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WHEEL PROVIDED WITH SUBWHEELS

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(57) Claim

1. A wheel provided with sub-wheels, which comprises:

wheel means for forming a wheel having a circular rim formed around the outer periphery thereof;

a plurality of sub-wheel supporting means mounted on and around said circular rim so as to be directed radially and outwardly; and

a plurality of sub-wheels each rotatably supported by a respective one of said sub-wheel supporting means for rotation about an axis extending tangentially to said circular rim, said plurality of sub-wheels being arranged on the outer periphery of said wheel for constituting a tire;

wherein each sub-wheel supporting means comprises two inclined surfaces each inclined by a specific angle towards each other, and a respective main shaft on each said inclined surface so as to project therefrom, each said main shaft having at the center portion thereof a hole and having on the outer periphery thereof another of said sub-wheels mounted rotatably;

wherein a joint protector is interposed between each adjacent pair of said sub-wheel supporting means, said joint protector having a wedge-shaped section and being provided with two short shafts fitted in the center holes of said sub-wheel supporting shafts; and

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wherein an elastic interposition member is disposed around the circumference of the wheel and has radially outward projections interposed between each adjacent pair of said sub-wheel, said interposition member having an outermost diameter which is substantially the same as the outermost peripheral diameter of the tire constituted by the sub-wheels.

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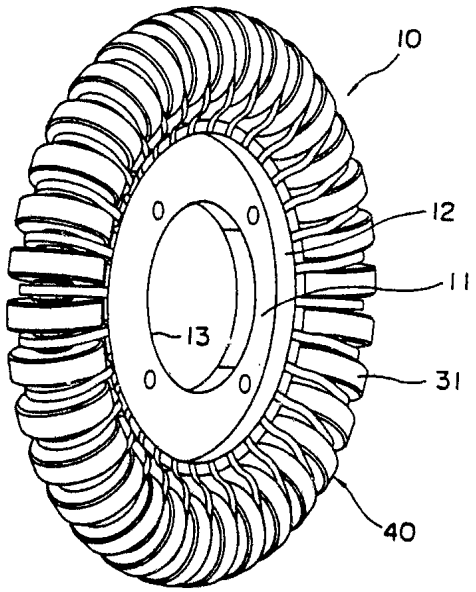

(57) Abstract

A composite wheel device wherein a plurality of auxiliary wheels (31) supported rotatably about axes in directions identical with tangent lines of a circular rim portion (12) of a wheel are provided on the circular rim portion so as to form a tire (40), and rotation of the tire and rotations of the auxiliary wheels are combined together so as to make the wheel run in a desirable direction.

WHEEL PROVIDED WITH SUB-WHEELS

Technical Field

The present invention relates to a wheel which runs in rotation, and more particularly to a wheel provided with sub-wheels having two directions of running in rotation which intersect perpendicularly to each other.

Background Art

Almost all wheels which run on the ground or the floor comprise a tire part which is made of rubber or metal, this tire part constituting the outer peripheral portion of the wheel, a rim part for supporting the tire part, and a disk or spoke which connects the rim part to the hub.

Since the wheel as stated above is rotated about a wheel axle or shaft, the running direction thereof is limited to a direction perpendicular to the wheel shaft.

For this reason, in the case where the running direction of the wheel is required to be changed, a method is adopted comprising swinging the wheel shaft itself to a direction perpendicular to the running direction by using a steering gear connected to the wheel shaft.

However, it is often difficult to carry out the swinging operation of the wheel using the method comprising swinging the entire wheel in the running direction together with the wheel shaft because of the greater contact frictional force between the tire and the ground (the floor) during stoppage of the wheel. Furthermore, the wheel is required to uselessly follow a locus of a circular arc until it is directed to a desired running direction, which makes change in the running direction of the wheel within a narrow space difficult.

As a means for solving such a problem, a caster device is used which serves to swing the entire wheel about a shaft orientated perpendicular to the wheel shaft and provided at an eccentric position. However, the

caster device cannot perfectly solve the above-mentioned problem, and still includes problems such as difficulty in changing the running direction of the wheel during stoppage thereof or difficulty in conversion of the direction of the wheel to that perpendicular to the running direction. In addition, since the caster device easily changes the direction of the wheel shaft during the running thereof, there is a restriction in its use which makes it impossible to increase the running speed of the wheel and the diameter thereof.

Furthermore, a further means to solve the above-mentioned problems has been developed and comprises a wheel device in which two independent wheels with wheel shafts perpendicularly intersecting each other are combined. However, this wheel device has a disadvantage in that it is necessary to provide a means for shifting and drawing in one of the wheels when the other is being used, which results in a complicated construction and a larger-sized device.

Disclosure of Invention.

The problem to be solved by the invention is to simply change the running direction of a wheel without describing a locus of a circular arc. A further problem is to realize a wheel device which permits simple change in the running direction of the wheel as mentioned above, with a simple and smaller-sized construction.

The present invention provides a wheel provided with sub-wheels, which comprises:

wheel means for forming a wheel having a circular rim formed around the outer periphery thereof;

a plurality of sub-wheel supporting means mounted on and around said circular rim so as to be directed radially and outwardly; and

a plurality of sub-wheels each rotatably supported by a respective one of said sub-wheel supporting means for rotation about an axis extending tangentially to said circular rim, said plurality of sub-wheels being arranged on the outer periphery of said wheel for constituting a tire;

wherein each sub-wheel supporting means comprises two inclined surfaces each inclined by a specific angle towards each other, and a respective main shaft on each said inclined surface so as to project therefrom, each said

main shaft having at the center portion thereof a hole and having on the outer periphery thereof another of said sub-wheels mounted rotatably;

wherein a joint protector is interposed between each adjacent pair of said sub-wheel supporting means, said joint protector having a wedge-shaped section and being provided with two short shafts fitted in the center holes of said sub-wheel supporting shafts; and

wherein an elastic interposition member is disposed around the circumference of the wheel and has radially outward projections interposed between each adjacent pair of said sub-wheel, said interposition member having an outermost diameter which is substantially the same as the outermost peripheral diameter of the tire constituted by the sub-wheels.

The wheel provided with sub-wheels according to the invention enables the tire to run in a direction perpendicular to that of the rotation of the wheel shaft because of the rotation of the sub-wheels, while enabling the tire to run in the direction of the rotation of the

wheel shaft. In addition, a combination of the rotation of the tire with that of the sub-wheels permits the wheel to run in an arbitrary direction without swinging the wheel shaft to the running direction thereof.

Brief Description of the Drawings

Fig. 1 is a perspective view showing the exterior appearance of an embodiment of a wheel provided with sub-wheels according to the invention;

Fig. 2 is a perspective view, partly in cross section, of a disk with sub-wheel supporting plates and sub-wheels mounted on the disk;

Fig. 3 is an exploded perspective view illustrating how the sub-wheels are mounted on the sub-wheel supporting plate;

Figs. 4(a) and (b) are a perspective view and a top plan view illustrating an example of the sub-wheel supporting plate, respectively;

Fig. 5 is a perspective view showing a plurality of sub-wheel supporting plates mounted on the disk;

Fig. 6 is a perspective view illustrating a second embodiment of the invention;

Fig. 7 is a perspective view indicating how the wheel provided with sub-wheels according to the second embodiment is assembled;

Fig. 8 is an exploded perspective view illustrating the construction for supporting the sub-wheel in the second embodiment;

Fig. 9 is a perspective view showing a sub-wheel supporting member in the second embodiment of the invention;

Fig. 10 is a perspective view showing a modification of the second embodiment of the invention;

Fig. 11 is a perspective view illustrating a third embodiment of the invention;

Fig. 12 is a perspective view indicating a state where the sub-wheels are incorporated into the sub-wheel supporting member in the third embodiment;

Fig. 13 is a perspective view of a joint protector;

Fig. 14 is a perspective view illustrating the construction for supporting the sub-wheels in the third embodiment;

Fig. 15 is a schematic perspective view indicating the rotation and braking function of the sub-wheels in the third embodiment;

Fig. 16 is a perspective view illustrating a modification of the third embodiment;

Fig. 17 is a perspective view illustrating a modification of the sub-wheel supporting member;

Fig. 18 is a perspective view of a joint protector;

Fig. 19 is a perspective view of a modification of the sub-wheel;

Fig. 20 is an exploded perspective view illustrating a method for assembly thereof;

Fig. 21 is a perspective view of one assembled block;

Fig. 22 is a partial sectional view illustrating the construction for supporting the sub-wheels;

Fig. 23 is an axial view illustrating a fourth embodiment of the invention;

Fig. 24 is an orthogonal view of the wheel in Fig. 23;

Fig. 25 is a sectional view taken along line A-A of Fig. 23;

Fig. 26 is a perspective view illustrating a fifth embodiment of the invention;

Fig. 27 is a sectional view of the wheel provided with sub-wheels according to the fifth embodiment; and

Fig. 28 is a perspective view illustrating the sub-wheel bearing in the fifth embodiment.

Best Modes for Carrying out the Invention

Now, embodiments of the invention will be described with reference to the drawings.

Fig. 1 is a perspective view illustrating an embodiment of a wheel 10 provided with sub-wheels according to the invention.

Referring to the drawings, numeral 11 designates a disk for supporting the entire wheel. The disk 11 is formed at the outer periphery thereof with a circular rim 12 and is provided at the center portion with an opening 13 through which a wheel axle or shaft (not shown) is inserted.

As shown in Fig. 2, a plurality of grooves 14 are provided on the circular rim 12 at equal pitch intervals and in the same direction as the axis of the circular rim 12. A base end 22 of each of sub-wheel supporting plates 21 is fitted in a respective one of the grooves 14.

Each of the sub-wheel supporting plates 21 is in the form of a plate and is provided with the base end 22 fitted in a groove 14 and a sub-wheel bearing 23 provided at the end opposite to the base end 22.

The base end 22 has a thickness t which is the same as or somewhat greater than the width T of the groove 14. The sub-wheel bearing 23 has bearing holes passing through the sub-wheel supporting plate 21, which are constituted by two bearing holes 25a and 25b having their respective axes 24a and 24b each inclined by an angle θ from a line perpendicular to the sub-wheel supporting plate 21 towards the side of the base end 22. Furthermore, the sub-wheel bearing 23 is provided with two inclined bosses 26, each having an inclined surface 26a inclined at an angle θ with respect to the sub-wheel supporting plate 21 so as to converge towards the base end 22 in order to make the bearing length of the two bearing holes 25a, 25b greater. The angle θ is determined by the number of grooves 14 provided on the circular rim 12, that is, the number of sub-wheels supported by the sub-wheel supporting plate 21.

As shown in Figs. 2 and 5, the sub-wheel supporting plates 21 of the construction as stated above, are

fixedly mounted on the outer periphery of the circular rim 12 at equal pitch intervals by fitting the base ends 22 of the plates 21 into the grooves 14 of the circular rim 12.

The sub-wheel supporting plates 21 are secured to the outer periphery of the circular rim 12 by fitting the sub-wheels 31 to the sub-wheel bearings 23 from opposite sides of the sub-wheel supporting plate 21, as shown in Fig. 3.

As shown in Figs. 1, 2 and 3, the sub-wheels 31 are in the form of disks, each one being formed at the center of each side surface thereof with a rotational supporting shaft 32 projecting therefrom. The width of the outer periphery of the sub-wheel is preferably made as large as possible, as long as it does not rub against the base end side of the sub-wheel supporting plate 21.

The outer diameter of the sub-wheel 31 is such that the radial outer end portion thereof, after being fitted to the sub-wheel supporting plate 21, projects outward beyond the outermost end portion of the sub-wheel supporting plate 21.

Each of the sub-wheels 31 is supported at each end thereof by a sub-wheel supporting plate 21, with the rotational supporting shafts 32 thereof being inserted in the bearing holes 25a, 25b of the sub-wheel bearing 23. In order to rotatably support the sub-wheel 31 with the rotational supporting shafts 32 thereof as a center, the bearing holes 25a, 25b and the rotational supporting shafts 32 are constituted as bearing constructions. For such bearing constructions, plain bearings, ball and roller bearings and the like may be employed depending on the load applied to the sub-wheel 31 or the rotational speed thereof.

As shown in Fig. 1, the outermost peripheral part (tire part) 40 of the wheel 10 is constituted by supporting rotatably each of a plurality of sub-wheels on the sub-wheel supporting plates 21 to thereby dispose

them at equal pitch intervals on the outer periphery of the circular rim 12.

The wheel 10 provided with sub-wheels 31 according to the embodiment of the construction as described above provides the following advantageous effects.

The wheel 10 provided with sub-wheels 31 is mounted on a wheel shaft using the opening 13 of the disk 11 and can be used as a wheel having the tire 40 constituted by a plurality of sub-wheels 31 mounted on the circumference. That is, when the wheel is rotated about the wheel shaft (not shown), it runs in the same direction as that of the rolling movement of the tire 40, similar to an ordinary wheel.

