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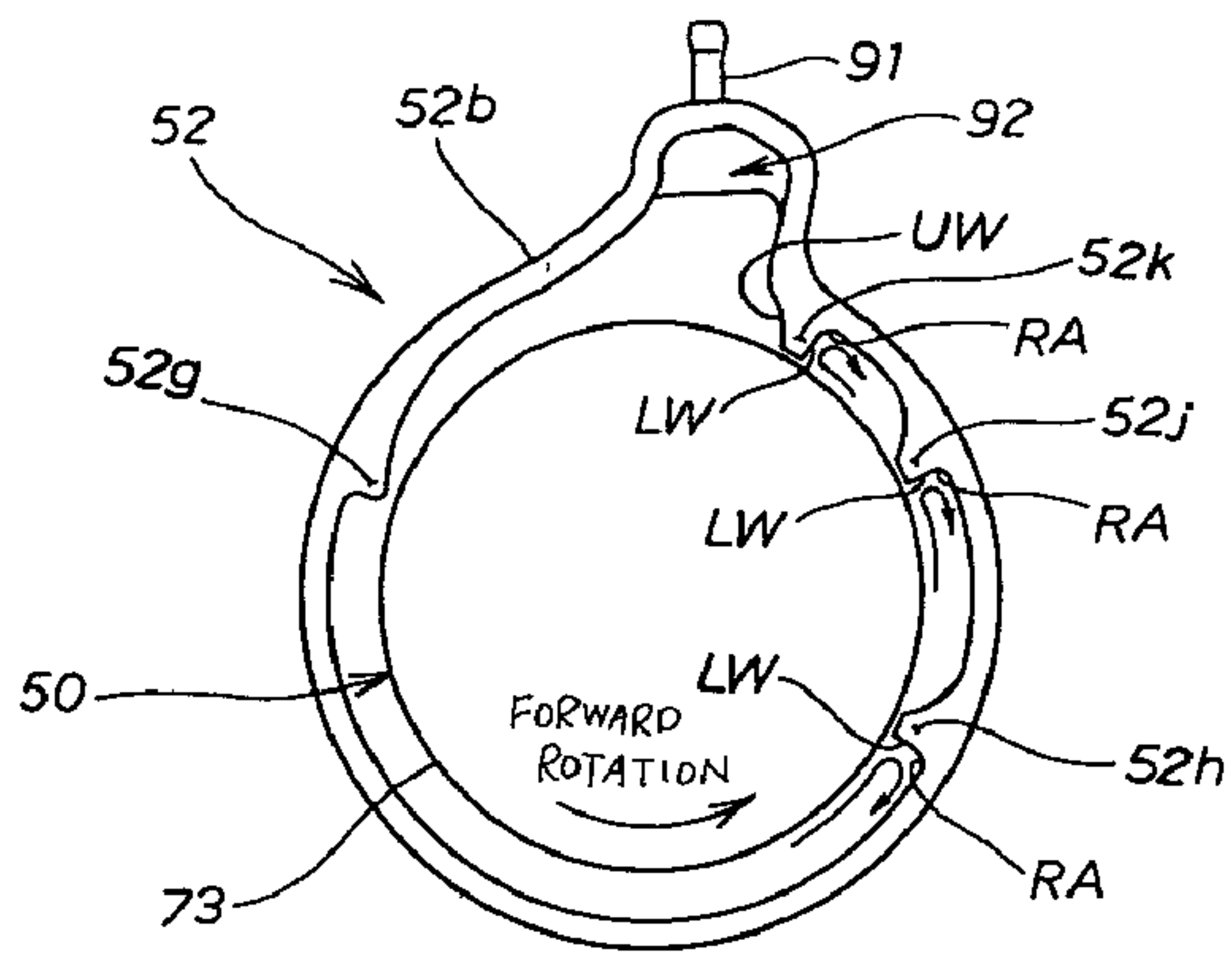
(54) Titre : RENIFLARD D'ENGRENAGE DE REDUCTION FINALE EQUIPE D'UN DIFFERENTIEL
(54) Title: BREATHER STRUCTURE FOR FINAL REDUCTION GEAR EQUIPPED WITH DIFFERENTIAL



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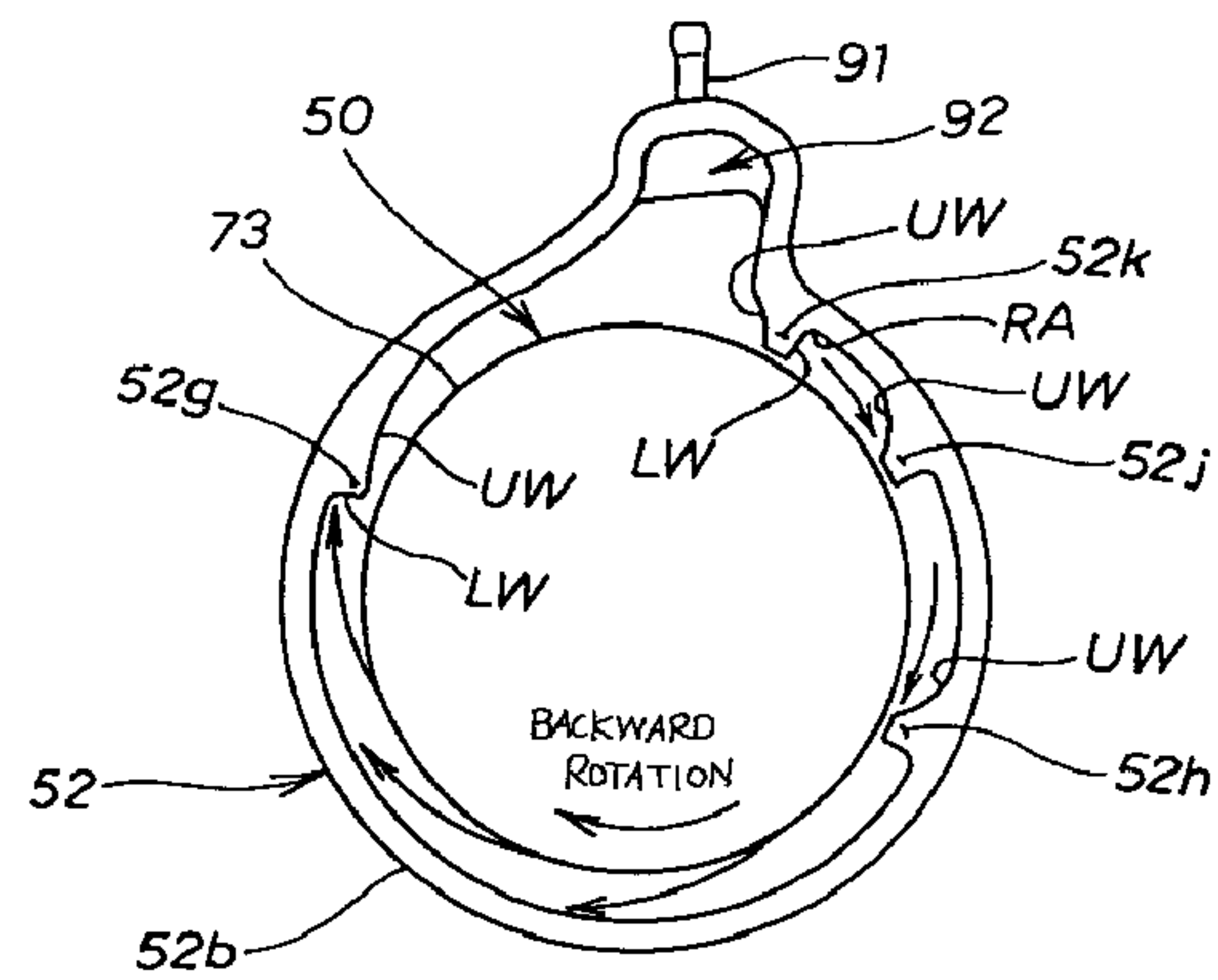

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(57) Abrégé/Abstract:
A breather structure for a final reduction gear equipped with a differential, which can prevent a cost increase, improve quietness and durability, and prevent oil leakage to the outside even though the differential rotates at an increased rotation frequency is

(57) Abrégé(suite)/Abstract(continued):
described. The breather structure is provided with a final reduction gear, in which an upper part of a housing is made into a breather chamber, which is communicated with an outside via a breather pipe, and a differential is rotatably stored in a housing. A plurality of oil stop ribs are provided, extending toward the differential, on an inner circumferential surface of the housing, to prevent oil having been scooped by the differential from flowing into the breather chamber. The oil stop ribs are provided at irregular intervals.

ABSTRACT OF THE DISCLOSURE

A breather structure for a final reduction gear equipped with a differential, which can prevent a cost increase, improve quietness and durability, and prevent oil leakage to the outside even though the differential rotates at an increased rotation frequency is described. The breather structure is provided with a final reduction gear, in which an upper part of a housing is made into a breather chamber, which is communicated with an outside via a breather pipe, and a differential is rotatably stored in a housing. A plurality of oil stop ribs are provided, extending toward the differential, on an inner circumferential surface of the housing, to prevent oil having been scooped by the differential from flowing into the breather chamber. The oil stop ribs are provided at irregular intervals.

TITLE: BREATHER STRUCTURE FOR FINAL REDUCTION GEAR EQUIPPED WITH DIFFERENTIAL

FIELD OF THE INVENTION

The present invention relates to a breather structure for a final reduction gear equipped with a differential, for suppressing cost increase and improving quietness and durability, and being suitable for preventing oil leakage.

BACKGROUND OF THE INVENTION

A gear box for storing a gear, a bearing, lubricant, and so on, has a communication-pipe like breather structure at the upper part thereof to prevent change in internal pressure due to an increasing temperature, so that the internal pressure is always made equivalent to the atmospheric pressure, whereby oil leakage and so on from a sealed part due to an increasing internal pressure is prevented.

As such a breather structure, one disclosed, for example, in Japanese Utility Publication No. Sho. 57-51940 entitled "Final Reduction Gear" is known.

The above application discloses, as shown in Fig. 4 thereof, a final reduction gear, in which an air introducing slot 9A of an air breather 9 is provided in a space surrounded by ribs 8, 8A and so on in the inside of the rear cover 5, and a shroud 10 is provided to the rear cover 5 for preventing oil having been scattered by a rotating hypoid gear from getting to the air introducing slot 9A and the upper surface of the rib 8A.

The above application also discloses, as shown in Fig. 5 thereof, another embodiment of a final reduction gear, in which a packing 6, provided between the housing 4 and the rear cover 5, is formed partly projecting so that oil is thereby prevented from getting to the air introducing slot 9A and the upper surface of the rib 8A.

According to the above technique, attachment of a shroud 10 to the rear cover 5 results in an increase of parts, including the shroud 10, a bolt for attachment, and so on, as well as costs.

Also, when the packing 6 is formed partly projecting, a thin packing that is less rigid is likely to vibrate, which results in deteriorated quietness and durability.

Further, as the hypoid gear 1 rotating at a high speed causes an increase in the speed and mount of scattered oil, a larger amount of oil may get to the air introducing slot 9A or the upper surface of the rib 8A through spaces between the rib 8A and the shroud 10 or between the rib 8A and the extension of the packing 6.

SUMMARY OF THE INVENTION

In view of the above, the present invention aims to provide a breather structure for a final reduction gear equipped with a differential, which can prevent a cost increase, improve quietness and durability, and prevent oil leakage to the outside even though the differential rotates at an increased rotation frequency.

In order to achieve the above objects, according to the present invention, in a final reduction gear, in which an upper part of a housing is made into a breather chamber, which is communicated with an outside via a breather pipe, and a differential is rotatably stored in a housing,

a plurality of oil stop ribs are provided, extending toward the differential, on an inner circumferential surface of the housing, to prevent oil having been scooped by the differential from flowing into the breather chamber, and

the oil stop ribs are provided at irregular intervals.

When the oil having been scooped by the differential is prevented from flowing into the breather chamber by the plurality of oil stop ribs formed on the inner circumferential surface of the housing, and the adjacent oil stop ribs are provided at irregular intervals, a place where the oil is to be accumulated is shifted from a place between adjacent oil stop ribs with a larger interval to a place between adjacent oil stop ribs with a smaller interval as the differential rotates at a higher rotation frequency, whereby an amount of oil to be blocked is gradually reduced.

In an aspect of the invention, the oil stopping ribs are formed having upper and lower surfaces of different shapes. Specifically, the upper surface of the oil stop rib is formed declining so that the blocked oil flows downward, and the lower surface thereof is formed as a receiver for directly receiving the rising oil.

The blocked oil flows downward along the declining upper surface of the oil stop rib, while the rising oil is received by the lower surface of the oil stop rib, formed as a receiving surface.

As a result, oil does not accumulate on the upper surface of the oil stop rib and an oil flow is blocked by the lower surface of the oil stop rib, so that the oil can accumulate in the lower part of the housing.

The present invention with the above arrangement can produce the following advantages.

With a breather structure for a final reduction gear equipped with a differential according to claim 1, in the final reduction gear, in which an upper part of a housing is made into a breather chamber, which is communicated with an outside via a breather pipe, and the differential is rotatably stored in a housing,

a plurality of oil stop ribs are provided on an inner circumferential surface of the housing to prevent oil having been scooped by the differential from flowing into the breather chamber, and

adjacent oil stop ribs are provided at irregular intervals.

When the oil stop ribs are formed on the housing, the need to provide other parts for oil stoppage on the housing is eliminated, so that the number of parts, as well as costs, can be suppressed, and noise or damage due to vibration can be prevented.

Also, when adjacent oil stop ribs are provided at different intervals, an amount of oil to be blocked can be gradually reduced as the differential rotates at a higher rotation frequency, so that the oil can be reliably prevented from flowing into the breather chamber.

Thus, oil leakage to the outside of the final reduction gear can be prevented.

With a breather structure for a final reduction gear equipped with a differential according to claim 2, the upper surface of the oil stop rib is formed declining and the lower surface thereof is formed as a receiving surface. With this arrangement, oil does not sump on the upper surface of the oil stop rib. Moreover, as an oil flow is blocked by the lower surface of the oil stop rib, the oil can sump in the lower part of the housing.

