appreciated that the member 32 does not need to be a complete annulus; a substantially "C"-shaped, part-annular member would suffice to support the strips 31).

As shown in Figure 9, in the edge of the central aperture 40 of each sprocket 4 are cut three grooves 41 of substantially rectangular cross-section. Three projections or ribs 42 are also formed on the periphery of the aperture 40 in each sprocket 4; each rib 42 is of semi-circular cross-section and extends axially of the sprocket the whole length of the aperture 40. Both the grooves 41 and the ribs 42 are symmetrically disposed around the aperture 40, the ribs 42 lying midway between each pair of grooves 41.

The sprocket assembly A is assembled as follows. The support strips 31 of the sprocket carrier 3, which are resiliently deformable, are deformed inwardly; sprockets 4 and spacers 5 are then passed alternately over the flanges 34 on the support strips 31 so that the grooves 41 on the sprockets 4 and grooves 51 on the radially-inward surface of the spacers 5 engage the support strips 31. The engagement between the strips 31 and the grooves 41 and 51 prevents the sprockets 4 and the spacers 5 from rotating relative to the carrier 3, whilst the spacers 5 keep the sprockets 4 spaced apart by the correct intervals. The support strips 31 are then allowed to resume their normal positions, whereupon the flanges 34 and 35 prevent the sprockets 4 and the spacers 5 from moving axially along the length of the strips 31. Thereafter, a ring 36 of spring steel is inserted within the free ends of the strips 31 to prevent the strips being inwardly deformed. (The ring 36 need not be a complete annulus; a part-annular member may alternatively be used).

Once the sprocket assembly has been assembled thus, it is slid as a unit around the outer member 2 (which has already been placed around the inner member 1 with the transmission mechanism 13, 23 interposed therebetween) so that the ribs 42 on the sprockets 4 engage the grooves 24 on the outer member 2; the engagement between these ribs and grooves renders the sprocket assembly non-rotatable relative to the outer member. One end of the sprocket assembly A (the left-hand end in Figure 3) co-acts with the flange 25 on the outer member 2, whilst the opposed end of the sprocket assembly A co-acts with a snap ring 8 which is inserted into the groove 26 on the outer member 2 after the sprocket assembly has been placed in position therearound: thus, the sprocket block cannot move axially of the outer member, but can readily be removed therefrom by removing the snap ring 8 and sliding the sprocket assembly axially off the outer member. It will be appreciated that the sprocket

assembly can be placed around the outer member after the spokes of the wheel have been placed in position in the flanges 72 and 73, so that placing of the spokes is not hindered by the presence of the sprockets 4 adjacent the flange 72.

The second multi-speed freewheel of the invention shown in Figures 10 to 12 is generally similar to that shown in Figures 1 to 9, and corresponding parts on the two freewheels are given the same reference numerals. However, the sprocket assembly A of the second freewheel does not incorporate any sprocket carrier 3; instead, the sprockets 4 and the spacers 5 of the sprocket assembly A are held in their correct relative positions by three elongate bolts 6 (best seeen in Figure 12). The head 61 of each bolt abuts the sprocket 4 lying on the axially-inward end of the outer member 2 (to the left in Figure 12), the shank of the bolt passes through apertures 43 formed in each sprocket 4 adjacent the central aperture 40 therethrough, and the end of the bolt remote from the head 61 engages a nut 62 by means of corresponding screw threads on the two integers In this embodiment of the invention, the spacers 5 are of sufficiently large diameter to pass outside the bolts 6, and the nuts 62 engage the axially-outward sprocket 4 (the right-hand one in Figure 12), so that all the sprockets 4 and spacers 5 are firmly clamped between the heads 61 of the bolts 6 and the nuts 62, thereby holding the sprockets and spacers in their correct relative positions.

The two embodiments of the invention shown in the accompanying drawings may be modified in various ways. For example, instead of incorporating spacers distinct from the sprockets, the spacers may be made integral with the sprockets by forming a part of at least all except one of the sprockets not intersecting the periphery of the sprocket thicker than the remainder of the sprocket, each thickened part of a sprocket being capable of contacting at least one adjacent sprocket, so that the periphery of each sprocket is held spaced from the adjacent sprocket(s).