The sub-wheels 31 are independently rotated by rotating each of the sub-wheels 31 about its axis by means of an actuator (not shown) or applying an external force thereto in the same direction as that of the wheel shaft. The rotation of the sub-wheels 31 causes the wheel 10 to move in the same direction as the wheel shaft (the direction perpendicular to that of the rolling movement of the tire 40). The movement of the wheel is simply carried out without requiring any greater force also in the state where the wheel 10 is stopped.

When the rolling movement of the tire 40 and the rotation movement of the sub-wheels 31 are carried out simultaneously, the wheel 10 runs in the direction of the combined vector of both movements. Consequently, if the rotation movement of the tire 40 and the rotation movement of the sub-wheels 31 are controlled simultaneously, the wheel 10 can be moved in an arbitrary direction without turning the wheel shaft.

Figs. 6 to 9 are views illustrating a second embodiment of the invention.

In this embodiment, sub-wheel supporting members 42 for rotatably supporting the sub wheels 41 are made greater in size than those of the preceding embodiment to thereby increase the strength thereof.

As shown in Fig. 9, the sub-wheel supporting member 42 includes a notched inclined plate-like disk 43 prepared by cutting off the bottom of the inclined disk member of the trapezoid-like cross-section with two inclined surfaces 43a along a cut surface 43b parallel to the bottom side. Furthermore, the notched inclined disk member 43 is provided in the outer periphery thereof with outer peripheral edges 43c extending outwardly in the axial direction from the two inclined surfaces 43a.

The two inclined surfaces 43a are each inclined by an angle of θ in the direction of convergence with each other with respect to a surface perpendicular to the cut surface 43b. A main shaft 44 is provided on one of the two inclined surfaces 43a and a sub-shaft 45 is provided on the other, each of the shafts extending outward perpendicularly to the respective inclined surfaces. That is, the respective axes 44a and 45a of the main shaft 44 and the sub-shaft 45 are inclined by the angle of θ with respect to a line parallel to the cut surface 43b. The main shaft 44 is provided at the center thereof with a hole 44b in which the sub-shaft 45 of an adjacent sub-wheel supporting member 42 can be fitted.

A guide rail member 46 of the T-shaped cross-section is secured to the end opposite the cut surface 43b of the notched inclined disk member 43, substantially parallel to the cut surface 43b.

As shown in Fig. 8, a hollow cylindrical sub-wheel 41 with a diameter smaller than that of the notched inclined disk member 43 is rotatably mounted on the main shaft 44 of the sub-wheel supporting member 42. A bearing member such as a ball or roller bearing or a plain bearing (not shown) is interposed in the fitting part between the main shaft 44 and the sub-wheel 41.

As shown in Fig. 7, the sub-wheel supporting members 42 with the respective sub-wheels 41 mounted thereon, are fitted to the circular rim member 47 by inserting them into a plurality of grooves 48 formed on the outer

periphery thereof in the same direction as the axis of the wheel at equal pitch intervals.

The sub-wheel supporting members 42 are continuously fitted to the outer periphery of the circular rim member 47 in such a manner that the sub-shafts 45 of the adjacent sub-wheel supporting members 42 are fitted in the center holes 44b of the main shafts 44, which results in a construction wherein the main shafts 44 are supported at both ends thereof.

A rim cover 49 is subsequently attached to the rim member 47 and a wheel 50 provided with the sub-wheels 41 is obtained as shown in Fig. 6. This wheel 50 permits a possible increase in the load applied to each sub-wheel 41, because the sub-wheel 41 is rotatably supported on the main shaft 44 with a greater diameter and simultaneously the free end of the main shaft 44 is mounted on and held by the sub-shaft 45 of the adjacent sub-wheel supporting member 42.

Since a portion of the sub-wheel 41 is arranged so as to extend radially outwardly from the cut surface 43b of the sub-wheel supporting member 42, the wheel 50 can be moved in the same direction as the wheel shaft, similarly as in the preceding embodiment. The outermost peripheral part (tire part) of the wheel 50 is formed by the plurality of sub-wheels arranged at equal pitch intervals so that the wheel 50 can run in the same direction as that of the rolling movement of the tire, similarly as in the case of an ordinary wheel.

The wheel 50 according to the invention can be used as a wheel to which a greater load is applied. The outer diameter of the notched inclined disk member 43 made greater than the diameter of the sub-wheel 41 is capable of preventing any foreign matter from colliding with the sub-wheels 41 from the side of the wheel 50.

Fig. 10 is a perspective view illustrating a modification of the embodiment shown in Fig. 6. In a wheel 60 provided with sub-wheels according to this

embodiment, two ends 53b of a cut surface 53a of a notched disk member of each of sub-wheel supporting members 51 for supporting rotatably sub-wheels 41 are contoured in a smooth circular arc.

Since the construction other than that stated above is the same as the preceding second embodiment, description thereof is omitted.

The contour of a circular arc at the two ends of the cut surface 53a of the sub-wheel supporting member 51 provides a smooth configuration for the outer periphery of the wheel 60, which results in fewer collisions of a part of the sub-wheel supporting member 51 with the ground in the rolling movement of the wheel 60 and movement of the sub-wheels 41 in the direction of the wheel shaft due to rotation of the sub-wheels. The wheel 60 according to this embodiment is particularly suitable in the case where the wheel is used in an inclined state.

Figs. 11 to 15 are views illustrating a third embodiment of the invention.

In this embodiment, the sub-wheel supporting member is fitted, at both ends of a cut surface thereof, with elastic members made of something like an edge rubber. Fig. 12 shows the sub-wheel supporting member 71 used in the present embodiment. The sub-wheel supporting member 71 includes a notched disk member 72 made by cutting off a portion of the disk member along a cut surface 72a parallel to the diametrical direction, and a rim 73 formed along the outer periphery of the notched disk member 72. A guide rail member 76 of a T-shaped section is secured to the rim 73 at the end opposite the cut surface 72a, parallel to the axis of the notched disk member 72. The rim 73 is fitted at both ends thereof with edge rubbers 74, each having an inclined surface 74a inclined so as to diverge outwardly, each said edge rubber 74 projecting from the cut surface 72a. Furthermore, the notched disk member 72 is provided at the center of each of the sides thereof with a sub-wheel

supporting shaft 75 projecting therefrom and having a hole 75a including a straight line portion. The sub-wheel supporting shafts 75 are provided so as to be perpendicular to the notched disk member 72.

Each of the hollow cylindrical sub-wheels 77 is rotatably fitted around the sub-wheel supporting shafts 75 from opposite sides of the notched disk member 72. As shown in Fig. 14, a joint protector 78 is fitted to each of the sub-whcels 77 mounted on the sub-wheel supporting shafts 75. As shown in Fig. 13, the joint protector 78 comprises a wedge-like plate 78a formed so as to have an angle θ between its opposite surfaces and two short shafts 78b extending from both surfaces of the wedge-like plate 78a and intersecting perpendicularly thereto. Each of the short shafts 78b has a cross section for fitting into a center hole 75a of the sub-wneel supporting shaft 75.

The joint protector 78 is fitted to each sub-wheel 77 with the side thereof which is greater in thickness being directed in the direction of the cut surface 72a of the notched disk member 72, and the sub-wheel supporting shafts 75 of the adjacent sub-wheel supporting members 71 are continuously connected through the short shafts 78b of the joint protector 78.

A wheel 70 provided with sub-wheels is constituted, as shown in Fig. 11, by inserting the guide rail members 76 of the sub-wheel supporting members 71 with the sub-wheels 77 rotatably supported therein, into a plurality of grooves 48 formed on the outer periphery of the circular rim member 47 at equal pitch intervals, similarly as in the preceding embodiments.

The wheel 70 according to the present embodiment performs a function of causing the edge rubber 74 to come into contact with the floor when the wheel 70 is inclined more than a predetermined angle, thereby braking the rotation of the sub-wheels 77. That is, as shown in Fig. 15, when the wheel 70 is inclined by an angle of α and

the position of the floor Z reaches a position of X, the edge rubber 74 starts to come into contact with the floor X.

As the wheel 70 is further inclined until the position of the floor varies from X to Y, the edge rubber 74 becomes elastically deformed, causing the action of braking the rotation of the sub-wheel 77 to increase.

When the wheel 70 is further inclined until the position of the floor exceeds a position Y, the elastic deformation of the edge rubber 74 reaches a limit and the sub-wheel 77 leaves the floor Y. This stops the movement of the sub-wheel 77 in the direction perpendicular to the running direction of the wheel 70 due to the rotation of the sub-wheel 77. Accordingly, the wheel 70 runs in the direction of the rotation of the main shaft thereof due to the contact of the edge rubber 74 with the floor Y.

This function provides particularly superior effects in the case where the wheel 70 according to this embodiment is used for a sporting good which runs on a slope. For example, the wheel 70 according to the present embodiment can be fitted to an elongated plate member on which an operator can put his one foot, to thereby constitute a running device. If a pair of the running devices are prepared and the operator runs on a slope with each foot on one of the running devices, he can then carry out a lateral sliding motion with a feeling similar to that of an ordinary ski, thereby permitting the control of the running speed and direction thereof.

Furthermore, since in the wheel 70 according to the present embodiment, the sub-wheel supporting shafts 75 are supported by means of the joint protectors 78 in the construction of supporting at both ends, the sub-wheels 77 can be loaded by a great load.

Figs. 16 to 22 are views illustrating a modification of the third embodiment of the invention as described above.

In this embodiment, a sub-wheel supporting member is fitted at both ends of the cut surface thereof with elastic members such as rubber, similar to the third embodiment. Fig. 17 shows the sub-wheel supporting member 81 used for the present embodiment. The sub-wheel supporting member 81 comprises a notched disk member 82 formed by cutting off a portion of the disk member along a cut surface 82a parallel to the diametrical direction, and a rim 83 formed along the outer periphery of the notched disk member 82. A guide rail member 86 of T-shaped cross section is secured to the end of the rim 83 opposite the cut surface 82a, parallel to the axis of the notched disk member 82. Edge rubbers 84 with inclined surfaces inclined so as to expand outwardly are fitted to two ends of the rim 83, said edge rubbers projecting over the cut surface 82a. The two side surfaces of the notched disk member 82 are inclined by an angle of θ towards the guide rail member 86 and are each provided with a sub-wheel supporting shaft 85 projecting therefrom and having a hole 85a. Furthermore, a projection 87 is provided around the sub-wheel supporting shaft 85 to seal a clearance between the notched disk member 82 and the sub-wheel 88 in such a manner as a labyrinth. Each of the sub-wheel supporting shafts 85 and the projection 87 is so orientated as to be perpendicular to the side surfaces of the notched disk member 82.

Fig. 18 shows a joint protector used in combination with the sub-wheel supporting member 81. This joint protector 89 has substantially the same configuration as the sub-wheel supporting member 81 and is provided, in place of the sub-wheel supporting shaft 85, with joint shafts 85b which are shorter in length than the sub-wheel supporting shaft 85. Each of the joint shafts 85b is in the form of being fitted in the center hole of the sub-wheel supporting shaft 85. For parts other than those described above, the same reference numerals are affixed

to the same parts as in Fig. 17 and description thereof is omitted.

Each hollow cylindrical sub-wheel 88 is formed with a recess 88b to function as labyrinth type seal, as shown in Fig. 18. The sub-wheels 88 are rotatably fitted on the sub-wheel supporting shafts 85, from both ends of the sub-wheel supporting member 81, as shown in Figs. 20 to 22. Each of the projections 87 enters into the recess 88b of a sub-wheel 88 so that the labyrinth type seal is formed. The joint protectors 89 are fitted to the sub-wheel supporting shafts 85 with the sub-wheels 88 mounted thereon in such a manner that the joint shafts 85b are fitted in the center holes 85a. The sub-wheel supporting shafts 85 of the adjacent sub-wheel supporting members 81 are assembled so that they are continuously connected through the joint shafts 85b of the joint protectors 89.

The wheel 80 provided with the sub-wheels as shown in Fig. 16 is assembled from the sub-wheel supporting members 81 with the sub-wheels 88 rotatably mounted thereon and the joint protectors 89 fitted thereto, in such a manner that the guide rail members 86 are inserted into a plurality of grooves 48 formed on the outer circumference of the circular rim member 47 and subsequently the rim cover 49 is attached to the rim member 47, similarly as in the above described second embodiment.

When the wheel 80 according to the present embodiment is inclined more than a predetermined angle, the edge rubbers come into contact with the floor and perform a function of braking the rotation of the sub-wheels 88, similarly as in the third embodiment. In addition, the combination of the projections 87 with the sub-wheels 88 forms the labyrinth type seals which prevent any foreign matter from the outside from entering into the clearances between the sub-wheel supporting shaft 85 and the sub-wheels 88.