Thus, oil does not flow into the breather chamber, and so the oil can be prevented from flowing to the outside of the final reduction gear via the breather pipe.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are shown in the drawings, wherein:

Figure 1 is a perspective view showing a saddled vehicle equipped with a final reduction gear according to the present invention;

Figure 2 is a perspective view showing a power transmission mechanism of a saddled vehicle equipped with a final reduction gear according to the present invention;

Figure 3 is an exploded perspective view showing a differential according to the present invention;

Figure 4 is an exploded perspective view showing a differential case assembly of a differential according to the present invention;

Figure 5 is a cross sectional view of Fig. 2 along the line 5-5;

Figure 6 is a diagram explaining an input block of a differential according to the present invention;

Figure 7 is a diagram explaining a breather structure of a front final assembly equipped with a differential according to the present invention;

Figure 8 is a developed diagram showing an input block and an output cam of a differential according to the present invention, which are being developed in a circumferential direction (a schematic diagram);

Figure 9 is an operation diagram explaining operation of a differential according to the present invention;

Figure 10 is an operation diagram explaining driving force distribution by a saddled vehicle equipped with a differential according to the present invention, running straight;

Figure 11 is an operation diagram explaining a steering force of a saddled vehicle equipped with a differential according to the present invention;

Figure 12 is an operation diagram explaining comparison of steering forces of a vehicle equipped with a differential; and

Figure 13 is an operation diagram explaining operation of a breather structure of a front final assembly equipped with a differential according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described with reference to the accompanying drawings. Note that the drawings are to be viewed in the direction of the reference numerals.

Fig. 1 is a perspective view showing a saddled vehicle equipped with a final reduction gear according to the present invention, in which the saddled vehicle 10 comprises a handle 12 rotatabily attached to a vehicle frame 11, front wheels 13, 14 (13 for a left front wheel, 14 for a right front wheel) steerably connected to the handle 12 via a steering device (not shown), and vertically movably attached to the vehicle frame 11 via an arm (not shown), a seat 15 arranged on the upper part of the vehicle frame 11, a power unit 16 comprising an engine and a transmission, arranged below the seat 15, and rear wheels 17, 18 (17 for a left rear wheel, 18 for a right rear wheel (not shown)) to be driven, together with the front wheels 13, 14, by the power unit 16 via a power transmission mechanism (described later).

21 is a front final assembly as a final reduction gear, or one of the components of the power transmission mechanism. The front final assembly 21 incorporates a differential (described later), and is installed between the left front wheel 13 and the right front wheel 14. Note that 22 is a front bumper, 23 is an under cover, 24 is a front fender, 25 is a headlamp, 26 is a rear fender, and 27 is a muffler.

Fig. 2 is a perspective view showing a power transmission mechanism of a saddled vehicle equipped with a final reduction gear according to the present invention, in which the power transmission mechanism 30 comprises a front propeller shaft 31 extending frontward from the bottom of the power unit 16, a front final assembly 21 connected to the leading end of the front propeller shaft 31, front drive shafts 32, 33 connected on the left and right sides of the front final assembly 21, hubs 34, 35 connected to the respective ends of the front drive shafts 32, 33, a rear propeller shaft 36 extending backward from the bottom of the power unit 16, a rear final assembly 37 connected to the trailing end of the rear propeller shaft 36, a rear drive shaft 38 penetrating the rear final assembly 37 in the left and right direction thereof, and hubs 42,43 connected to the respective ends of the rear drive shaft 38. Note that 45, 46, 47 are tubes covering the rear propeller shaft 36 and left and right sides of the rear drive shaft 38, and 48 is a supporting member for supporting the tubes 45, 47.

The hubs 34, 35, 42, 43 are members for attaching the hubs 34, 35, 42, 43 to the left front wheel 13, the right front wheel 14, the left rear wheel 17, and the right rear wheel 18, shown in Fig. 1, respectively.

Fig. 3 is an exploded perspective view showing a differential according to the present invention, in which the front final assembly 21 comprises a differential case assembly 50 as a differential, a housing 52 for rotatably storing the differential case assembly 50 via the bearings 51, 51, a drive pinion 54 for insertion into the housing 52 from the rear side thereof via the bearing 53, a bearing 55 for rotatably installing the driving pinion 54 to the housing 52, a lock nut 56 for preventing displacement of the bearing 55, and a joint 58 to be installed on an end of the driving pinion 54.

Here, 52a is a housing body, 52b is a housing cover, 61, 61 are oil seals, 62, 63 are bolts, 64, 64 are spacers, 65 is a maintenance hole plug, 66 is an O-ring, 67 is a spacer, 68 is an oil seal, and 69 is an O-ring.

Fig. 4 is an exploded perspective view showing a differential according to the present invention, in which a differential case assembly 50 comprises a differential case 71 and a storage part 72 to be stored in the differential case 71.

The differential case 71 comprises a column-like case body 73, a ring-geared cap 75, in which a ring gear 75a is integrally formed on a left cap (described later) to be attached to one of the openings of the case body 73, and a right cap 76 to be attached to the other opening of the case body 73.

The storage part 72 comprises two types of input blocks 77, 78, for rotating integrally with the differential case 71, left and right output cams 81, 82 for sandwiching the input blocks 77, 78 so as to allow them to slide relative to each other, and capable of rotating independently due to a frictional force with the respective blocks, thrust bearings 83, 83, arranged adjacent to the left and right output cams 81, thrust washers 84, 84, and a disk spring 85. Note that the thrust bearings 83, 83 may be omitted.

Fig. 5 is a cross sectional view of Fig. 2 along the line 5-5.

The front final assembly 21 is a device in which a differential case assembly 50 is assembled by forming a ring-geared cap 75 through integral formation of a ring gear 75a to a left cap 74, providing a left output cam 81 in the inside of the ring-geared cap 75 via a disk spring

85, a thrust washer 84, and a thrust bearing 83; installing the case body 73 to the ring-geared cap 75 by using a bolt 87, arranging input blocks 77, 78 in the case body 73 in the circumferential direction so as to contact the left output cam 81, arranging a right output cam 82 so as to contact the input blocks 77, 78, providing a right cap 76 adjacent to the right output cam 82 via a thrust bearing 83 and a thrust washer 84, and attaching the right cap 76 to the case body 73.

Also, the front final assembly 21 is a device in which the housing 52 is assembled by attaching a column part 75b of the ring-geared cap 75 to a journal part 52c of the housing body 52a via a bearing 51, attaching a cylinder part 76a of the right cap 76 to the journal part 52d of the housing cover 52b via the bearing 51, and attaching the housing cover 52b to the housing body 52a by using bolts 62 (see Fig. 3), 63 (only one is shown), and the differential case assembly 50 is rotatably provided inside the housing 52.

Further, the front final assembly 21 is a device in which the end 54a of a driving pinion 54 is attached in the inside of a rear cylinder part 52e of the housing body 52a via a bearing 53, the middle part 54b of the driving pinion 54 is attached to the rear cylinder part 52e via the bearing 55 to thereby cause the driving pinion 54 to be engaged with the ring gear 75a, a lock nut 56 is screwed into the inner circumferential part of the rear cylinder part 52e to thereby prevent displacement of the bearing 55, a joint 58 is attached to the trailing end of the driving pinion 54, and an oil seal 68 is provided between the inner circumferential part of the rear cylinder part 52e and the joint 58.

The input blocks 77, 78 each have convex parts 77a, 78a, which are fixed to axial slots 73a, 73b, formed on the inner surface of the case body 73, whereby the input blocks 77, 78 can rotate together with the case body 73.

The left and right output cams 81, 82 transmit a driving force to the left and right front wheels 13, 14 (see Fig. 1) by spline connecting the front drive shafts 32, 33 to the cylinder parts 81a, 82a, respectively.

The drive pinion 54 transmits a driving force from the power unit 16 (see Fig. 1) to the differential case assembly 50 by spline connecting the front propeller shaft 31 (see Fig. 2) to the joint 58.

As described above, a differential case assembly 50 of the present invention is characterized by the fact that a ring gear 75a is integrally formed on the left cap part 74, which is a part of the differential case 71.

With the above structure, the ring gear 75a is integrally formed on the left cap 74 of the differential case 71 so that the left cap part 74 and the ring gear 75a can be formed as a single part, and a conventional bolt for connection is unnecessary, compared to a conventional design, in which a case and a ring gear are different entities. Thus, the number of parts can be reduced, and molding can be facilitated, as a result of which manufacturing costs can be reduced.

Figs 6(a) to (c) are diagrams explaining an input block of a differential according to the present invention.

(a) shows an internal state of the differential case assembly 50 with the ring-geared cap 75 (see Fig. 5) and the left output cam 81 both removed.

Input blocks 77, 78 are arranged alternately every two blocks in the circumferential direction such that convex parts 77a, 78a are fitted into the axis direction slots 73a, 73b, respectively, formed on the inner surface of the case body 73.

(b) is an enlarged diagram of essential parts of (a), showing the case body 73 and the input block 77 in engagement with the case body 73.

The axis direction slot 73a is a slot having a substantially trapezoidal shape. The convex 77a is a part having a shape substantially analogous to the shape of the axis direction slot 73a. Here, the width of the upper part of the convex 77a is defined as L1.

(c) is a enlarged diagram of essential parts of (a), showing a case body 73 and an input block 78 in engagement with the case body 73.

The axis direction slot 73b is a slot having a substantially trapezoidal shape. The convex part 78a is a part having a shape substantially analogous to the shape of the axis direction slot 73b. Here, the width of the upper part of the convex part 78a is defined as L2. That is, the upper width L2 differs from the upper width L1 in (b), i.e., L1?pL2.

≠ - option =

Although L1>L2 is held in (b) and (c), L1<L2 may be possible.

Also, the axis direction slot 73b has a projection 73c at the bottom thereof, and the convex 78a has a hollow 78b on the upper surface thereof, which corresponds to the above-described projection 73c.

Fig. 7(a), (b) are diagrams explaining a breather structure for a front final assembly equipped with a differential according to the present invention. (a) is a view in the direction of arrow 7 in Fig. 2, while (b) is a cross sectional view of (a) along line b-b.

In (a), the front final assembly 21 has a breather joint 91 on the upper part of the housing cover 52b, as a breather pipe for communicating between inside and outside of the housing 52.

In (b), the housing cover 52b is a cover, in which an upper part thereof is formed projecting to form a breather chamber 92, and the breather joint 91 is attached on the wall in the upper part of the breather chamber 92.

Also, a plurality of oil stop ribs 52g, 52h, 52j, 52k are formed with irregular intervals and substantially parallel to the rotation axis of the differential case assembly 50, on the inner surface of the housing cover 52b below the breather chamber 92. These oil stop ribs 52g, 52h, 52j, 52k are set close to the case body 73 of the differential case assembly 50.

Here, the direction in which the differential case assembly 50 rotates when the associated vehicle runs forward is determined as a forward rotation direction, which is the direction of the arrow in the drawing.

The oil stop ribs 52g, 52h, 52j, 52k are formed such that the lower surfaces thereof, or walls LW, which are further from the breather chamber 92, rise substantially vertically with respect to the inner surface of the housing cover 52b, with corners RA having a small arc radius r1, and the walls UW, which are closer to the breather chamber 92, are formed like an arc, having a large arc radius r2. That is, r2>r1.

The oil stop rib 52g is formed on the other side of the inner surface of the housing cover 52b, with the differential case assembly 50 intervening, from the surface where the oil stop ribs 52h, 52j, 52k are formed.

Respective intervals between the oil stop ribs 52g, 52h, 52j, 52k correspond to angles C1, C2, C3, respectively, wherein C1>C2>C3.

The relationship among the angles C1, C2, C3 in terms of degrees, represents a relationship in an amount of oil allowed to accumulate between adjacent oil stop ribs 52g, 52h, 52j, 52k.

That is, (an amount of oil accumulating between the oil stop ribs 52g, 52h)>(an amount of oil accumulating between the oil stop ribs 52h, 52j)>(an amount of oil accumulating between the oil stop ribs 52j, 52k).

In other words, the breather structure of a front final assembly 21 equipped with a differential case assembly 50 of the present invention is characterized by the fact that, in a front final assembly 21, in which the upper part of the housing 52 is made into a breather chamber 92, which communicates with the outside via a breather joint 91 and the differential case assembly 50 is rotatably accommodated in the housing 52, a plurality of oil stop ribs 52g, 52h, 52j, 52k are formed on the inner circumferential surface of the housing 52, extending toward the differential case assembly 50, so that the oil having been scooped by the differential case assembly 50 is prevented from getting to the breather 92, and that intervals between adjacent oil stop ribs 52g and 52h, 52h and 52j, 52j and 52k are made irregular.

In the above structure, when oil stop ribs 52g, 52h, 52j, 52k are provided on the housing 52, the need to provide other oil stoppers on the housing 52 is eliminated. Thus, the number of parts does not increase, and a cost increase can be suppressed. Moreover, as the oil stop ribs 52g, 52h, 52j, 52k are integrally formed on the housing 52, the oil stop ribs 52g, 52h, 52j, 52k can be prevented from vibrating and being damaged due to the housing 52 vibrating.

Also, the breather structure of a front final assembly 21 equipped with a differential case assembly 50 of the present invention is characterized by the fact that the walls UW, LW are formed in different shapes. Specifically, the oil stop ribs 52g, 52h, 52j, 52k are formed such that the upper surface walls UW are formed declining so that blocked oil flows downward therealong, and the lower surface walls LW are formed as a receiver for directly receiving rising oil.

Fig. 8(a) to (d) are development diagrams (schematic diagrams) showing an input block and an output cam of a differential of the present invention, being developed in the circumferential direction. (a) to (d) show chronological steps, in which the left output cam 81 moves leftward in the drawing, relative to the right output cam 82, as time passes.

In (a), the input block 77 has a hexagonal shape, when developed, which is opposite in terms of left and right directions from the shape of the input block 78 being developed.

The left output cam 81 has an uneven cam surface 81b, which alternates connection of a left first inclining surface 81c and a left second inclining surface 81d.

The right output cam 82 has an uneven cam surface 82b, which alternates connection of a right first inclining surface 82c and a right second inclining surface 82d.

Here, S1, S2 are reference lines using a part of the right output cam 82 as a reference.

(b) shows a state in which, relative to the state shown in (a), upon receipt of a force in the circumferential direction (leftward in the drawing), the input block 77 moves from the right output cam 82 side to the left output cam 81 side by a distance V1, and also the right output cam 82 moves relatively in a direction opposite (rightward in the drawing) from the input block 77 by a distance H1, and the left output cam 81 moves leftward relative to the right output cam 82 by a distance M1.