The flanges 34 on the free ends of the support strips 31 of the sprocket carrier 3 in the first embodiment of the invention may be replaced by cotter pins separate from the support strips 31; in this case, there is no need for the support strips 31 to be resiliently deformable since the underformed strips will pass through the apertures 40 in the sprockets. Indeed, the support strips may, in this case, take the form of a cylinder or part-cylinder, no separate annular member 32 being necessary, whilst the second annular member or ring 36 can also be eliminated.

In the second embodiment of the invention, the apertures 43 in the axially-outward sprocket remote from the heads 61 of the bolts 6 may be threaded so that the threaded portion of the shank of each bolt is engaged with the thread in this aperture 43, the nuts 62 being eliminated.

The snap ring 8 in either embodiment of the invention may be replaced by any suitable form of retaining means; for example, the axially-outward end of the outer member 2 could be threaded and a retaining nut engaged therewith. Again, although both embodiments of the invention specifically described incorporate five sprockets, any number of sprockets from two upwards may be used.

Instead of ribs 42 being provided on the sprocket assembly and grooves 24 on the outer member, ribs or other projections may be provided on the outer member and corresponding or other recesses on the sprocket assemly. The projections or recesses on the sprocket assembly need not be formed only on the sprockets; alternatively or in addition, the projections or recesses may be provided on the spacers and/or on the sprocket carrier (if such a carrier is included in the freewheel). It is belived that the necessary modifications of the relative dimensions of the various parts of the sprocket assembly for each of these possible modifications will be obvious to those skilled in the art.

The multi-speed freewheel of the invention may incorporate more than one set of projections and recesses on its outer member and sprocket assembly. For example, the outer member may be provided with at least one first projection and at least one second recess, whilst the sprocket assembly is provided with at least one first recess, which can accomodate the first projection on the outer member, and with at least one second projection which can extend into the second recess in the outer member.

It will be appreciated that the two embodiments of the invention specifically described above incorporate a sprocket assembly having a plurality of regularly spaced sprockets, this sprocket assembly being detachably mountable on the outer member of the freewheel as a unit. Accordingly, the sprocket block can readily be removed from a bicycle wheel hub when it is desired to mount spokes on the wheel hub, so allowing the spokes to be mounted without the hinderance caused by sprockets: this is not possible with prior art hubs of the "unit" type. Furthermore, when it is desired to change one or more of the sprockets, for example in order to replace a damaged sprocket or to fit sprockets having different numbers of teeth, the sprocket assembly may readily be removed from the wheel and replaced thereon without any need for special tools, such as are required for this purpose with most prior art multi-speed freewheels. Finally, since all the sprockets have central apertures of the

same size and shape, all the sprockets are fully interchangeable.

WHAT WE CLAIM IS:—

1. A multi-speed freewheel for a bicycle comprising an inner member capable of being fixedly mounted on or of forming part of a bicycle wheel hub, an outer member mounted on and rotatable around the inner member, an unidirectional transmission mechanism connecting the inner and outer members and arranged to transmit torque from the outer member to the inner member in one direction of rotation of the outer member and to allow the outer member to rotate freely about the inner member in the opposite direction of rotation of the outer member, a sprocket assembly fitted over the outer member as an axially removable unit, said sprocket assembly comprising a plurality of sprockets detachably clamped together as a unit formed with a bore through which the outer member fits, the surface of the bore being formed with spaced configurations engaged with complementary configurations on the outer surface of the outer member such that the sprocket assembly cannot rotate relatively to the outer member but can slide axially thereon, and disengageable retaining means for preventing axial movement of the sprocket assembly on the outer member.

2. A multi-speed freewheel as claimed in claim 1, in which the inner and outer members are both substantially cylindrical in form.

3. A multi-speed freewheel as claimed in any one of the preceding claims, in which the sprockets of the sprocket assembly are formed with aligned central apertures and are mounted upon a sprocket carrier, which fits over the outer member.

4. A multi-speed freewheel as claimed in claim 3, in which the sprocket carrier comprises a plurality of elongate support strips extending through the central apertures in the sprockets and engaging grooves formed in the sprockets, one end of each support strip being fixed to or integral with an annular member lying in a plane substantially perpendicularly to the support strips and extending at least partially around the outer member.

5. A multi-speed freewheel as claimed in claim 4 including a second annular member located within the sprocket carrier at the free ends of the support strips.