Moreover, the alternate combination of the joint protectors 89 with the sub-wheel supporting members 81 makes it possible to make greater the width of the sub-wheel 88 which can be supported by the sub-wheel supporting member 81, as compared with the third embodiment.

Figs. 23 to 25 show a fourth embodiment of the invention. In a wheel 90 according to this embodiment, plurality of sets of sub-wheels are mounted around the outer periphery of the wheel 90. Each set comprises a plurality of sub-wheels 91 (three sub-wheels in this embodiment) mounted in tandem with parallel axes. That is, the wheel 90 is constituted so that the three sub-wheels 91 are rotatably mounted each with a supporting shaft 93 as a center within each of a plurality of sub-wheel supporting blocks 92, the sub-wheels projecting particularly therefrom, and the sub-wheel supporting blocks 92 are arranged on the outer periphery of the disk rim member 94 at equal pitch intervals.

The present embodiment in which the plurality of sub-wheels 91 are arranged in tandem enables the width of the wheel 90 to be made greater so that the load applied to the wheel 90 may be increased.

Figs. 26 to 28 are views illustrating a fifth embodiment of the invention. In a wheel 100 provided with sub-wheels according to the invention, elastic interpositions are arranged between respective sub-wheels. These elastic interpositions form an outermost peripheral circle having substantially the same diameter as that of the outermost peripheral circle formed by all of the sub-wheels mounted on the wheel.

In this embodiment, a cover member 103 made of an elastic material such as rubber is fitted to the outer peripheral circle of the circular rim member 47. The cover member 103 is formed at the outer periphery thereof with a plurality of opened holes 102 having a width which allows mounting of the sub-wheels 101, these opened holes

102 being arranged in the circumferential direction at equal distances. Interpositions 105 provided with a plurality of radial projections 104 (in Fig. 26, three projections at the center and the left and right sides) are provided between adjacent opened holes 102 and 102.

These projections 105 are so constituted that the diameter of the circumference formed by connecting the center projections 104 of the interpositions 105 arranged in the circumferential direction is substantially the same as that of the circumference of the tire part formed by all of the sub-wheels 101 arranged in the circumference.

As shown in Fig. 28, each sub-wheel 101 is rotatably supported on a sub-wheel bearing 110 having a half cylindrical surface 111 to be mounted on the rim member, a portion of the sub-wheel 101 projecting towards the side opposite the surface 111. That is, the sub-wheel bearing 110 is provided with hollow cylindrical portions 112 concentric with the surface 111 to be mounted on the rim member. The rotary shaft 114 of the sub-wheel 101 is supported at both ends thereof within the hollow cylindrical portions 112 by bearing members such as ball or roller bearings.

As shown in Fig. 27, the sub-wheel bearing 110 is mounted so that an elastic member 116 is interposed between the outer peripheral surface of the circular rim member 47 at the center thereof and the surface 111 to be mounted on the rim member, and the hollow cylindrical portions 112 are covered by the interpositions 105 of the cover member 103. Preferably, the mounting of the sub-wheel bearing 111 is carried out after the mounting of the sub-wheel 101 therein as shown in Fig. 28.

In the wheel 100 according to the present embodiment, since the surfaces of the sub-wheels 101 which come in contact with the ground and the surfaces of the center projections 104 of the interpositions 105 which come in contact with the ground are arranged

substantially on the same circumference, the sub-wheels 101 and the interpositions 105 come in contact with the ground alternately when the wheel 100 runs straight ahead.

This brings about smooth rotational movement of the wheel 100, thereby permitting vibration caused during the running thereof to be reduced. In addition, since the load applied to the wheel 100 can be received by both the sub-wheels 101 and the interpositions 105, the load applied to the wheel 100 can be increased.

Moreover, in the wheel 100 according to the present embodiment, when the inclination thereof occurs during the running thereof, the projections 104 of the interpositions 105 is elastically deformed in proportion to the inclination so that the straight running of the wheel 105 and the running thereof in the direction perpendicular thereto are not hindered.

Besides, also when the wheel 100 is inclined by more than a specific angle, the projections 104 of the interpositions 105 are elastically deformed so as not to cause excessive friction between the floor and the projections.

Industrial Applicability

As described above, the present invention permits the running direction of the wheel to be changed arbitrarily and simply without describing a locus of a circular arc. Further, since it is not constituted as a combination of wheels required to provide a steering handle for a wheel shaft and perform an operation of shifting depending on the running direction, the construction for mounting the wheel is simple and complicated and larger-sized construction of the wheel is not required.

The wheel provided with sub-wheels according to the invention can be used as a single constitution similar to the conventional wheel, and if it is used for wheels for vehicles required to change the running direction in a

narrower space, an operating robot required to change the running direction without describing a locus of a circular arc, or a running wheel for sporting goods which requires special control, it provides particularly superior effects.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A wheel provided with sub-wheels, which comprises:

wheel means for forming a wheel having a circular rim formed around the outer periphery thereof;

a plurality of sub-wheel supporting means mounted on and around said circular rim so as to be directed radially and outwardly; and

a plurality of sub-wheels each rotatably supported by a respective one of said sub-wheel supporting means for rotation about an axis extending tangentially to said circular rim, said plurality of sub-wheels being arranged on the outer periphery of said wheel for constituting a tire;

wherein each sub-wheel supporting means comprises two inclined surfaces each inclined by a specific angle towards each other, and a respective main shaft on each said inclined surface so as to project therefrom, each said main shaft having at the center portion thereof a hole and having on the outer periphery thereof another of said sub-wheels mounted rotatably;

wherein a joint protector is interposed between each adjacent pair of said sub-wheel supporting means, said joint protector having a wedge-shaped section and being provided with two short shafts fitted in the center holes of said sub-wheel supporting shafts; and

wherein an elastic interposition member is disposed around the circumference of the wheel and has radially outward projections interposed between each adjacent pair of said sub-wheel, said interposition member having an outermost diameter which is substantially the same as the outermost peripheral diameter of the tire constituted by the sub-wheels.

2. A wheel provided with sub-wheels as claimed in claim 1, wherein each sub-wheel supporting means is provided in the inclined surface thereof with a ring-like projection concentric with a rotational axis of the sub-wheel, and the

sub-wheel rotatably supported by the sub-wheel supporting means is provided on the side surface thereof with a circular concave groove in which said ring-like projection can enter.

3. A wheel provided with sub-wheels as claimed in claim 1, wherein each sub-wheel supporting means is provided with edge means at both ends thereof.

DATED this 11th day of September, 1995.

HOMMA SCIENCE CORPORATION

WATERMARK PATENT & TRADEMARK
ATTORNEYS
4TH FLOOR, "DURACK CENTRE"
263 ADELAIDE TERRACE
PERTH W.A. 6000
AUSTRALIA

ABSTRACT

A wheel provided with sub-wheels, in which a plurality of sub-wheels 31 supported rotatably about an axis extending in the same direction as that tangential to the circular rim 12 of the wheel are arranged on the circular rim to constitute a tire 40. The rotation of the tire and that of the sub-wheels are combined to cause the wheel to run in an arbitrary direction.