(c) shows a state in which, relative to the state shown in (a), upon receipt of a force in the circumferential direction (leftward in the drawing), the input block 77 moves from the right output cam 82 side to the left output cam 81 side by a distance V2, as well as the right output cam 82 moves relatively in a direction opposite from the input block 77 by a distance H2, and the left output cam 81 moves leftward relative to the right output cam 82 by a distance M2.

(d) shows a state in which, relative to the state shown in (a), upon receipt of a force in the circumferential direction (leftward in the drawing), the input block 77 moves from the right output cam 82 side to the left output cam 81 side by a distance V3, as well as the right output cam 82 moves relatively in a direction opposite from the input block 77 by a distance H3, and the left output cam 81 moves leftward relative to the right output cam 82 by a distance M3.

As represented by the input block 77, described above, when the moving speed, or a rotating frequency, is different between the left output cam 81 and the right output cam 82, the input blocks 77, 78 perform relative movement, or relative rotation, while causing a frictional force between the left and right output cams 81, 82, respectively.

When no difference is caused in rotation frequency between the left output cam 81 and the right output cam 82, the input blocks 77, 78 and the left and right output cams 81, 82 do not rotate relatively, but rotate together.

Operation of the above-described differential will be described as follows.

Figs. 9(a), 9(b) are operation diagrams explaining operation of a differential according to the present invention.

(a) is an enlarged diagram of the input block 77 (the leftmost one) and the left and right output cams 81, 82, shown in Fig. 8(a), in which the inclination angle of the left first inclining surface 81c of the left output cam 81 is denoted as Θ, that of the right first inclining surface 82c of the right output cam 82 is denoted as Θ.

In (b), an example will be described in which, when a leftward force F is applied to the input block 77, for example, the left output cam 81 rotates at a high speed, and the right output cam 82 rotates at a low speed, resulting in a difference in rotation frequency between the left output cam 81 and the right output cam 82.

In this case, assume that if the input block 77 pushes the left first inclining surface 81c of the left output cam 81 with a force N perpendicular to the inclining surface 81c, and the right first inclining surface 82c of the right output cam 82 with a force N perpendicular to the inclining surface 82c, the leftward component of the force N is $N\sin\Theta$.

Also, when the left output cam 81 moves leftward relative to the input block 77, a frictional force ?fN is caused between the input block 77 and the left first inclining surface 81c, in which a rightward component of the frictional force μN is $N\cos\Theta$, i.e., a leftward component is $-\mu N\cos\Theta$.

Therefore, a leftward force applied from the input block 77 to the left output cam 81 is $N\sin\Theta-\mu N\cos\Theta$.

On the other hand, when the right output cam 82 moves rightward relatively to the input block 77, a frictional force μN is caused in the input block 77 and the right first inclining surface 82c, in which a leftward component of the frictional force μN is $\mu\ N\cos\Theta$.

Therefore, a leftward force applied from the input block 77 to the right output cam 82 is $N\sin\Theta+\mu N\cos\Theta$.

As described above, when a difference in a rotation frequency is caused between the left output cam 81 and the right output cam 82, a larger force is caused to the right output cam 82, which rotates at a lower speed, compared to the force caused to the left output cam 81, which rotates at a high speed.

The ratio of leftward forces applied to the left output cam 81 and the right output cam 82 are denoted as $(N\sin\Theta-\mu N\cos\Theta)\ :\ (N\sin\Theta\ +\mu\ N\cos\Theta)=\ (\sin\Theta+?\mu\cos\Theta)\ :\ (\sin\Theta+\mu s\cos\Theta)$, which varies depending on a friction coefficient μ, and an inclination angle Θ.

The above ratio is ultimately a ratio at which to distribute driving torque to the left and right front wheels.

As described with reference to Fig. 4, in this embodiment, a differential case assembly 50 comprises a plurality of input blocks 77, 78 for moving in a circumferential direction, following the rotating ring gear 75a, two left and right output cams 81, 82 for sandwiching the blocks 77, 78 so as to allow them to perform relative movement, and capable of rotating independently by utilizing a frictional force with the respective blocks 77, 78, and a differential case 71 for storing the input blocks 77, 78 and left and right output cams 81, 82.

With the above structure, driving torque can be distributed to the output cams 81, 82 differently according to a predetermined ratio, depending on a frictional force direction, which varies due to relative sliding of the input blocks 77, 78 and the output cams 81, 82 based on the rotation frequency of the two output cams 81, 82. Thus, even though a driving force for some wheels becomes smaller due to a change in a friction coefficient of a road surface, a driving force for other wheels does not drop, so that total driving force can be ensured and traveling performance can be improved.

Next, distribution of a driving force when a saddled vehicle equipped with a differential runs straight will be described.

Figs. 10(a), 10(b) are operation diagrams explaining distribution of a driving force when a saddled vehicle equipped with a differential of the present invention runs straight. Note that the length of the black arrows in the drawing corresponds to the magnitude of a driving force.

In (a), when the rear wheels 17, 18 come to be on a road with a small friction coefficient, such as mud Mu, and so on, the rear wheels 17, 18 slip, so that driving forces D1, D1 become smaller, as shown by the arrow. However, if the front wheels 13, 14 are then on a road with a large friction coefficient, large driving forces D2, D2, as shown by the arrow, are caused.

In (b), when the vehicle are running straight, if, e.g., the right front wheel 14 and the rear wheels 17, 18 come to be on a road with a small friction coefficient, such as mud Mu, and so on, a driving force D3 of the right front wheel 14 and driving forces D4, D4 of the rear wheels 17, 18 become smaller, as shown by the arrows. However, if the left front wheel 13 is then on a road with a large friction coefficient, a difference in a rotation frequency will be caused between the left front wheel 13 and the slipping right front wheel 14. As a result, a large driving force D5, as shown by the arrow, will be caused to the left front wheel 13 due to operation of the front final assembly 21.

Next, a steering force of a saddled vehicle equipped with a differential will be described.

Figs. 11(a), 11(b) are operating diagrams explaining a steering force of a saddled vehicle equipped with a differential according to the present invention. Note that the length of black arrows in the drawing corresponds to the magnitude of a driving force, and the length of the outlined arrows corresponds to the magnitude of a resistance force when the vehicle is running.

In (a), in a saddled vehicle of the present invention, a rotation frequency for the rear wheels 17, 18 is set slightly higher than that for the front wheels 13, 14 for reduction of a steering force.

With this arrangement, when the vehicle is running straight, although the driving forces D6, D6 for the rear wheels 17, 18 become larger, as shown by the black arrows, driving forces D7, D7 for the front wheels 13, 14 become smaller, as shown by the black arrows, and resistance forces R1, R1 are caused to the front wheels 13, 14, as shown by the outlined arrows.

In (b), when the front wheels 13, 14 are steered while the vehicle is running, a larger resistance force R2 is caused to the front wheel 13, which then runs inside, than a resistance force R3, caused to the front wheel 14, which then runs outside, because of a slightly higher rotation frequency set for the rear wheels 17, 18 than the front wheels 13, 14, and of an operation of the front final assembly 21. This enables reduction of a steering force.

Fig. 12 is an operation diagram explaining a comparison example of steering forces of a vehicle equipped with a differential, in which the differential distributes equal driving forces to the right and left front wheels to be steered. Note that the length of the black arrows in the drawing corresponds to the magnitude of a driving force, while the length of outlined arrows corresponds to the magnitude of a resistance force.

The vehicle 100 transmits a driving force of the power unit 101 to the differential 103 via the front shaft 102, and further from the differential 103 to the front wheels 106, 107 via the front drive shafts 104, 105.

The vehicle 100 also transmits a driving force of the power unit 101 to the differential 111 via the rear shaft 108, and further from the differential 111 to the rear wheels 114, 115 via the left and right rear drive shafts 112, 113.

In the vehicle 100, as the front wheels 106, 107 and the rear wheels 114, 115 rotate at the same rotation frequency and the differential 103 distributes equal driving forces, driving forces Dr, Dr for the left and right front wheels 106, 107 become equal when being steered. Moreover, even if a rotation frequency of the rear wheels 114, 115 is set slightly higher than that for the front wheels 106, 107, resistance forces Re, Re applied to the left and right front wheels 106, 107, become equal and no contribution to reduction of a steering force is thus obtained.

As described with reference to Fig. 11(b), in this embodiment, in a saddled vehicle 10 equipped with a differential case assembly 50 between the front left and right wheels 13, 14, and for running off-road, and so on, a device which distributes driving forces differently at a predetermined ratio to the left and right wheels 13, 14 when a difference is caused in rotation frequencies between the left and right wheels 13, 14, is employed as a differential case assembly 50.

With the above structure, when steering, a larger driving torque can be distributed to an inside wheel, running at a slower speed than an outside wheel, running at a higher speed, whereby a larger resistance force can be caused to the inside wheel than the outside wheel. As a result, steering performance can be further improved and a steering force can be further reduced. Thus, operability can be further enhanced.

Operation of the breather structure of the above-described front final assembly will next be described.

Figs. 13(a), 13(b) are operating diagrams explaining operation of a breather structure of a front final assembly equipped with a differential of the present invention.

In (a), when the differential case assembly 50 rotates forward as shown by the arrow, oil in the housing 52 tends to flow counterclockwise in a space between the external circumferential surface of the differential case assembly 50 and the inner surface of the housing cover 52b, following the rotation of the differential case assembly 50. However, the oil flow is blocked by the oil stop ribs 52h, 52j, 52k.

That is, when the differential case assembly 50 rotates at a lower rotation frequency, most of the oil is blocked by the oil stop rib 52h provided upstream of the oil flow, so that the blocked oil accumulates in a lower part of the housing cover 52b, or between the two oil stop ribs 52g, 52h.

When the differential case assembly 50 rotates at a higher rotation frequency, a lot of oil passes through the space between the differential case assembly 50 and the oil stop rib 52h. The passed oil is then blocked by the oil stop rib 52j, and accumulates between two oil stop ribs 52h, 52j.

When the differential case assembly 50 rotates at an even higher rotation frequency, a lot of oil passes through the space between the differential case assembly 50 and the oil stop rib 52j. The passed oil is then blocked by the oil stop rib 52k, and accumulates between the oil stop ribs 52j, 52k, so that the oil can be prevented from flowing into the breather chamber 92.

As described above, provision of a plurality of oil stop ribs 52g, 52h, 52j, 52k, enables oil blocking in a broad range of rotation frequency of the differential case assembly 50.

Also, setting of irregular intervals between the adjacent oil stop ribs 52g, 52h, 52j, 52k enables blocking and accumulation of a lot of oil upstream of the oil flow, compared to a design with regular intervals, so that the amount of oil to be blocked downstream of the oil flow can be reduced. In particular, it is difficult for oil to overflow from between the oil stop ribs 52j, 52k, and can be prevented from flowing into the breather chamber 92.

Further, as the walls LW of the oil stop rib 52h, 52j, 52k, further from the breather chamber 92, are formed sharply rising, with corners RA having a small arc radius, oil can be reliably blocked.

In (b), when the differential case assembly 50 rotates in a direction opposite from a forward direction, i.e., in a reverse direction, as shown by the arrow, the oil in the housing 52 then flows clockwise, following the rotation of the differential case assembly 50, in a space between the external circumference surface of the differential case assembly 50 and the inner surface of the housing cover 52b.

Then, with an arrangement, in which the walls UW of the oil stop ribs 52h, 52j, 52k, closer to the breather chamber 92, are formed declining having a large arc radius, the oil around the respective oil stop ribs 52h, 52j, 52k can be smoothly introduced to the respective spaces between the differential case assembly 50 and the oil stop ribs 52h, 52j, 52k, so that the oil can flow toward the lower part of the housing cover 52b.

Then, as the oil reaching the lower part of the housing cover 52b moves from the differential case assembly 50 side to the housing cover 52b side due to a centrifugal force, while flowing clockwise, as shown by the arrow, the oil can be efficiently blocked by the wall LW of the oil stop rib 52g.

As described above with reference to (a) and (b), when the differential case assembly 50 rotates forward, an amount of oil to be blocked can be reduced as the differential case assembly 50 rotates at a higher rotation frequency, so that oil can be reliably blocked from flowing into the breather chamber 92.

Therefore, oil leakage to the outside of the front final assembly can be prevented.

Also, when the differential case assembly 50 rotates forward, the climbing oil can be received by the walls LW, or receiver surfaces, of the oil stop ribs 52h, 52j, 52k, to thereby block the oil flowing. Thus, it is possible to make the oil to accumulate in the lower part of the housing 52.

On the other hand, when the differential case assembly 50 rotates backward, the blocked oil flows downward along the declining walls UW of the oil stop ribs 52h, 52j, 52k, without accumulating on the walls UW. The flowing oil is then received by the wall LW of the oil stop rib 52g, or a receiving surface, to thereby block the oil flow.

Therefore, oil does not reach the breather chamber 92 when the differential case assembly 50 rotates either forward or backward, so that oil can be prevented from flowing to the outside of the front final assembly via the breather joint 91. As a result, the life of the front final assembly can be prolonged.

A plurality of oil stop rigs 52g, 52h, 52j, 52k are provided, extending toward a differential 50, on the inner circumferential surface of a housing 52 to thereby block the oil having been scooped by the differential 50, from flowing into a breather chamber 92. Moreover, intervals between adjacent oil stop ribs 52g, 52h, 52j, 52k are made irregular.

Provision of oil stop ribs on the housing eliminates the need to provide other oil stopper parts to the housing. Thus, an increase of the number of parts can be suppressed, and noise, damage, and so on due to vibration can be avoided. Also, as irregular intervals are set between adjacent oil stop ribs, an amount of oil to be blocked can be gradually reduced as the differential comes to rotate at a higher rotation frequency, so that the oil can be reliably prevented from flowing into the breather chamber.

The present invention with the above arrangement can produce the following advantages.

With a breather structure for a final reduction gear equipped with a differential according to claim 1, in the final reduction gear, in which an upper part of a housing is made into a breather chamber, which is communicated with an outside via a breather pipe, and the differential is rotatably stored in a housing, a plurality of oil stop ribs are provided on an inner circumferential surface of the housing to prevent oil having been scooped by the differential from flowing into the breather chamber, and

adjacent oil stop ribs are provided at irregular intervals.

When the oil stop ribs are formed on the housing, the need to provide other parts for oil stoppage on the housing is eliminated, so that the number of parts, as well as costs, can be suppressed, and noise or damage due to vibration can be prevented.

Also, when adjacent oil stop ribs are provided at different intervals, an amount of oil to be blocked can be gradually reduced as the differential rotates at a higher rotation frequency, so that the oil can be reliably prevented from flowing into the breather chamber.