6. A multi-speed freewheel as claimed in claim 5, in which both ends of at least one support strip are provided with flanges extending substantially radially outwardly of the first annular member, at least the support strip(s) bearing the flanges being resiliently deformable such that said support strips can be deformed radially inwardly of the first annular member and passed through the central apertures in the sprockets, and the second annular member thereafter inserted between the free ends of the support strips, thereby holding the sprockets fixed relative to the sprocket carrier and forming the sprocket assembly.

7. A multi-speed freewheel as claimed in any of claims 3 to 6 in which at least some of the configurations by which the sprocket assembly engages the outer member are provided on the sprocket carrier.

8. A multi-speed freewheel as claimed in claim 1 or claim 2, in which the sprockets of the sprocket assembly are held in fixed positions relative to one another by elongate members passing through all said sprockets.

9. A multi-speed freewheel as claimed in claim 8, in which the elongate members have the form of bolts, the head of each bolt resting in contact with the sprocket at one end of the sprocket assembly, and the opposed end of each bolt screw-threadedly engaging either a threaded aperture formed in the sprocket at the opposed end of the sprocket assembly, or a nut contacting the sprocket at the opposed end of the sprocket assembly.

10. A multi-speed freewheel as claimed in any of the preceding claims, in which spacers are provided between the sprockets by means of which the sprockets of the sprocket assembly are spaced apart.

11. A multi-speed freewheel as claimed in claims 4 and 10, in which recesses are provided in the spacers to accomodate the support strips of the sprocket carrier.

12. A multi-speed freewheel as claimed in any of claims 1 to 9 in which the hub portion of at least selected sprockets is thicker than the peripheral portion of the sprocket, each hub portion of a sprocket contacting at least one adjacent sprocket, so that the peripheral portion of each sprocket is held spaced from the adjacent sprocket(s).

13. A mutli-speed freewheel as claimed in claim 1, in which the retaining means is a snap ring.

14. A multi-speed freewheel as claimed in claim 1 in which the configurations in the bore of the sprocket assembly are projection(s) and the configurations on the outer member are grooves.

15. A multi-speed freewheel as claimed in claim 1, in which the configurations in the bore of the sprocket assembly are grooves and the configurations on the outer member are projections.

16. A multi-speed freewheel as claimed in claim 14 or 15, in which the projections take the form of axial ridges.

17. A multi-speed freewheel as claimed

in claim 1 and substantially as herein described, with reference to and as illustrated in Figures 1 to 9 or Figures 10 to 12 of the accompanying drawings.