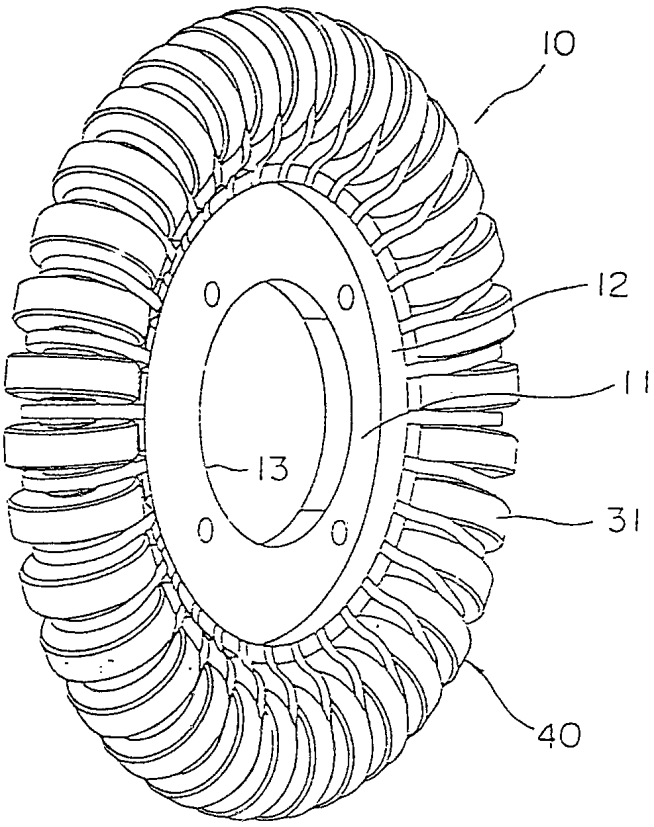

FIG. 1

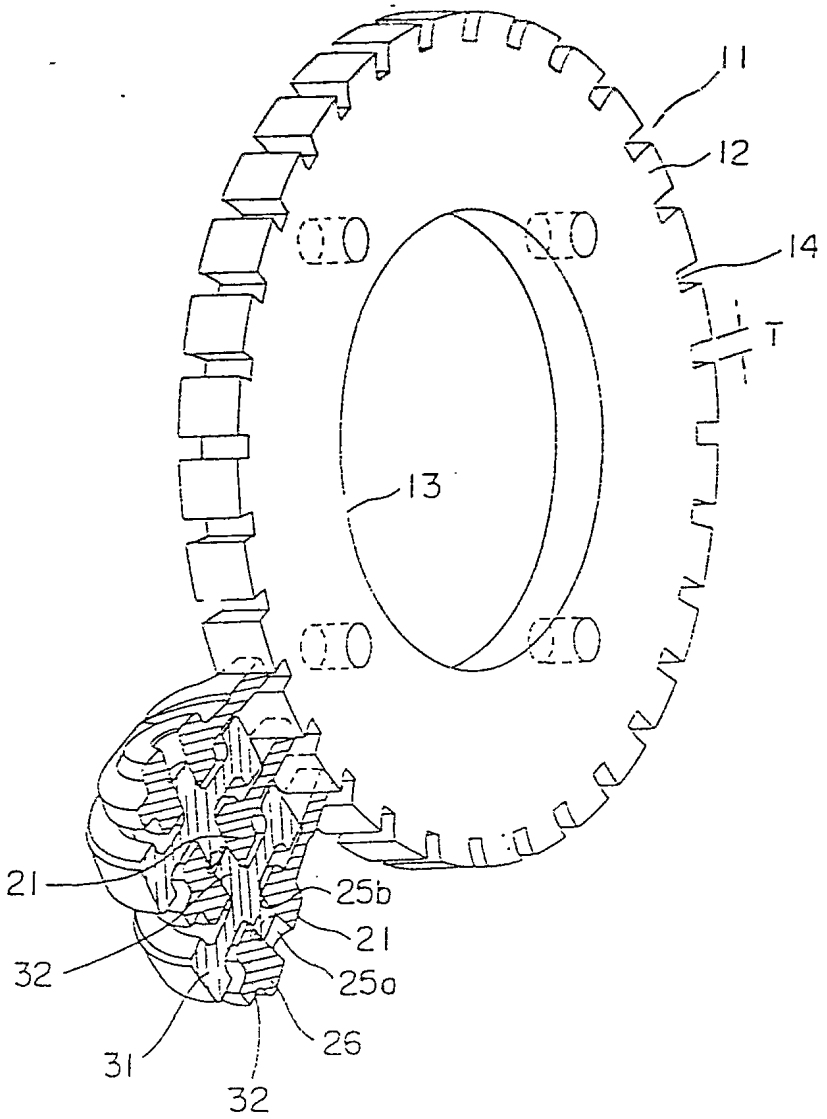

FIG. 2

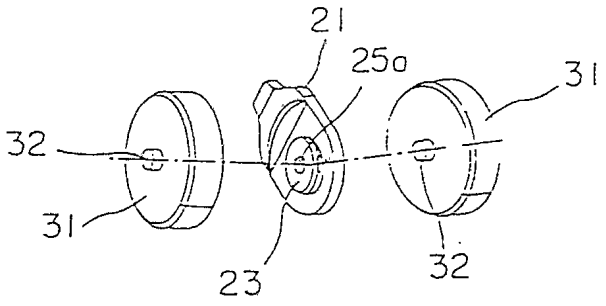

FIG. 3

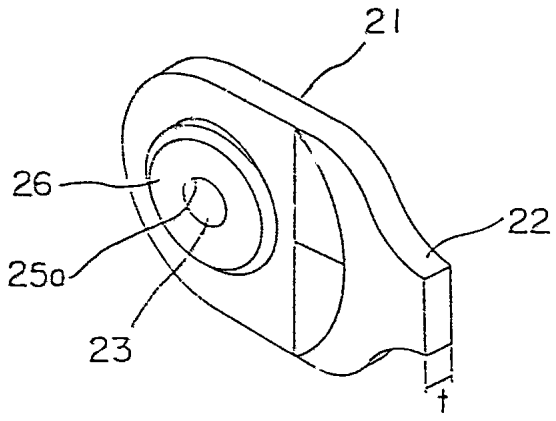

FIG. 4A

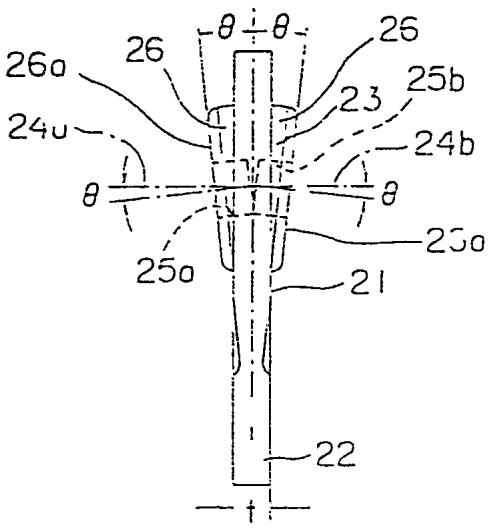

FIG. 4B

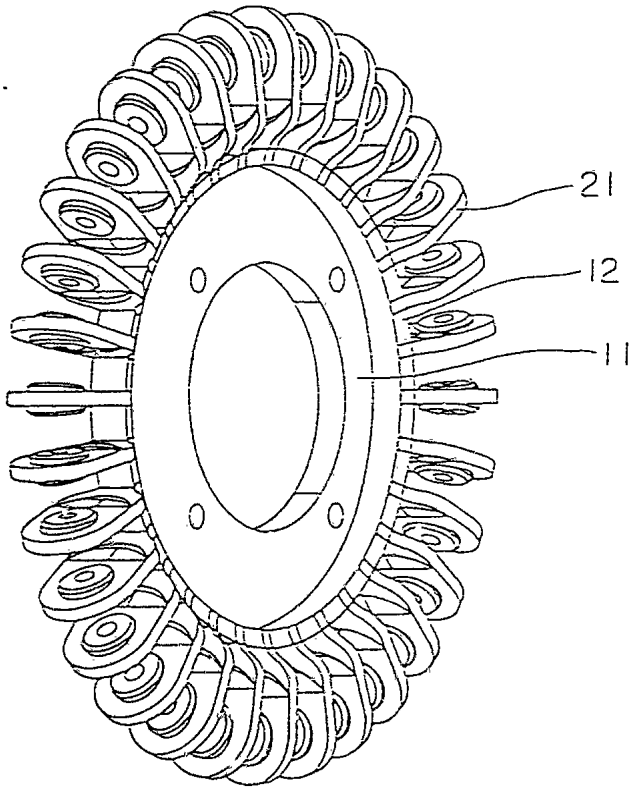

FIG. 5

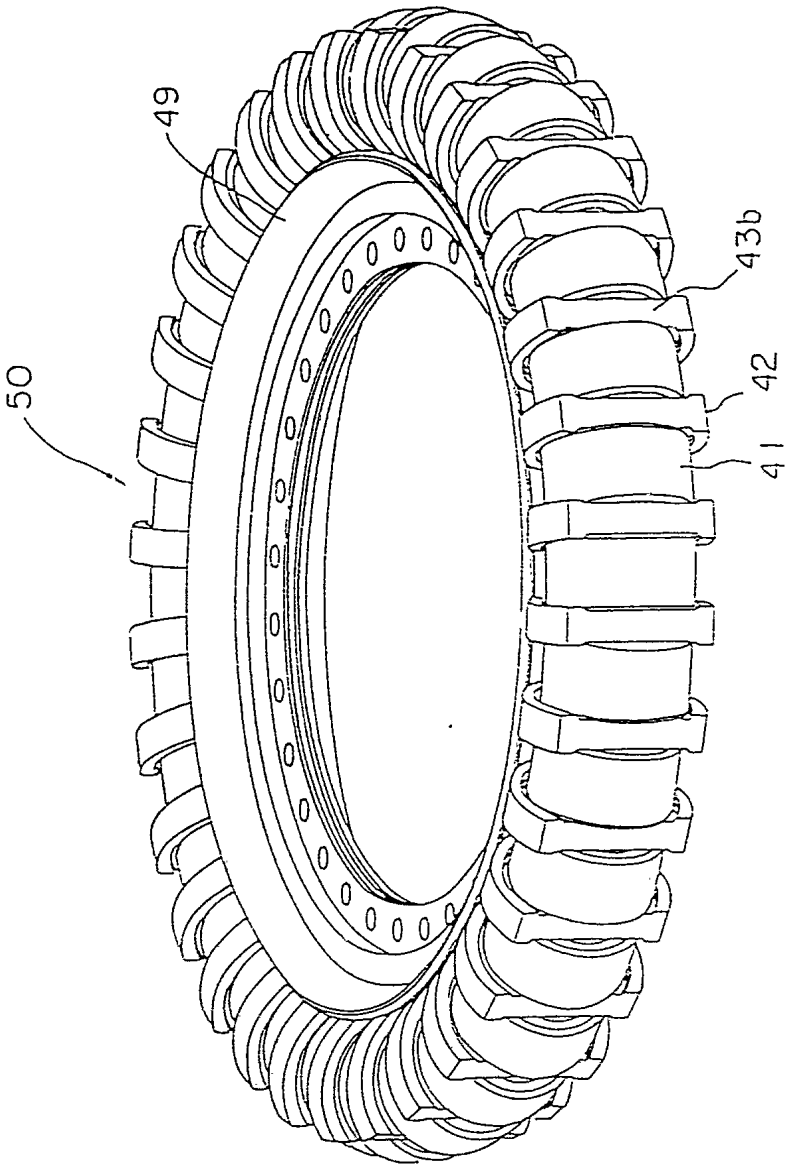

FIG. 6

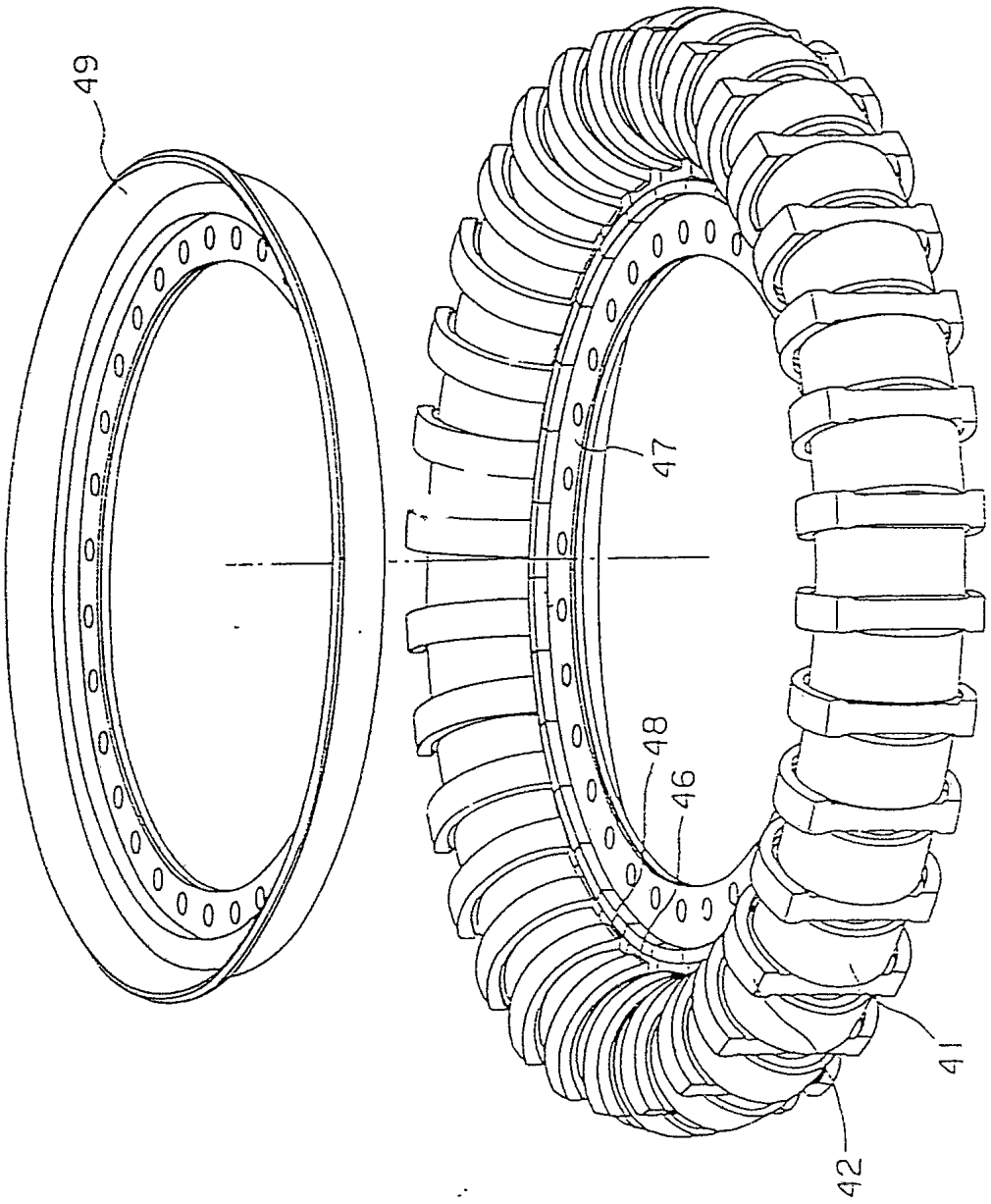

FIG. 7

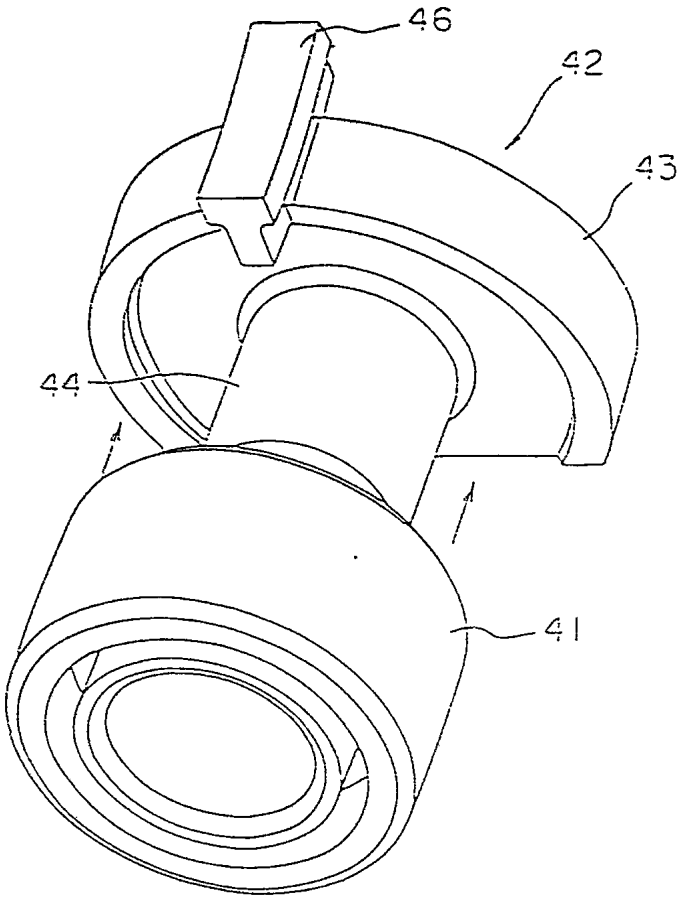

FIG. 8

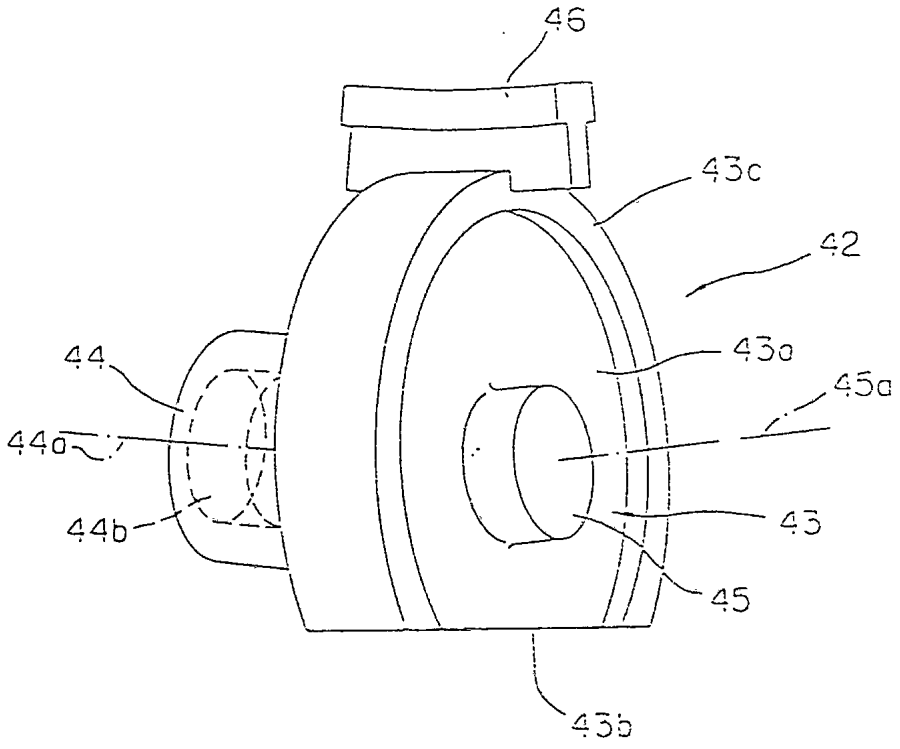

FIG. 9

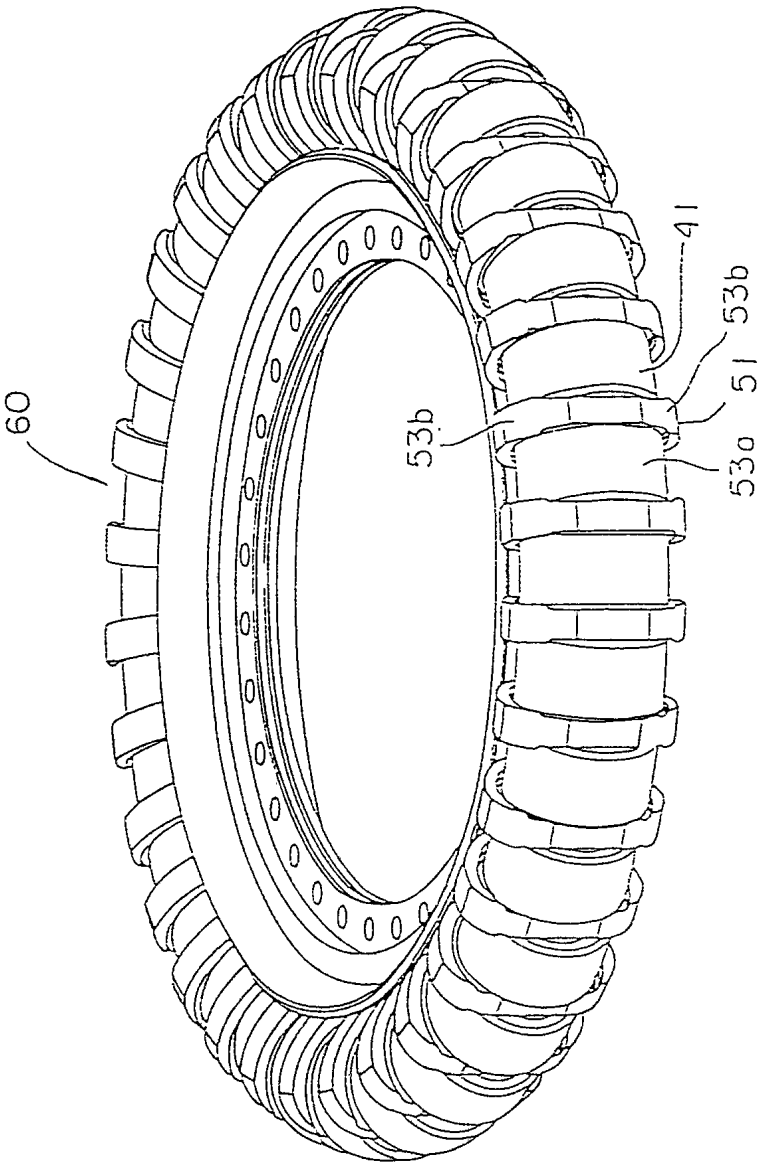

FIG. 10

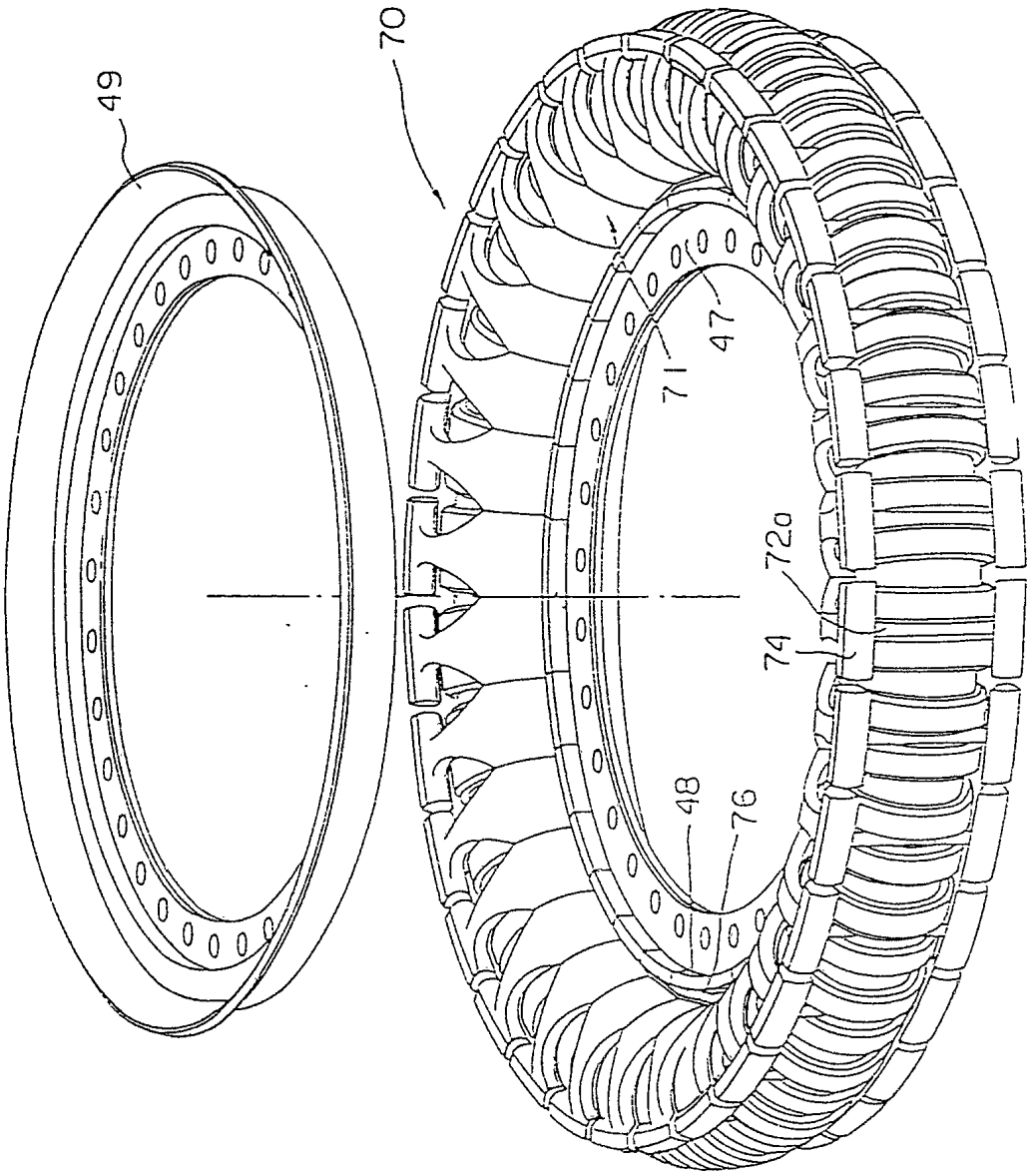

FIG. 11

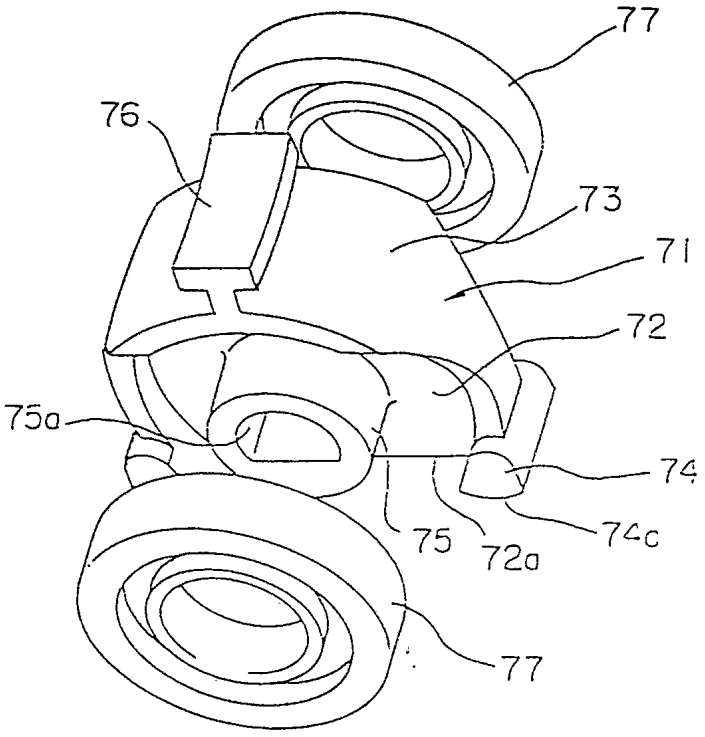

FIG. 12

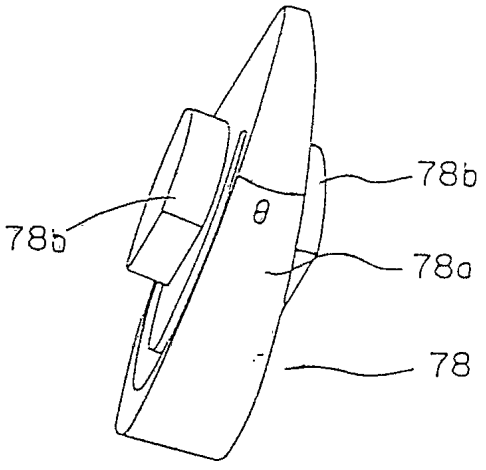

FIG. 13

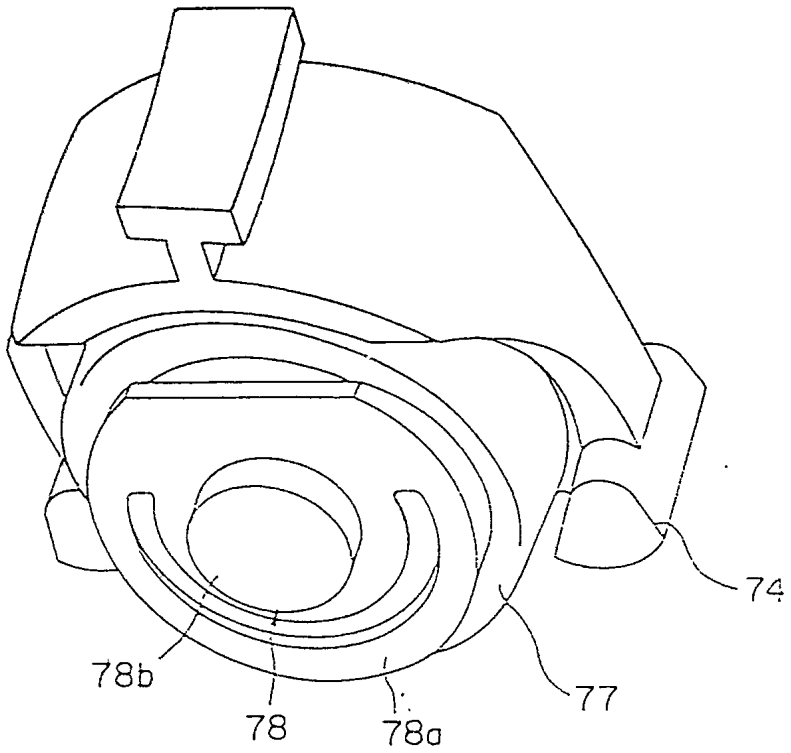

FIG. 14