Thus, oil leakage to the outside of the final reduction gear can be prevented.

With a breather structure for a final reduction gear equipped with a differential according to claim 2, the upper surface of the oil stop rib is formed declining and the lower surface thereof is formed as a receiving surface. With this arrangement, oil does not sump on the upper surface of the oil stop rib. Moreover, as an oil flow is blocked by the lower surface of the oil stop rib, the oil can sump in the lower part of the housing.

Thus, oil does not flow into the breather chamber, and so the oil can be prevented from flowing to the outside of the final reduction gear via the breather pipe.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A breather structure of a final reduction gear equipped with a differential, having the final reduction gear formed such that an upper part of a housing is made into a breather chamber, which is communicated with an outside via a breather pipe, and the differential is rotatably stored in the housing, wherein

a plurality of oil stop ribs are provided, extending toward the differential, on an inner circumferential surface of the housing, to prevent oil having been scooped by the differential from flowing into the breather chamber, and

the oil stop ribs are provided at irregular intervals.

2. A breather structure for a final reduction gear equipped with a differential according to claim 1, wherein

the oil stop ribs have upper surfaces and lower surfaces, which are shaped differently, the upper surface declining sharply so that blocked oil flows downwards, the lower surfaces being formed as a receiving surface for directly receiving rising oil.