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Fig. 1

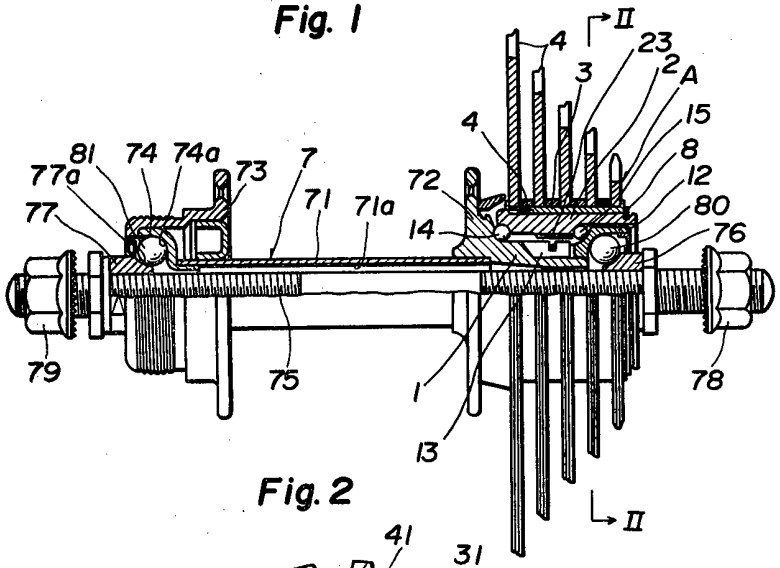

Fig. 2

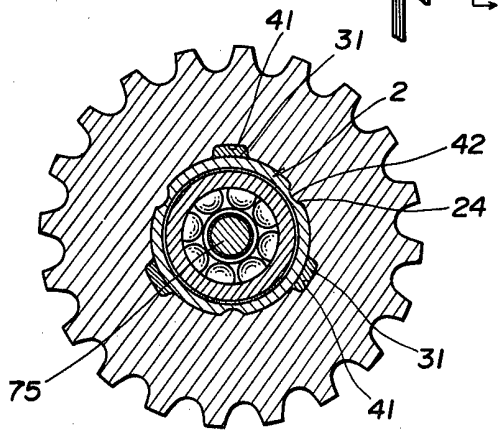

Fig. 3

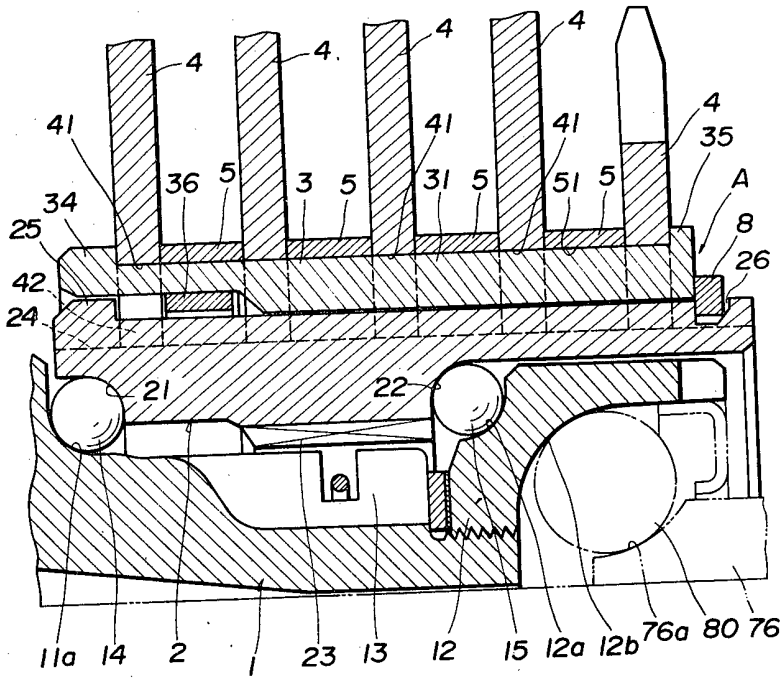
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Fig. 4

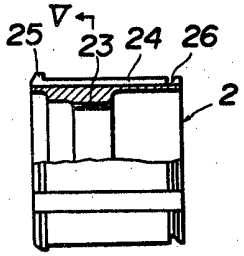


Fig. 5

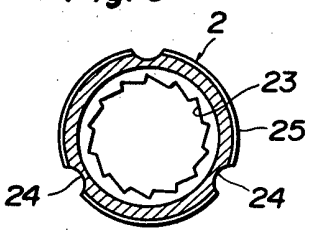
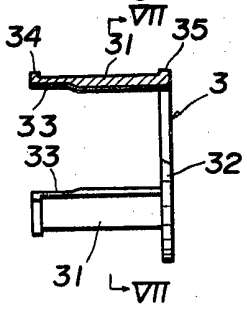


Fig. 6



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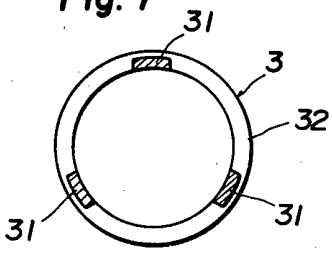