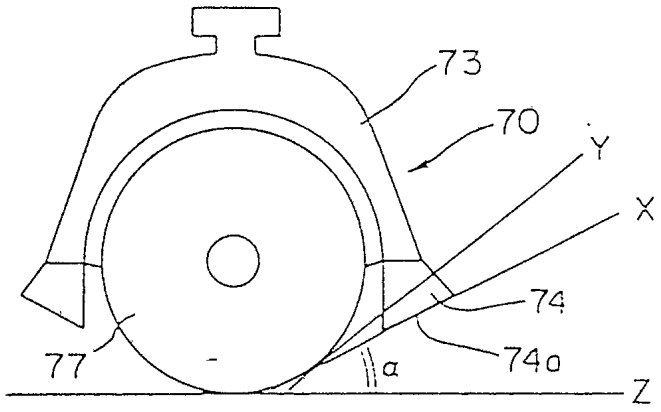

FIG. 15

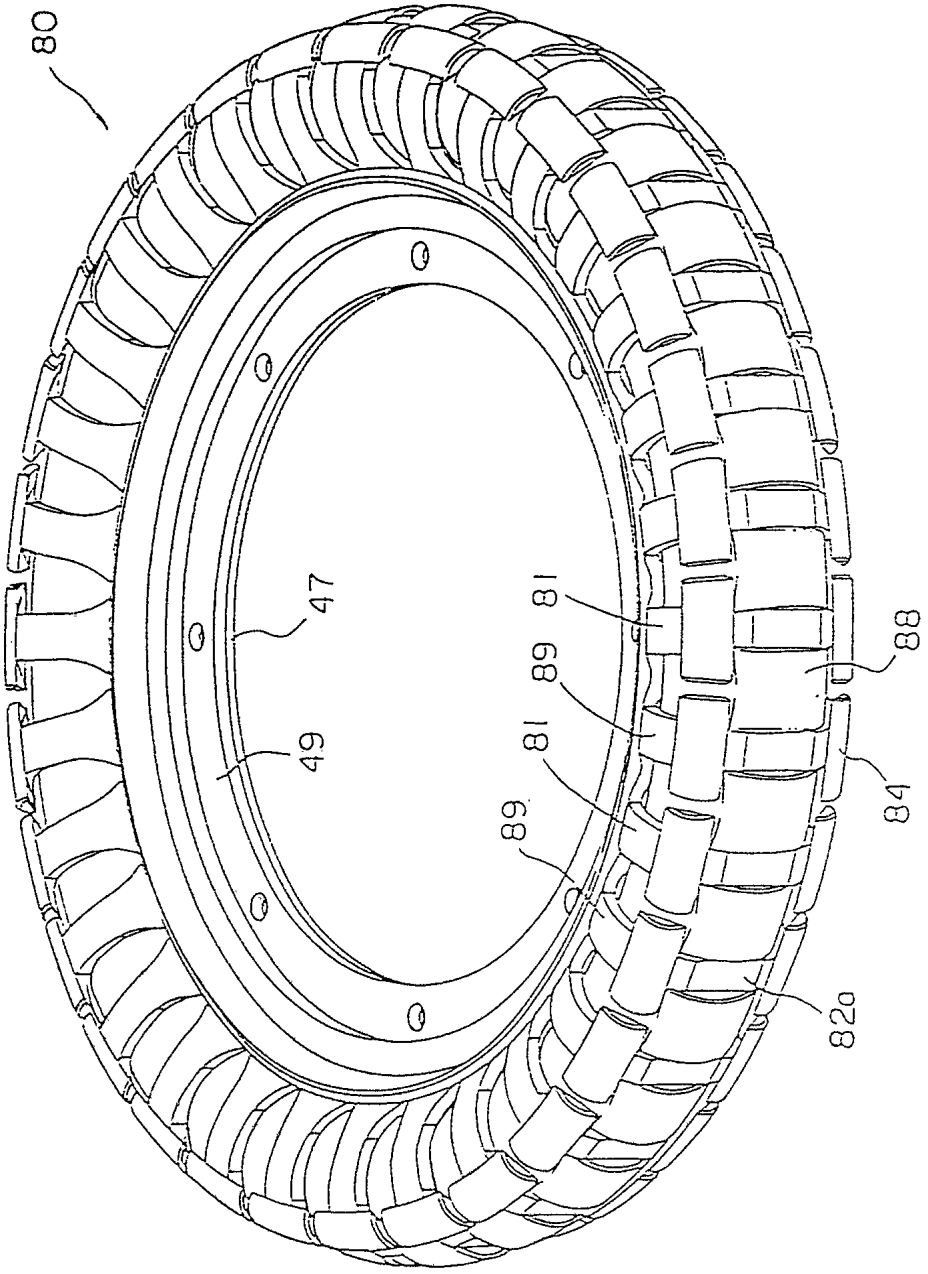

FIG. 16

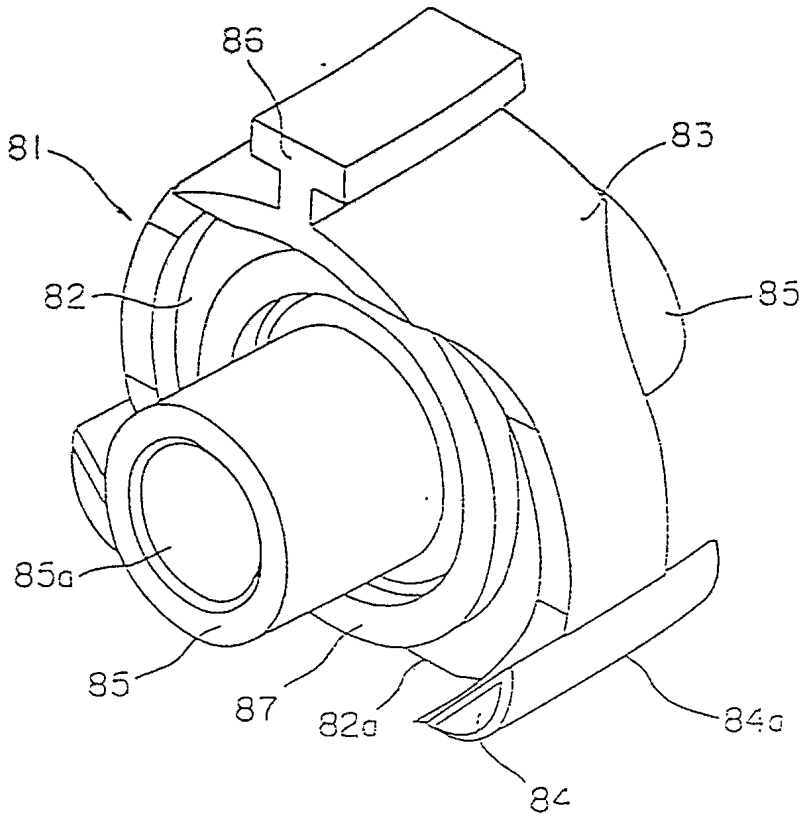

FIG. 17

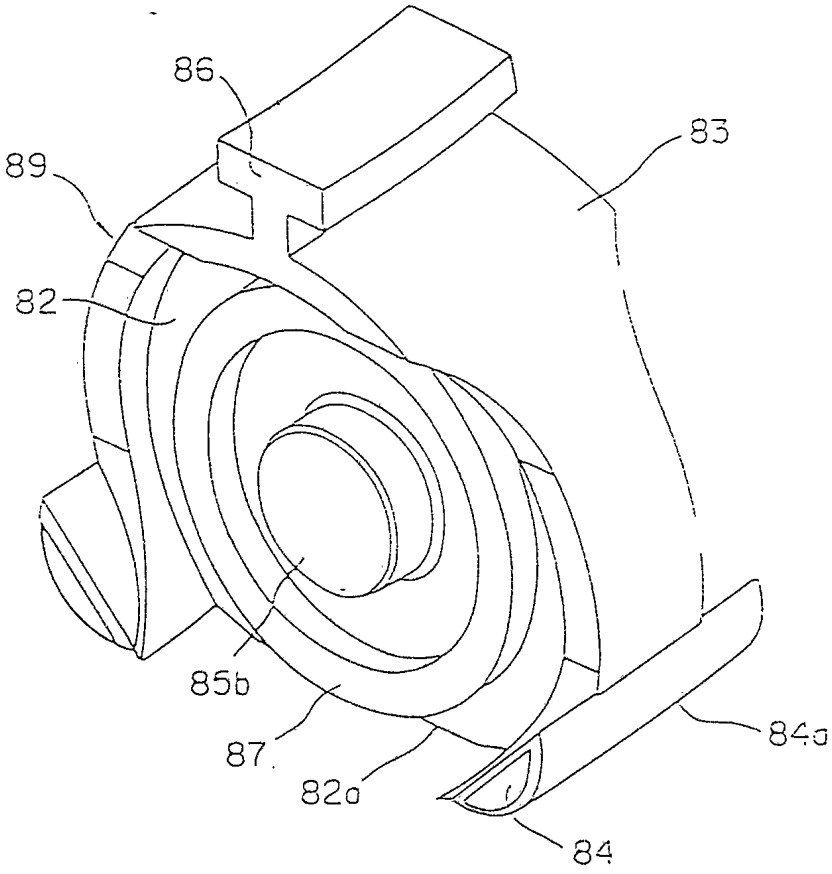

FIG. 18

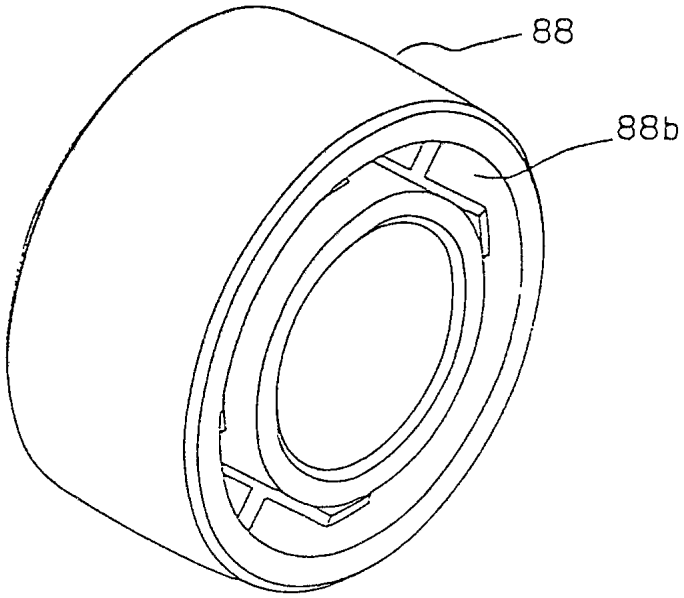

FIG. 19

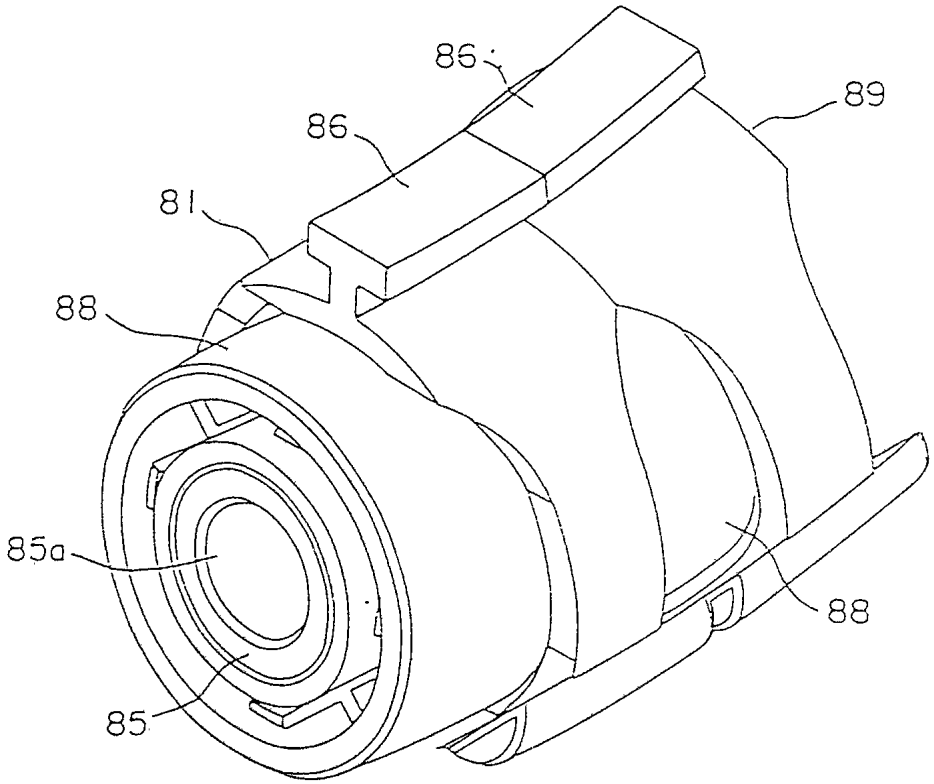

FIG. 21

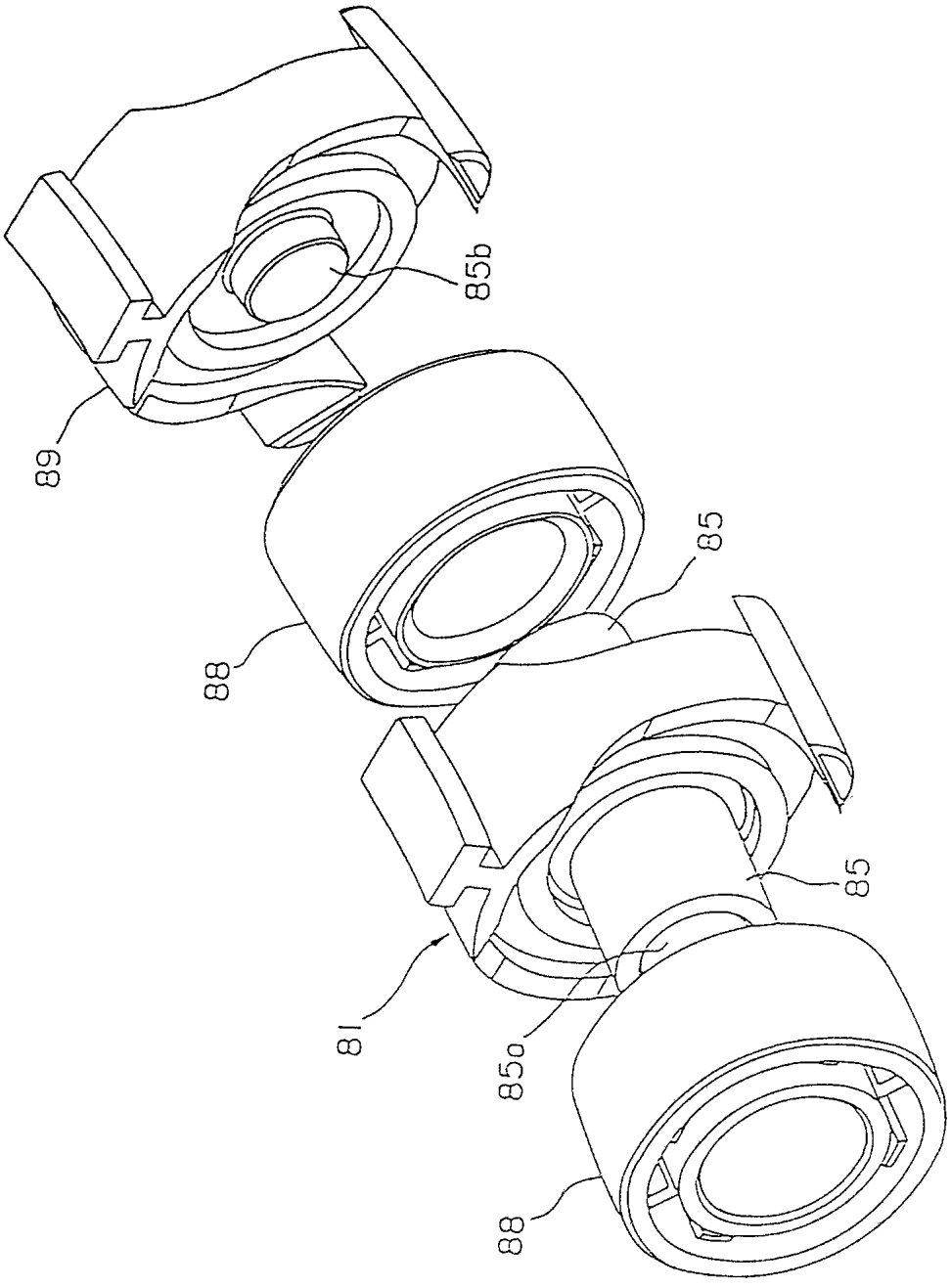

FIG. 20

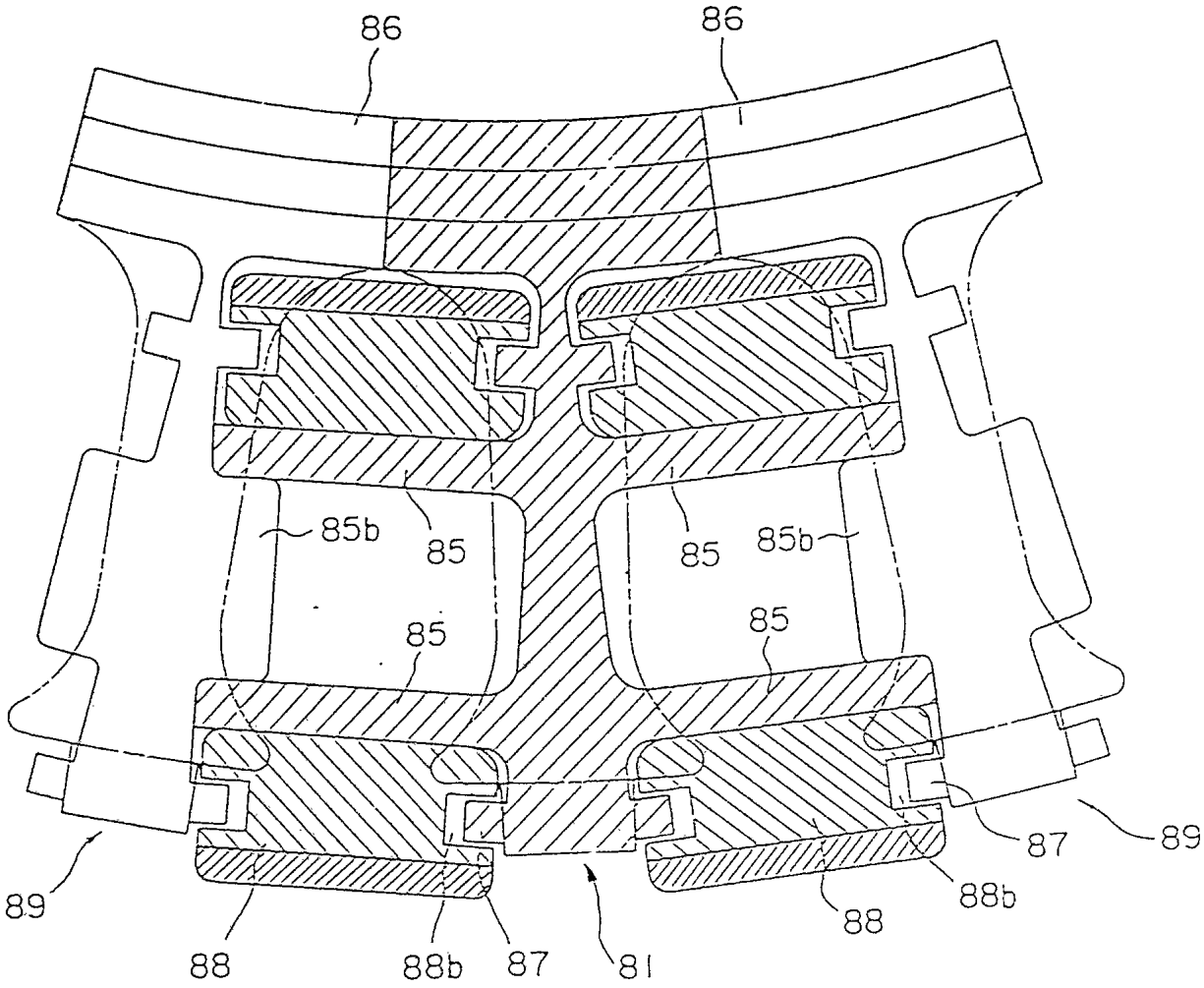

FIG. 22

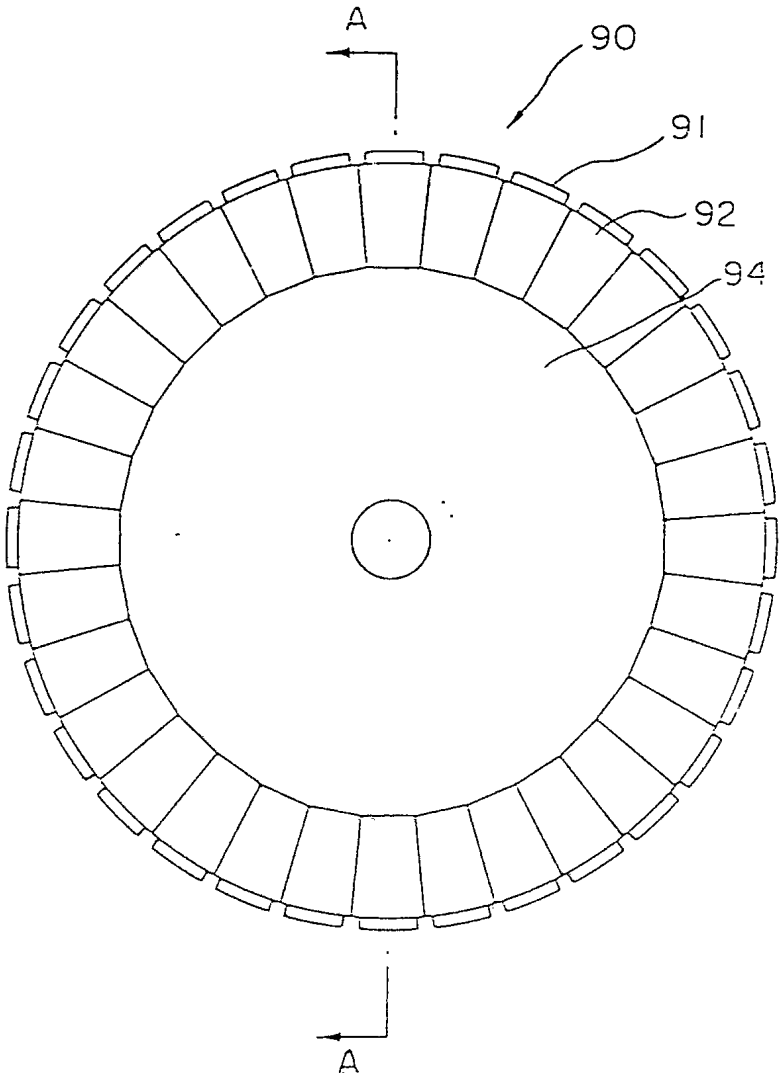

FIG. 23

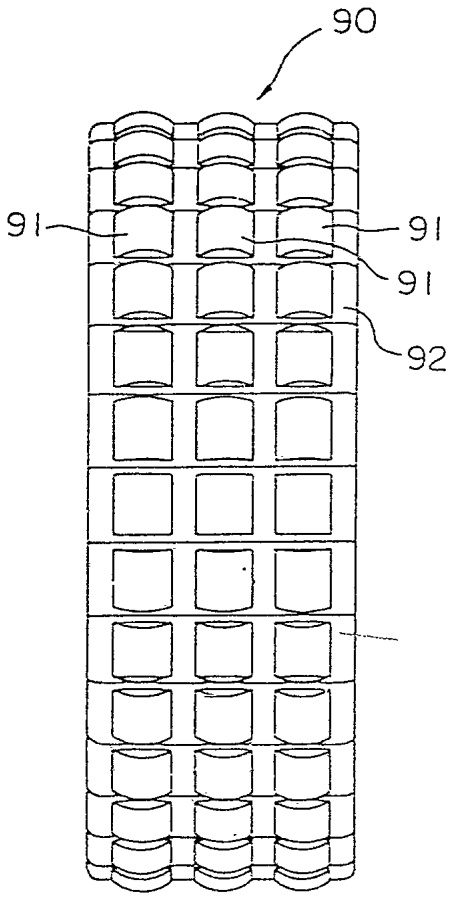

FIG. 24

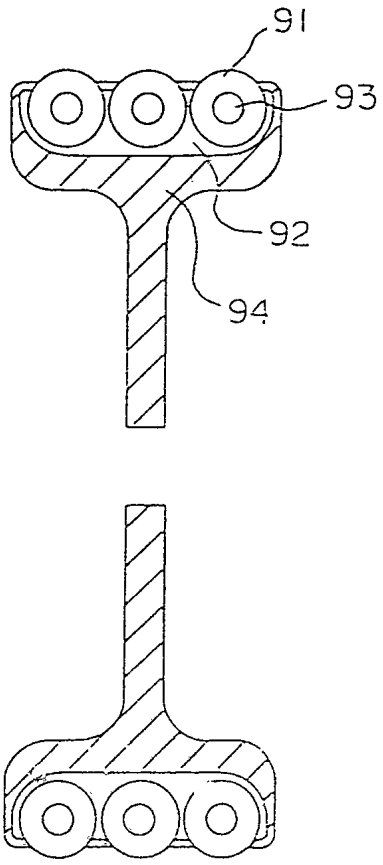

FIG. 25

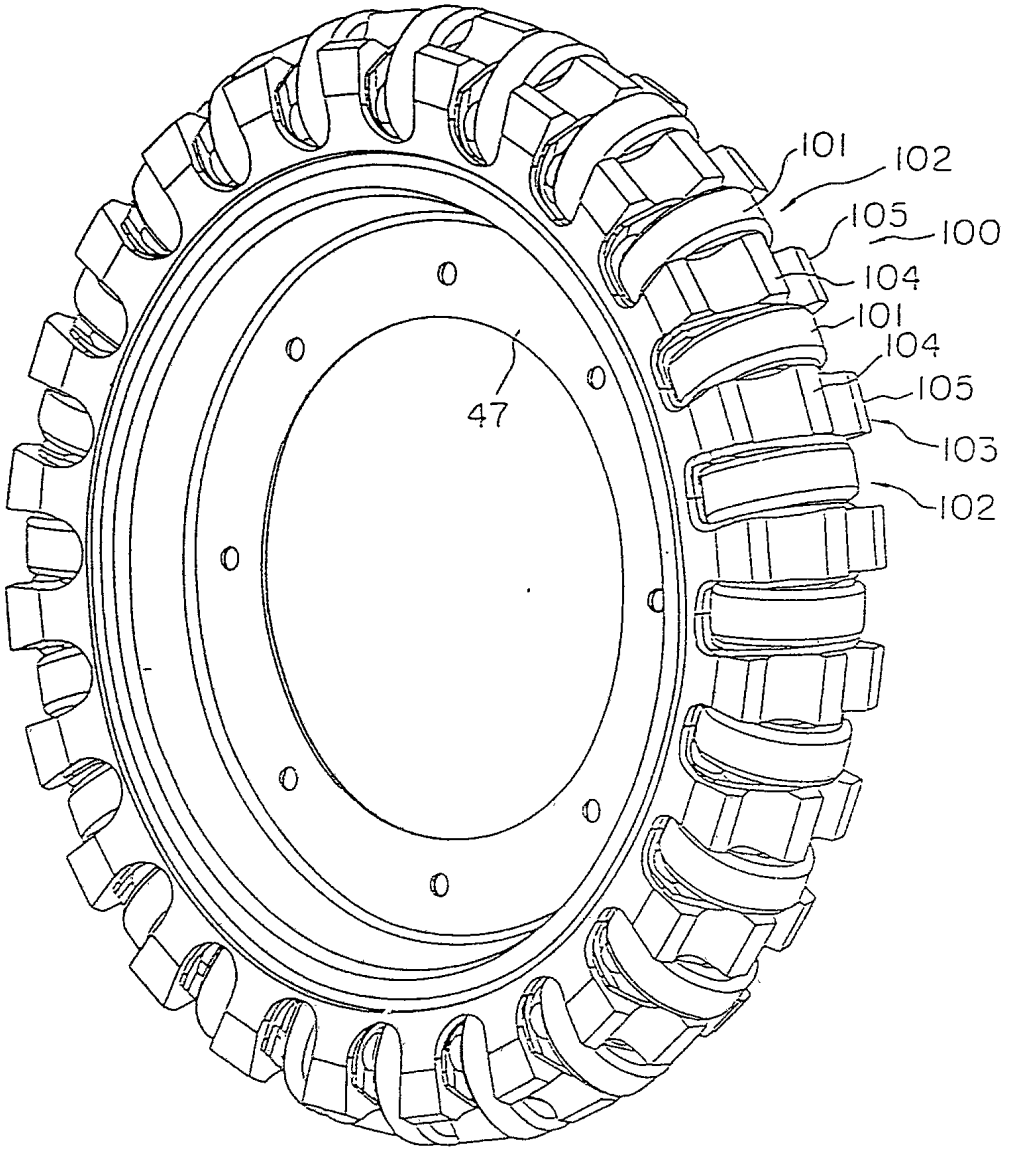

FIG. 26

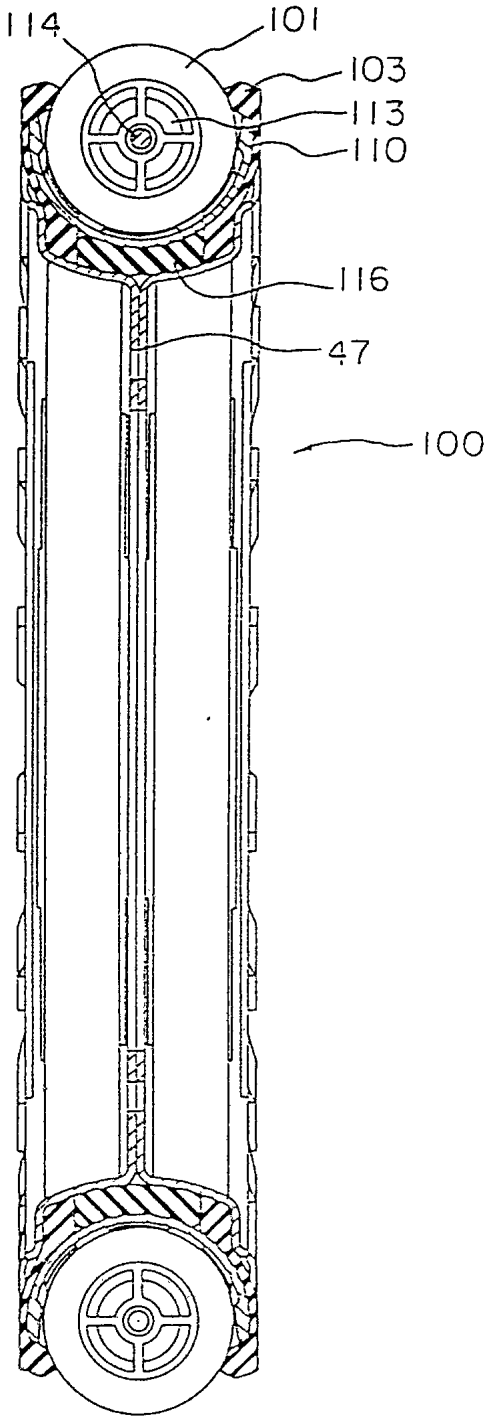

FIG. 27

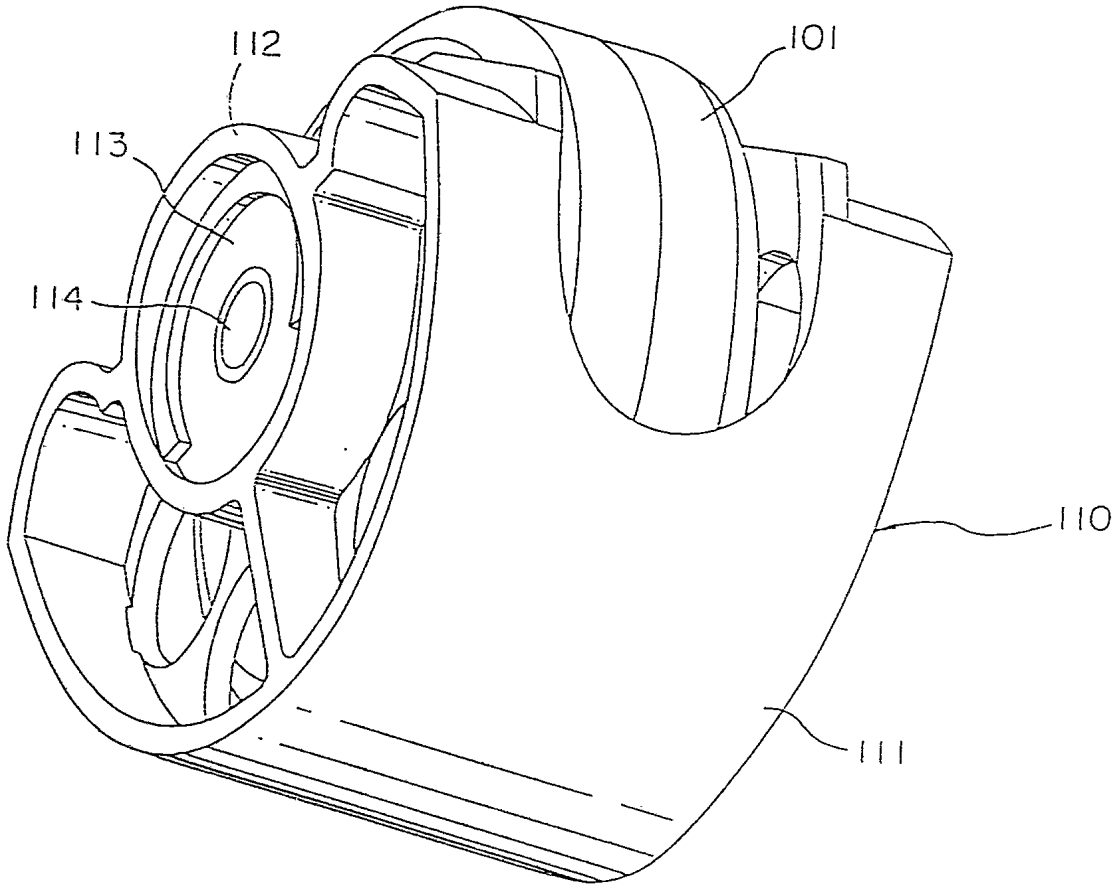

FIG. 28

INTERNATIONAL SEARCH REPORT

International Application No PCT/JP92/00952