Fig. 1

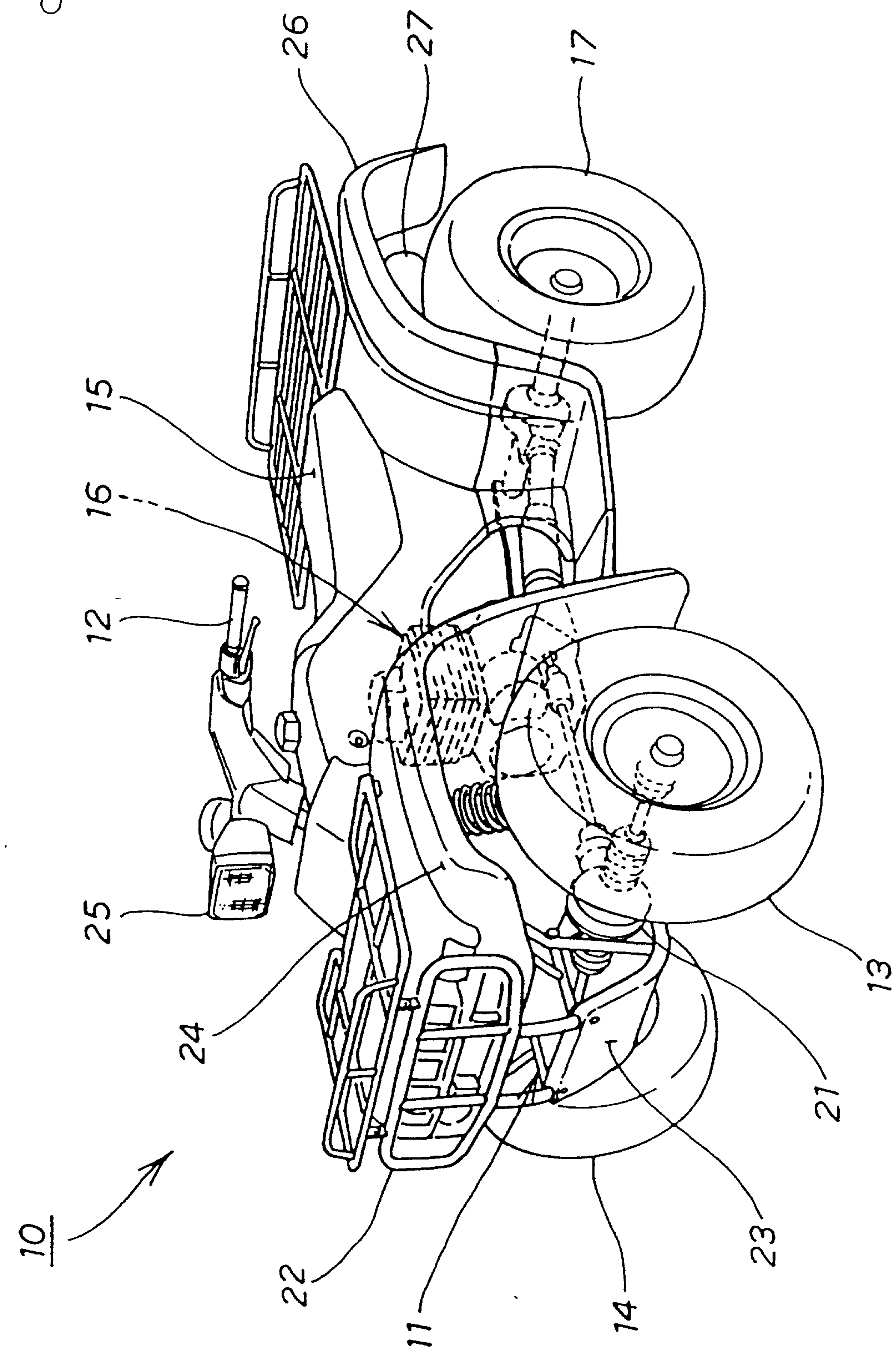


Fig. 2

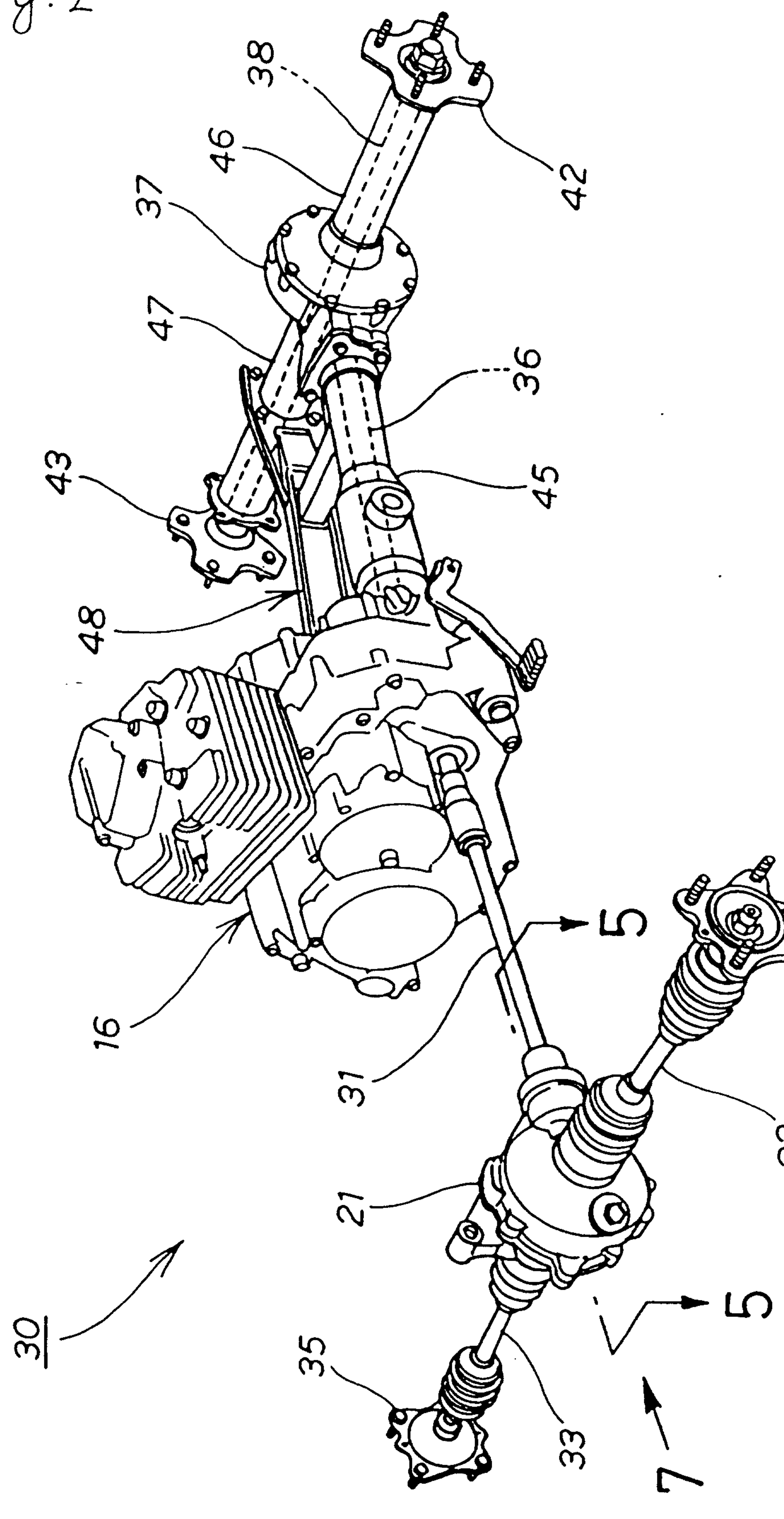


Fig. 3

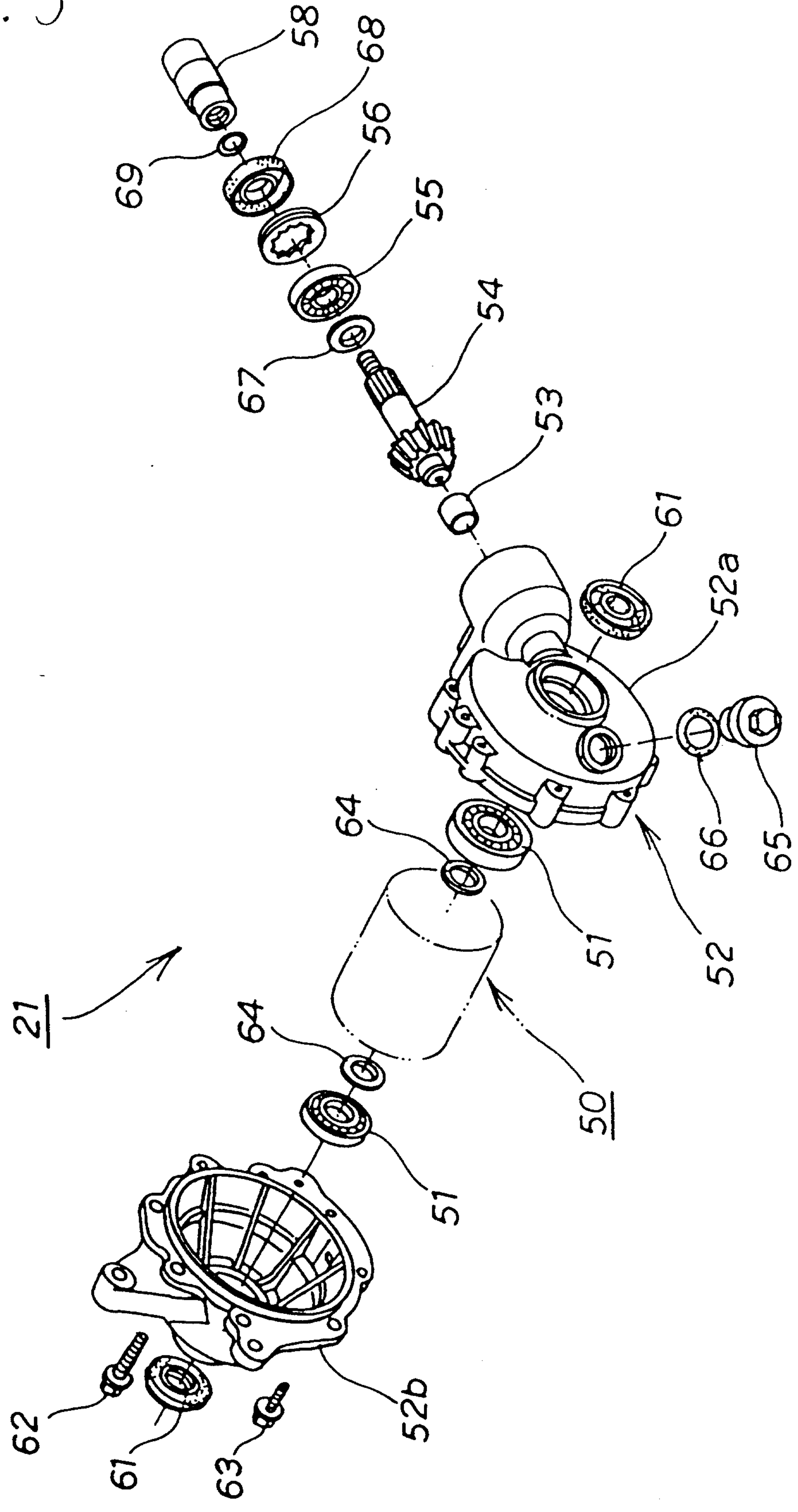


Fig.4

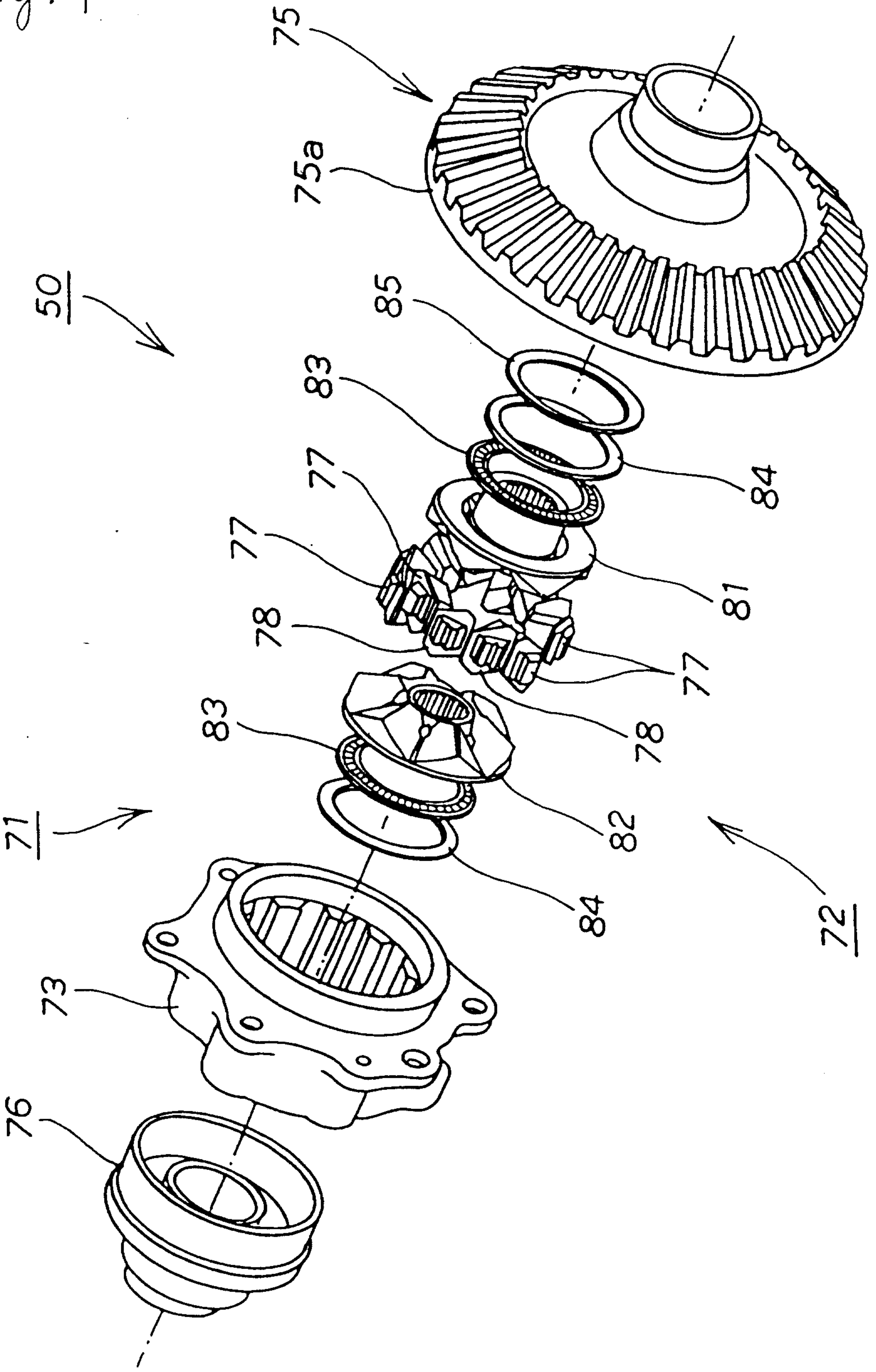


Fig5

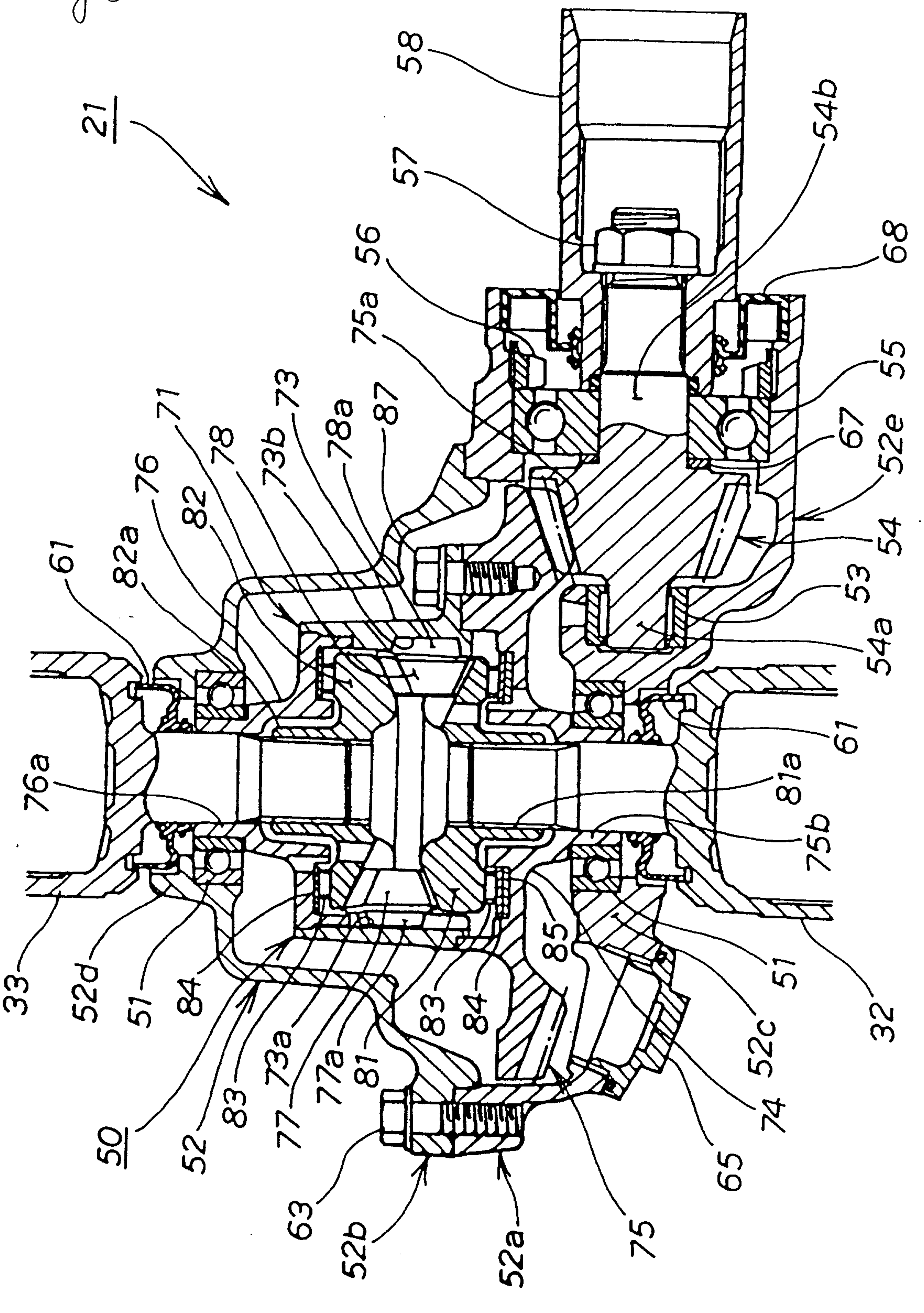

21
58
57
54b
56
68
75a
55
73
87
67
71
78a
52e
76
78
73b
54
82
53
82a
61
54a
61
81a
76a
75b
33
52d
51
84
85
51
32
50
52
83
73a
77
77a
81
83
84
52c
74
65
63
75
52b
52a

Fig. 6

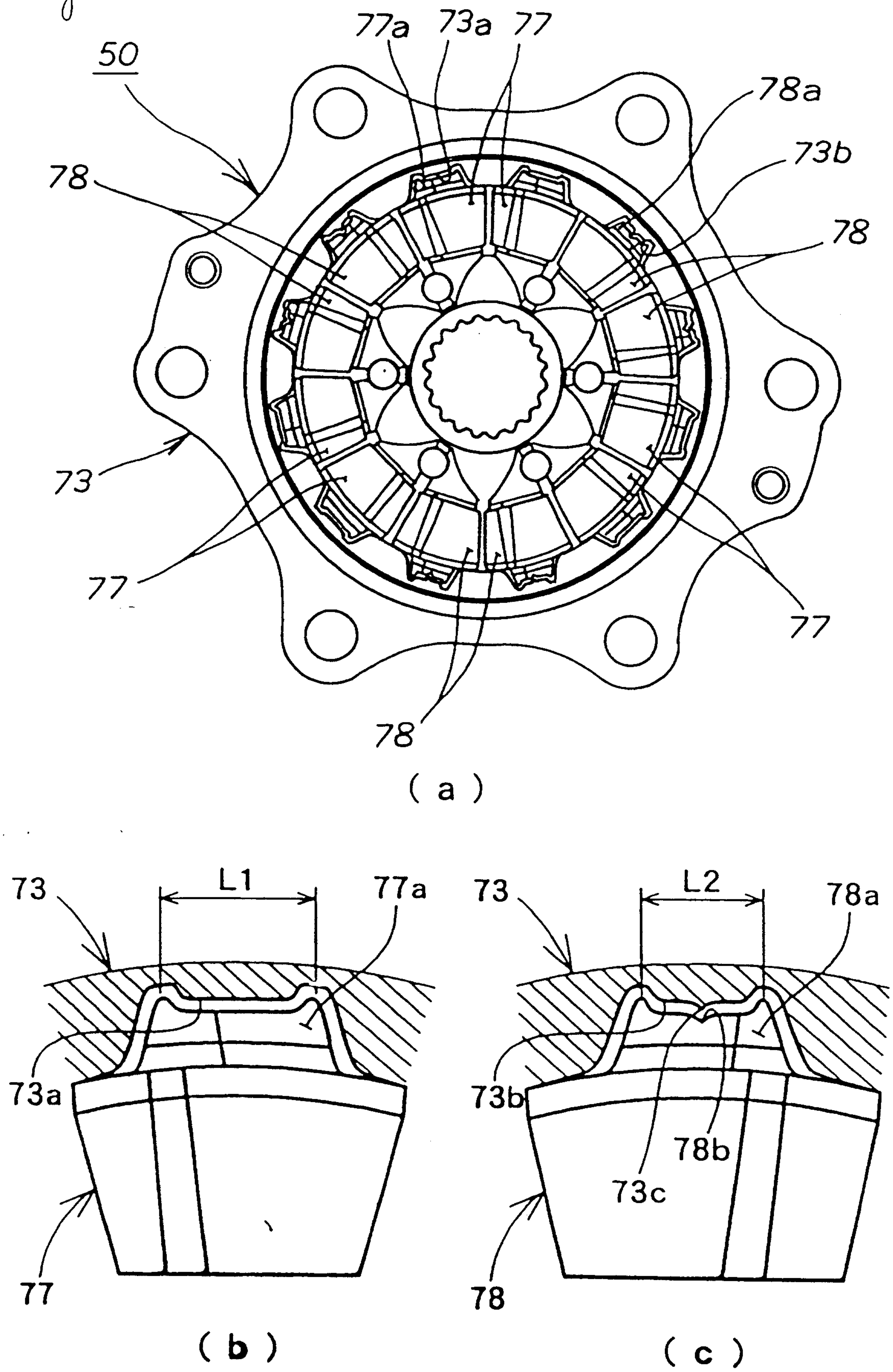
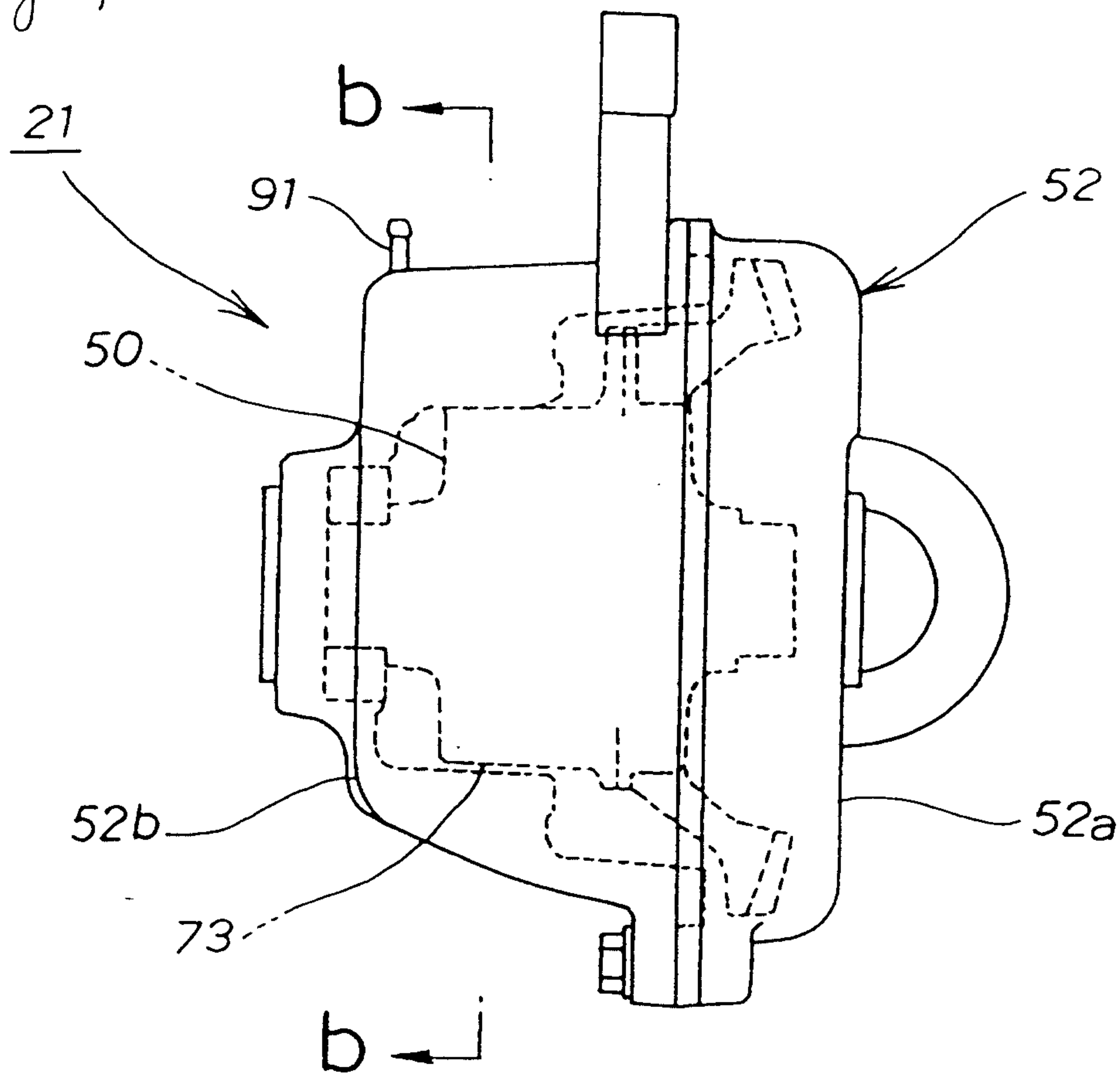
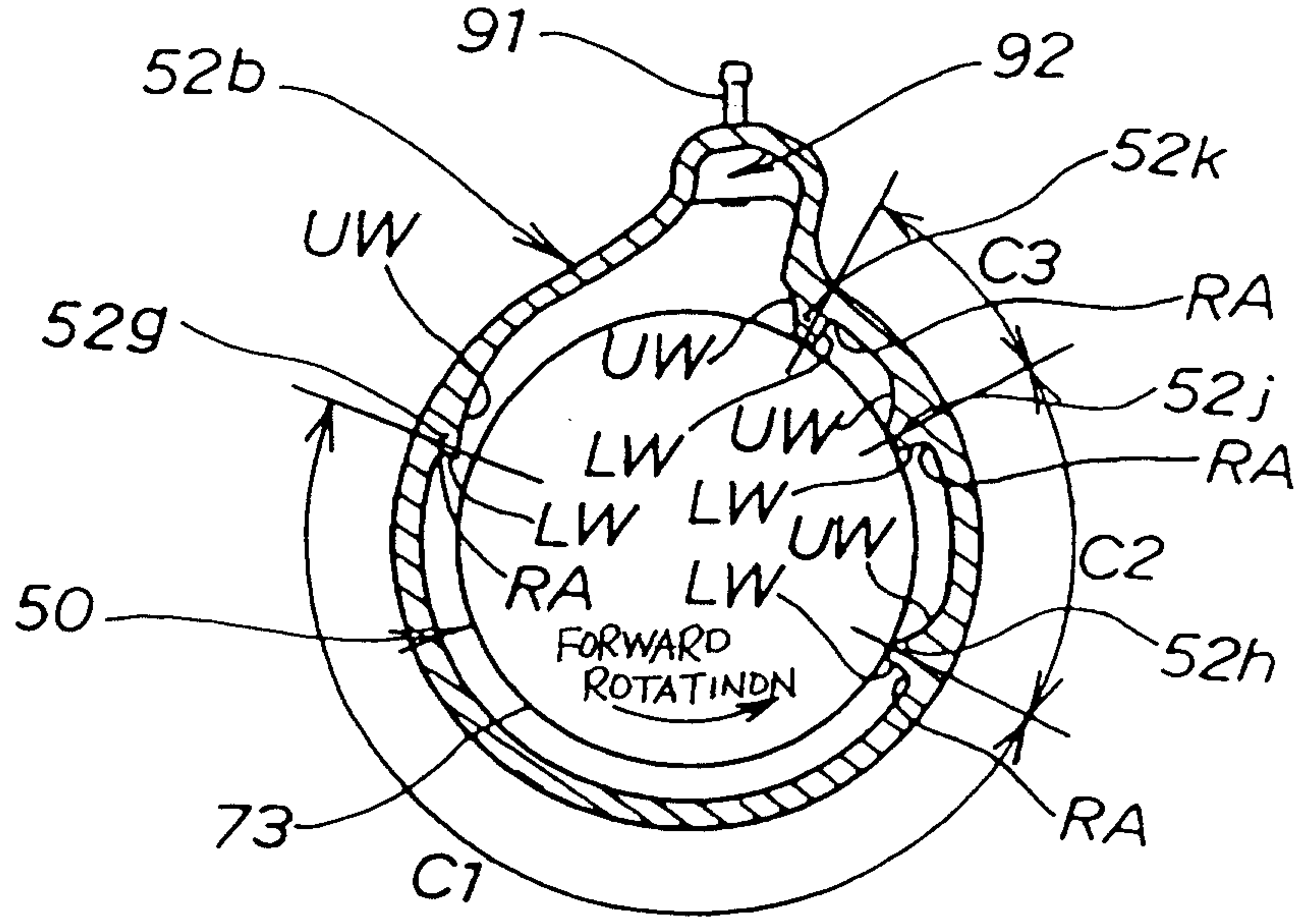