Fig. 8

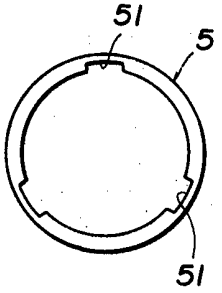

Fig. 9

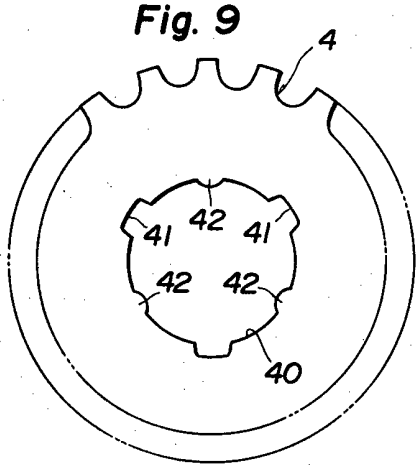

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Fig. 10

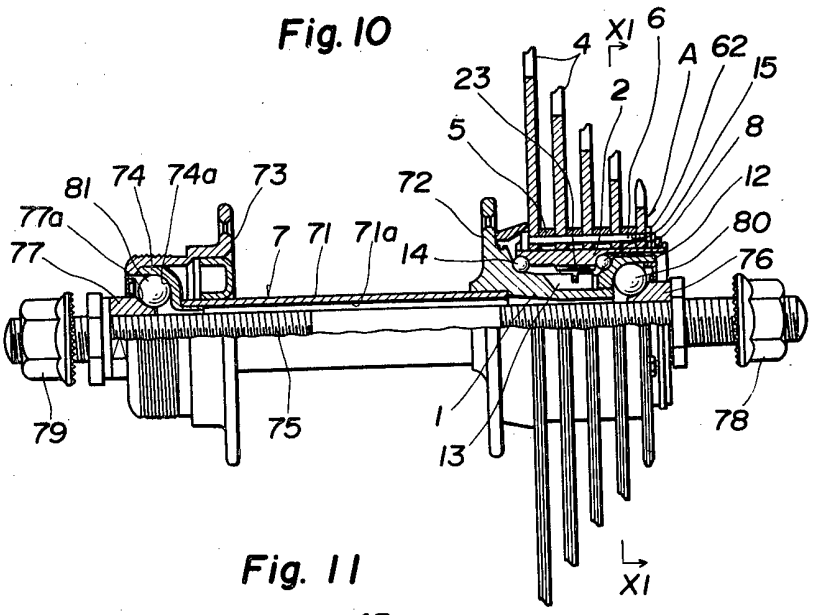

Fig. 11

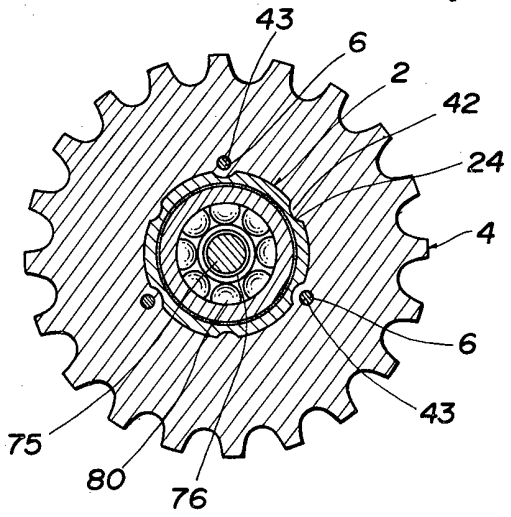

Fig. 12

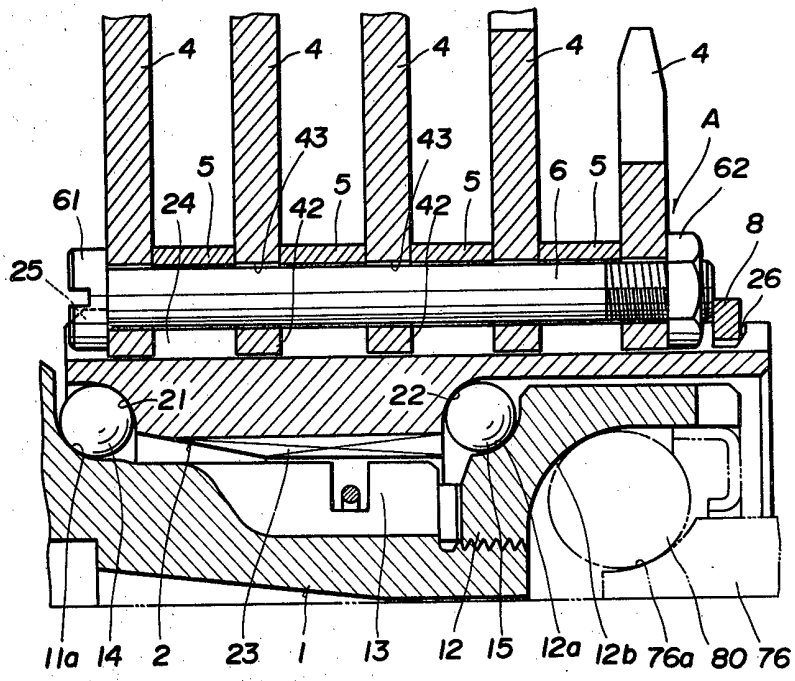
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Fig. 13