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl[5] B60B19/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	B60B19/00, 33/00-33/08

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho 1926 - 1992
Kokai Jitsuyo Shinan Koho 1971 - 1992

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	JP, U, 57-139406 (Mitsubishi Heavy Industries, Ltd.), August 31, 1982 (31. 08. 82), (Family: none)	1-2, 7
Y	JP, U, 57-139406 (Mitsubishi Heavy Industries, Ltd.), August 31, 1982 (31. 08. 82)	3-5
X	JP, U, 58-30424 (Shimadzu Corp.), February 28, 1983 (28. 02. 83), (Family: none)	1-2, 7
Y	JP, U, 58-30424 (Shimadzu Corp.), February 28, 1983 (28. 02. 83)	3-5
X	JP, A, 59-109402 (Kogyo Gijutsuin-cho), June 25, 1984 (25. 06. 84), (Family: none)	1-2, 6
X	JP, B1, 32-1751 (Ryoji Yokoyama), March 18, 1957 (18. 03. 57), (Family: none)	1-2, 7

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
September 16, 1992 (16. 09. 92)	October 6, 1992 (06. 10. 92)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Y	JP, B1, 32-1751 (Ryoji Yokoyama), March 18, 1957 (18. 03. 57)	3-5
X	DE, A1, 2619098 (Wienker, Ulrich-Wilhelm), November 24, 1977 (24. 11. 77), (Family: none)	1-2, 6

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers , because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers , because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

国 際 調 査 報 告

国際出願番号PCT/JP92/00952

I. 発明の属する分野の分類

国際特許分類（IPC）　Int. Cl.[5]
B60B19/00

II. 国際調査を行った分野

調査を行った最小限資料

分類体系	分類記号