50
77a
73a
77
78a
73b
78
78
73
77
77
78
(a)
73
L1
77a
73a
77
(b)
73
L2
78a
73b
78b
73c
78
(c)

Fig.7


b
21
91
52
50
52b
52a
73
b

(a)


91
92
52b
52k
UW
C3
RA
52g
UW
52j
LW
UW
LW
LW
RA
RA
UW
LW
C2
50
FORWARD
ROTATINON
52h
73
RA
C1

(b)

Fig. 8

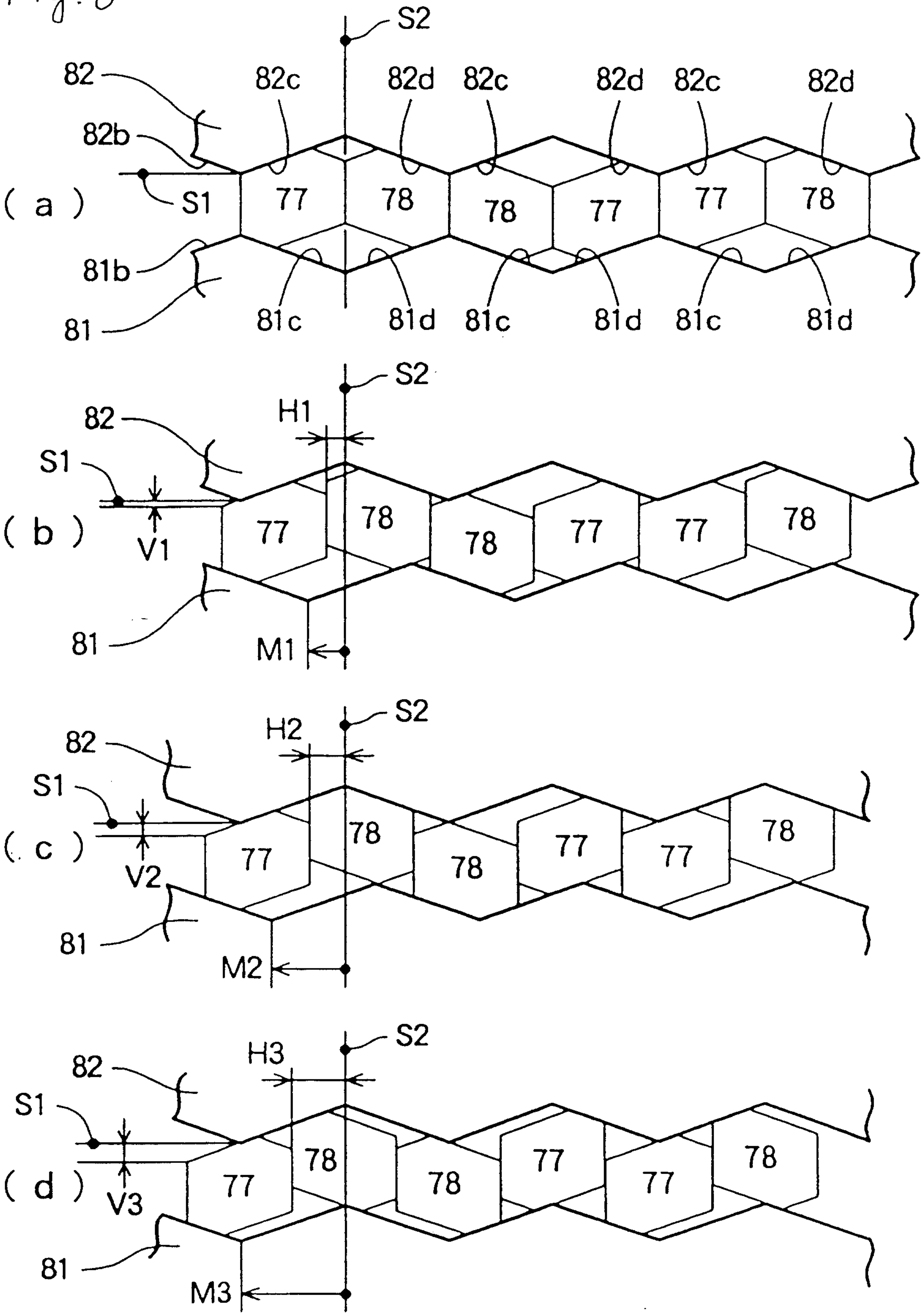
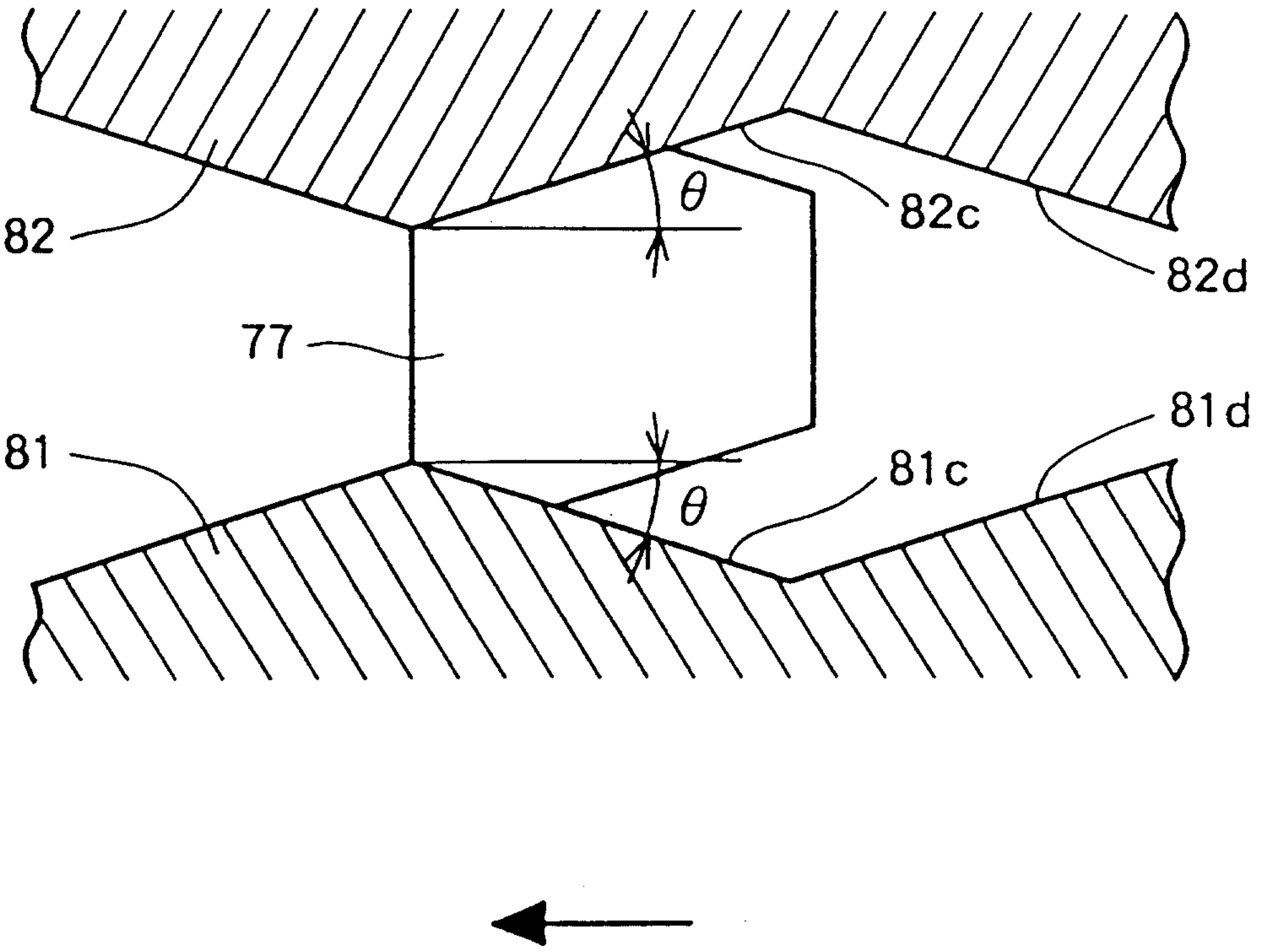

S2
82
82c
82d
82c
82d
82c
82d
82b
S1
(a)
77
78
78
77
77
78
81b
81
81c
81d
81c
81d
81c
81d
S2
H1
82
S1
(b)
V1
77
78
78
77
77
78
81
M1
S2
H2
82
S1
(c)
V2
77
78
78
77
77
78
81
M2
S2
H3
82
S1
(d)
V3
77
78
78
77
77
78
81
M3

Fig.9

(a)


82
θ
82c
82d
77
81
81d
81c
θ

(b)

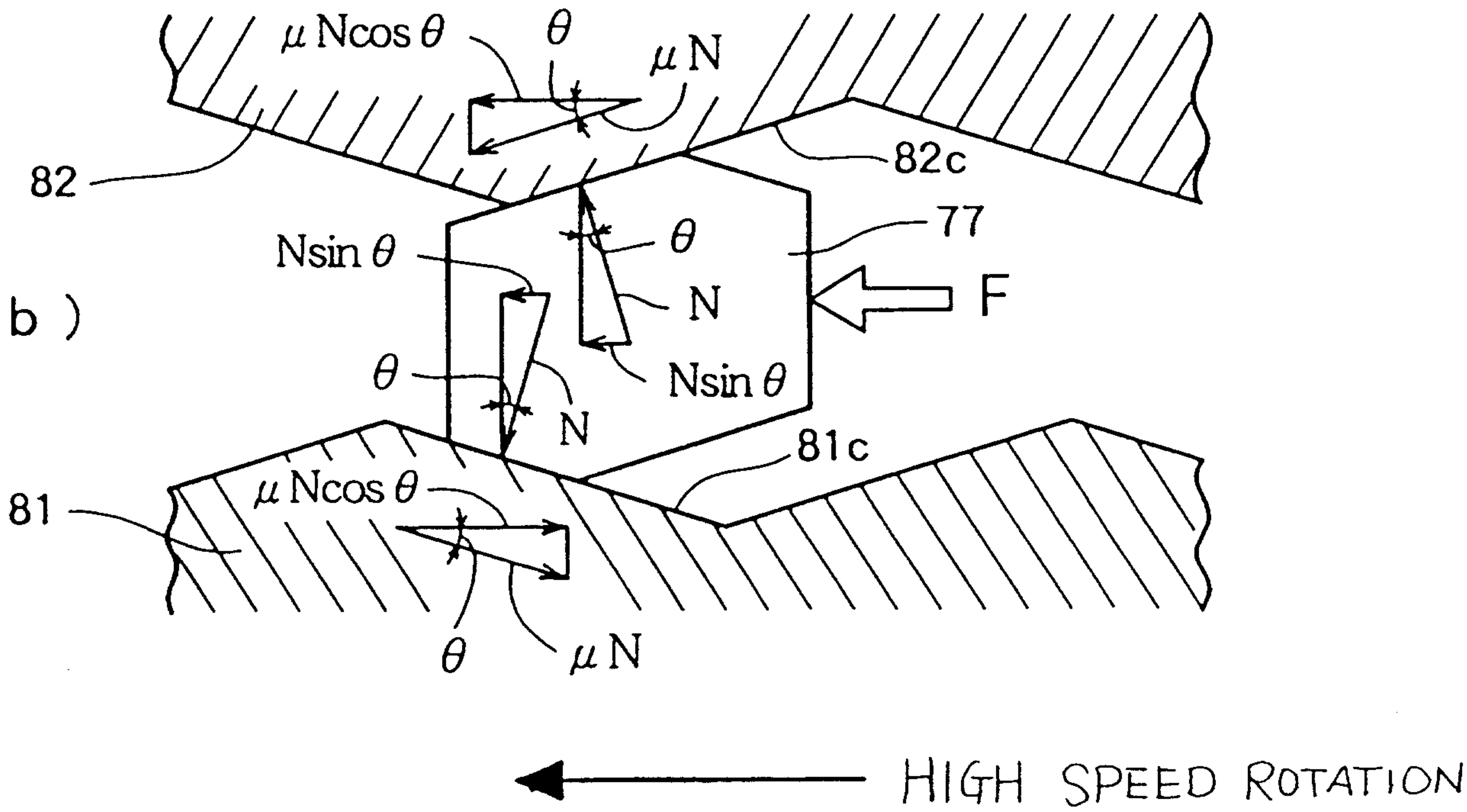
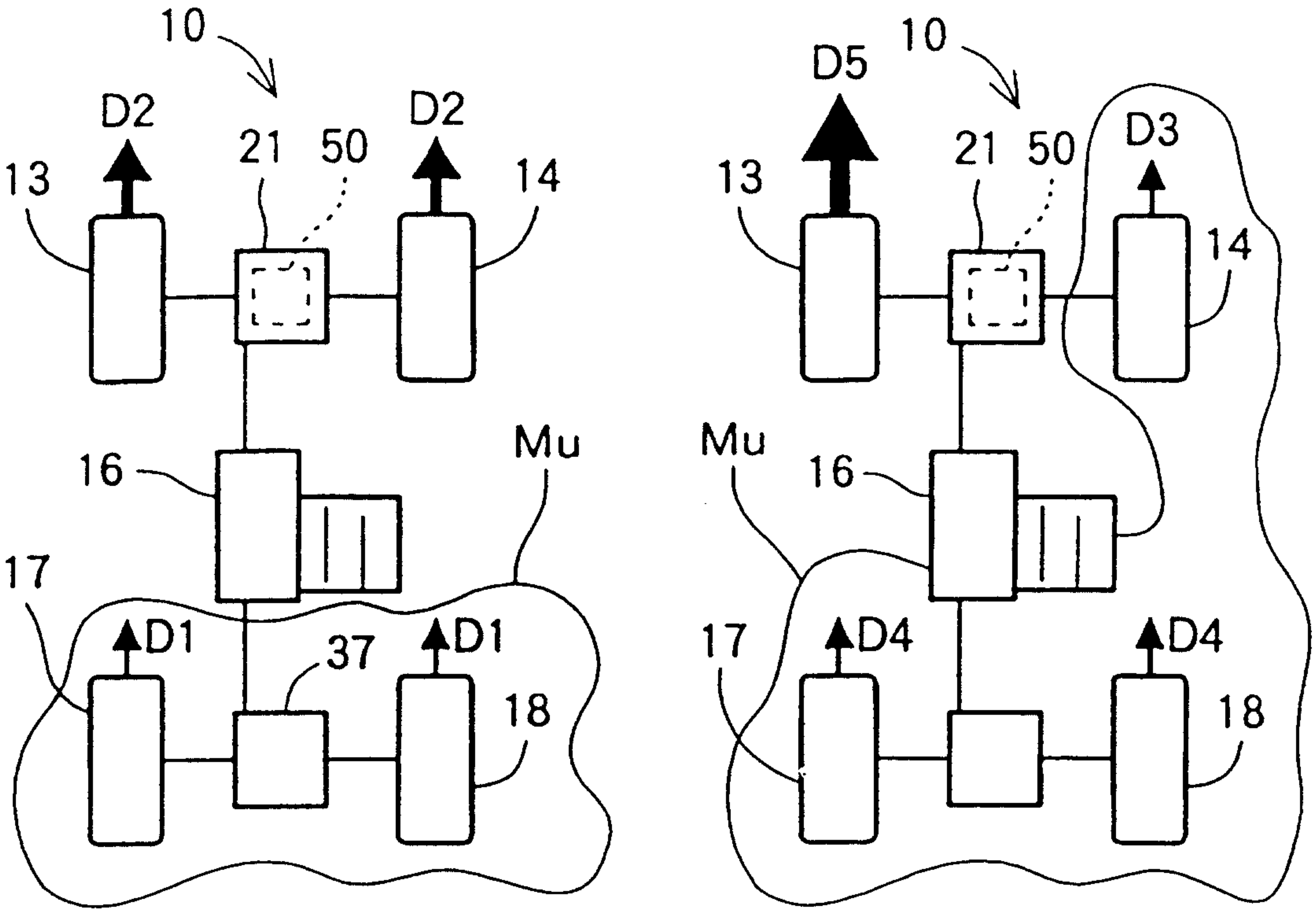
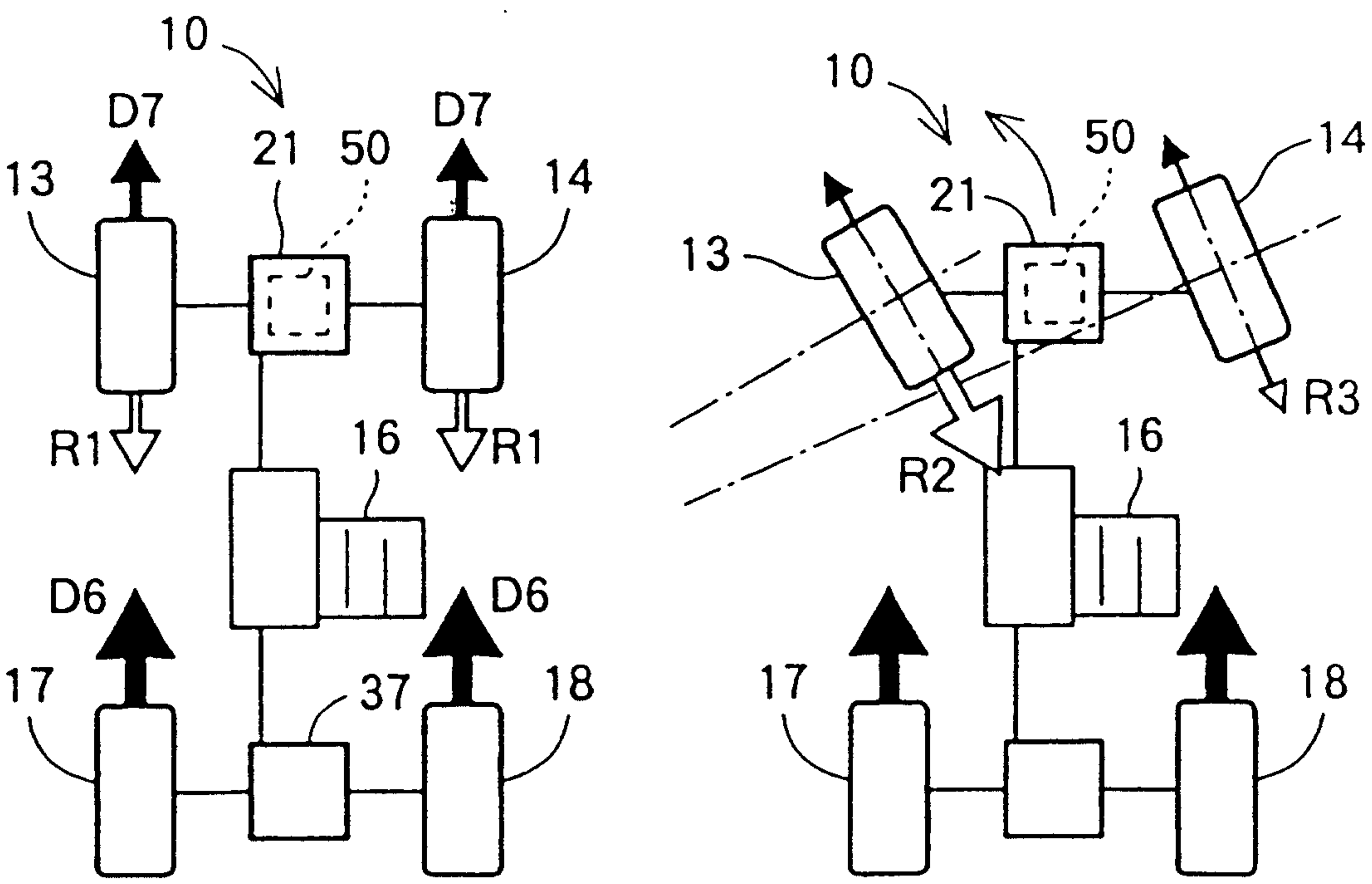

μNcosθ
θ
μN
82
82c
77
Nsinθ
θ
N
F
N
θ
Nsinθ
N
81c
81
μNcosθ
θ
μN
HIGH SPEED ROTATION

Fig. 10



(a)   (b)

Fig. 11



(a)   (b)

Fig. 12

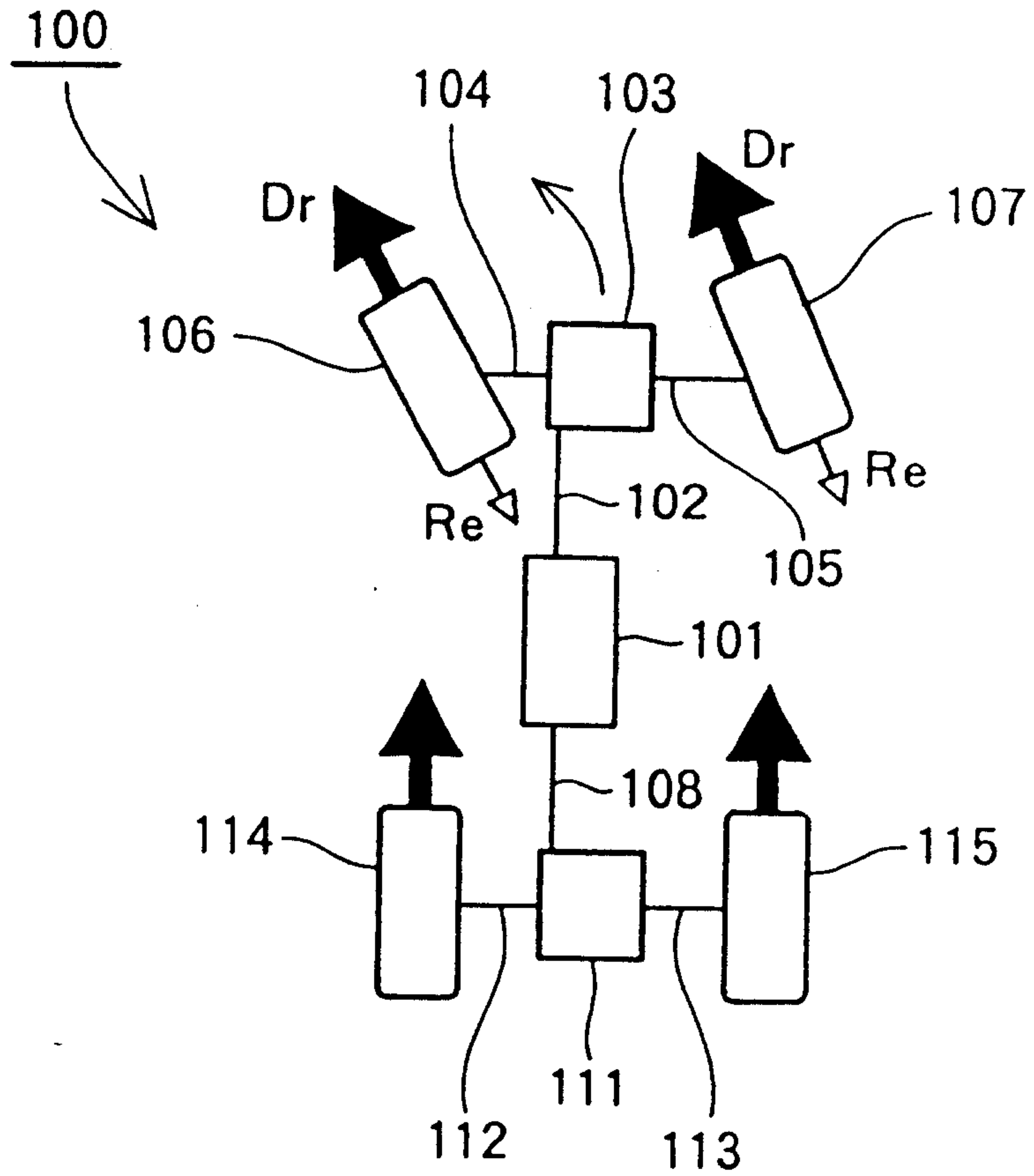
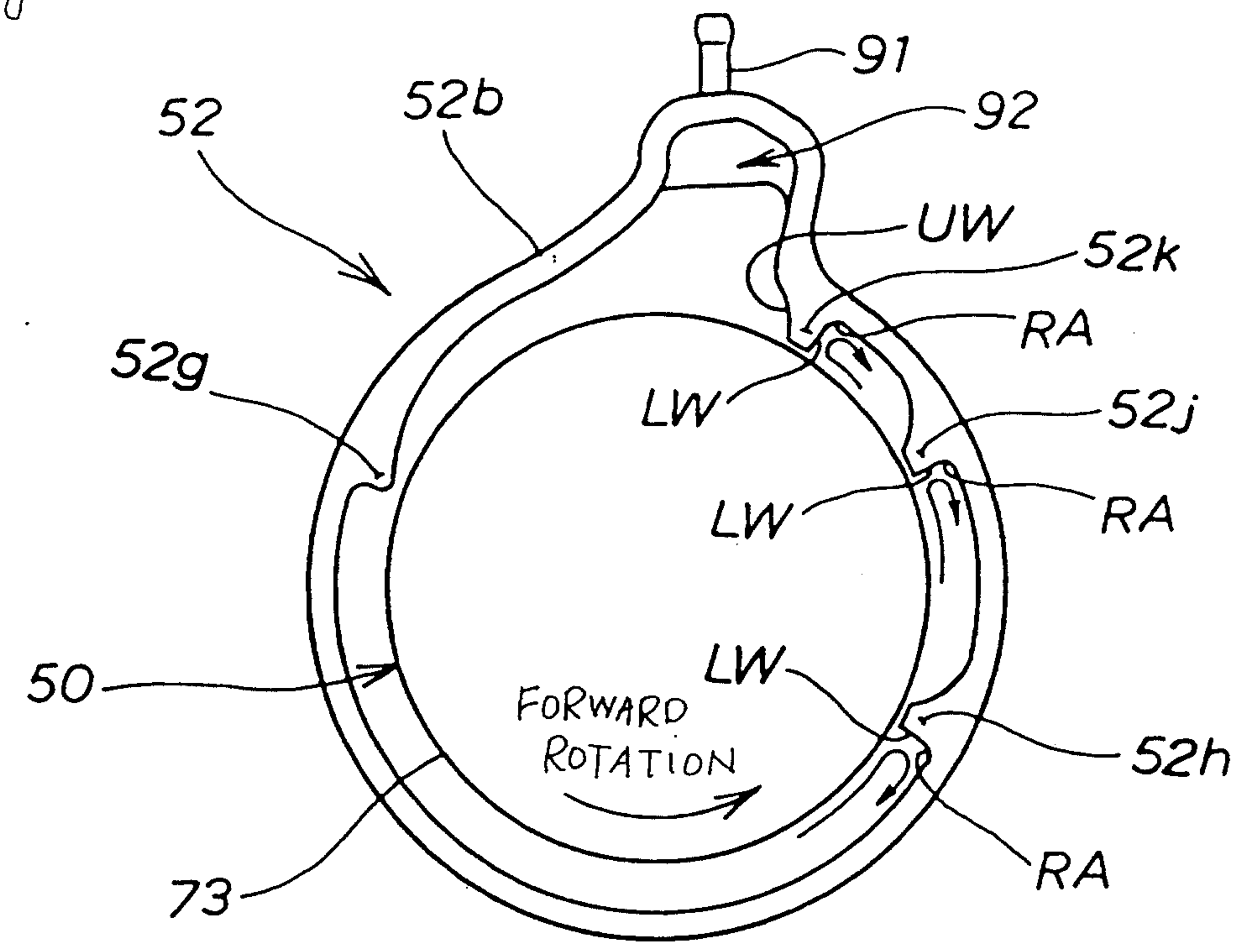
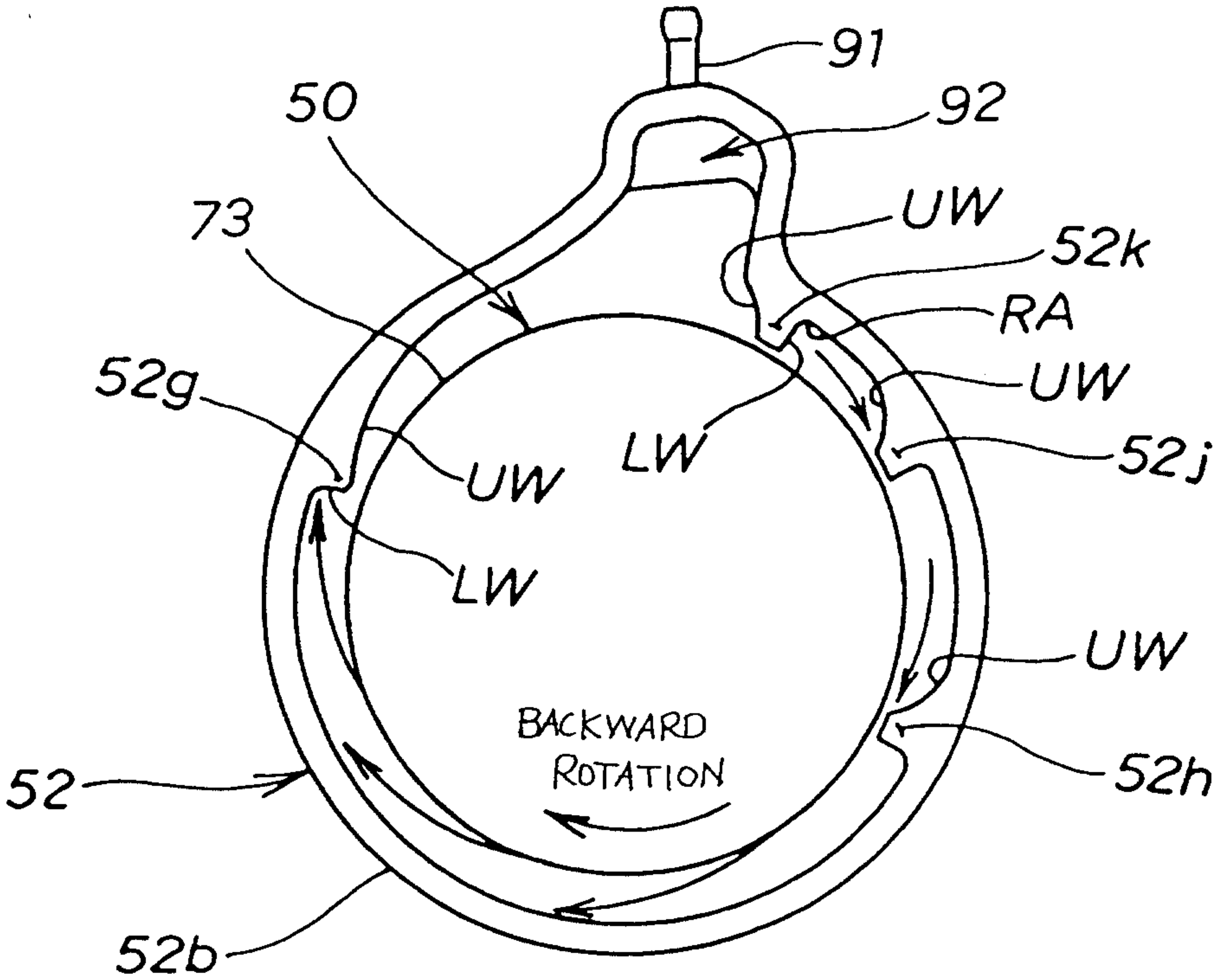

100
104
103
Dr
Dr
107
106
Re
102
Re
105
101
108
114
115
111
112
113

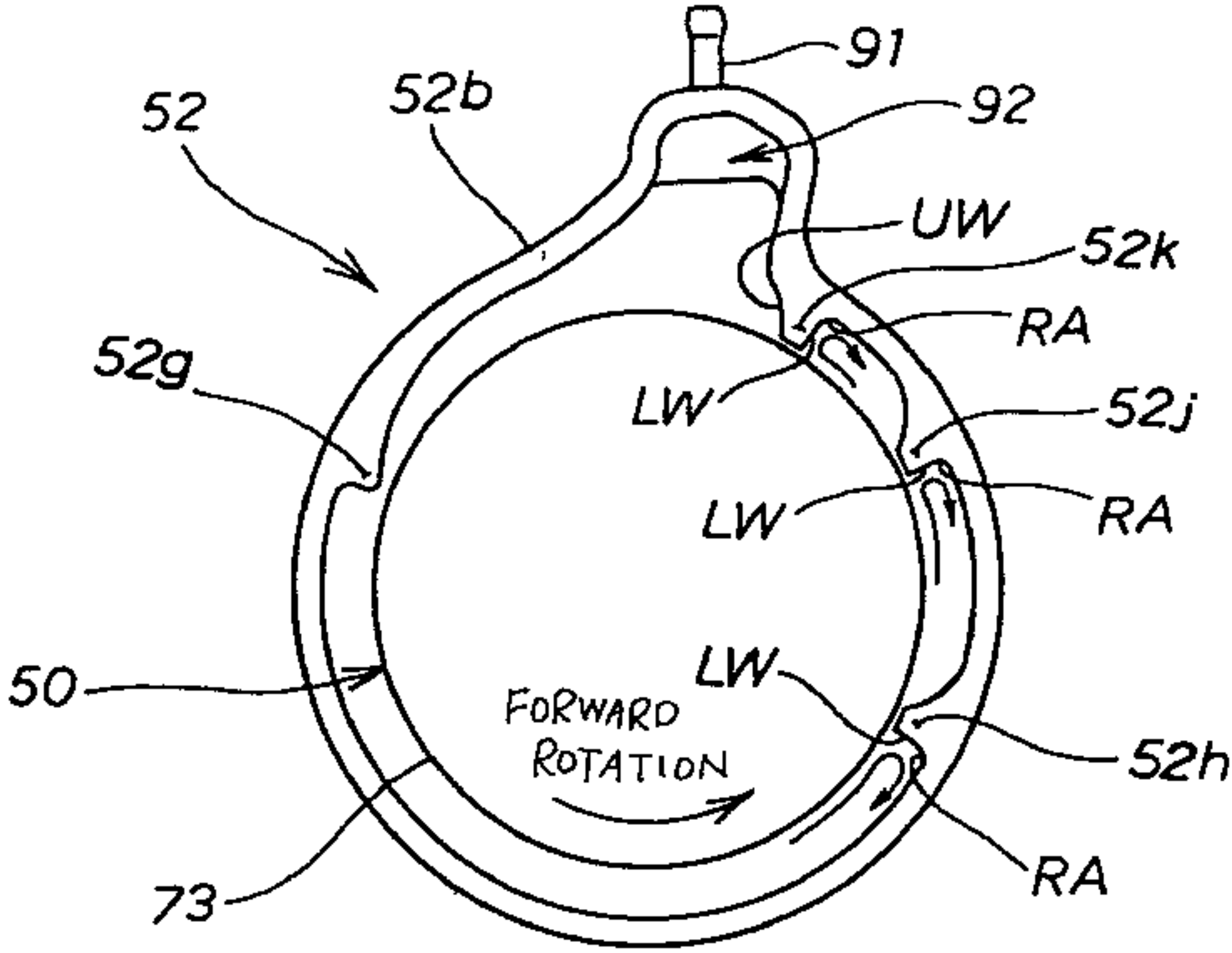
Fig. 13

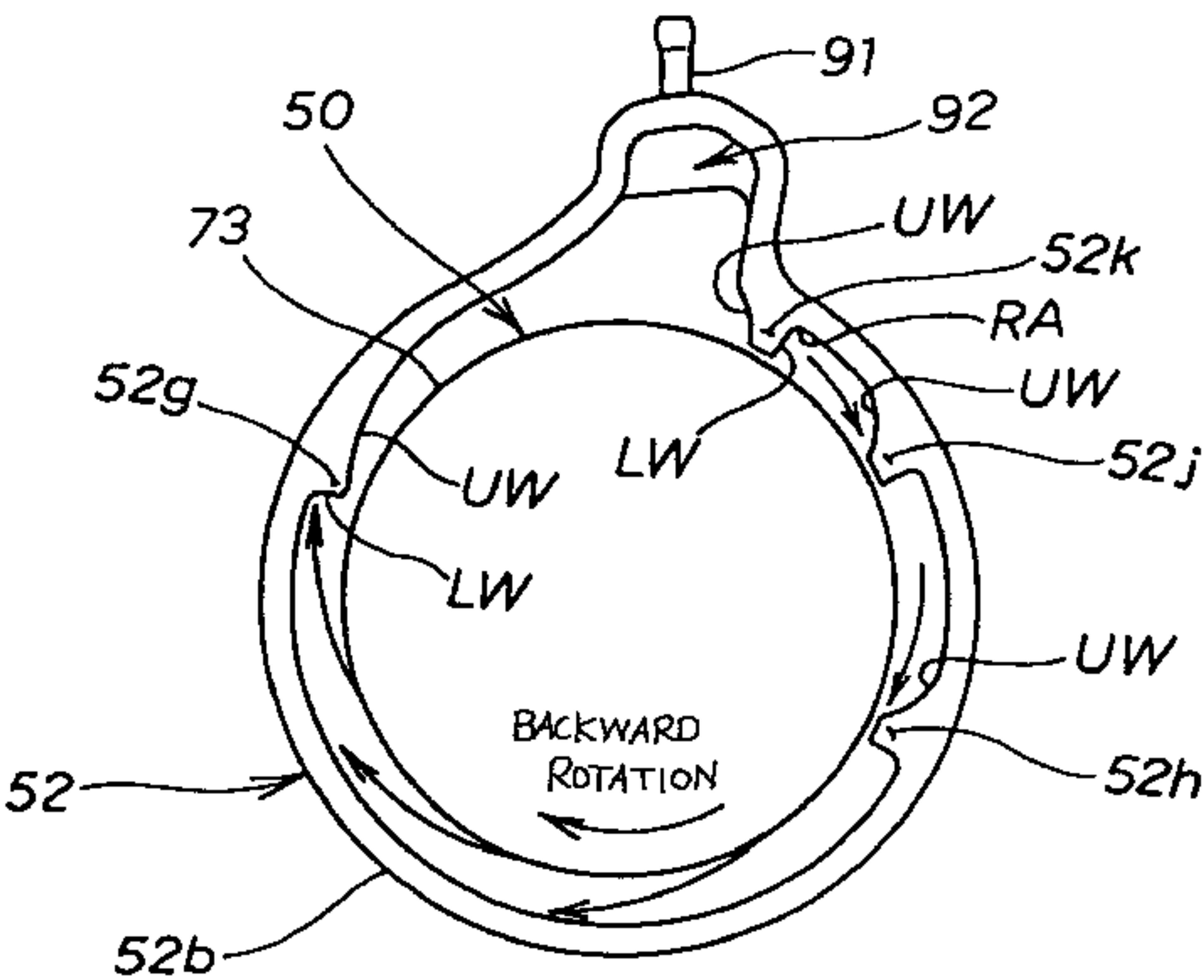

91
52
52b
92
UW
52k
RA
52g
LW
52j
LW
RA
50
LW
FORWARD
ROTATION
52h
73
RA

(a)


91
50
92
UW
73
52k
RA
52g
UW
LW
UW
52j
LW
UW
BACKWARD
ROTATION
52h
52
52b

(b)


91
92
52b
52
UW
52k
RA
52g
LW
52j
LW
RA
50
LW
FORWARD ROTATION
52h
73
RA
(a)


91
92
50
UW
73
52k
RA
52g
UW
LW
52j
UW
LW
BACKWARD ROTATION
UW
52h
52
52b
(b)