IPC	B60B19/00, 33/00-33/08

最小限資料以外の資料で調査を行ったもの

日本国実用新案公報　1926-1992年
日本国公開実用新案公報　1971-1992年

III. 関連する技術に関する文献

引用文献のカテゴリー※	引用文献名　及び一部の箇所が関連するときは、その関連する箇所の表示	請求の範囲の番号
X	JP, U, 57-139406 (三菱重工業株式会社), 31. 8月 1982 (31. 08. 82), (ファミリーなし)	1-2, 7
Y	JP, U, 57-139406 (三菱重工業株式会社), 31, 8月 1982 (31. 08. 82)	3-5
X	JP, U, 58-30424 (株式会社 島津製作所), 28. 2月 1983 (28. 02. 83), (ファミリーなし)	1-2, 7
Y	JP, U, 58-30424 (株式会社 島津製作所), 28. 2月 1983 (28. 02. 83)	3-5
X	JP, A, 59-109402 (工業技術院長), 25. 6月 1984 (25. 06. 84), (ファミリーなし)	1-2, 6
X	JP, B1, 32-1751 (横山良次),	1-2, 7

※引用文献のカテゴリー
「A」特に関連のある文献ではなく、一般的技術水準を示すもの
「E」先行文献ではあるが、国際出願日以後に公表されたもの
「L」優先権主張に疑義を提起する文献又は他の文献の発行日若しくは他の特別な理由を確立するために引用する文献（理由を付す）
「O」口頭による開示、使用、展示等に言及する文献
「P」国際出願日前で、かつ優先権の主張の基礎となる出願の日の後に公表された文献
「T」国際出願日又は優先日の後に公表された文献であって出願と矛盾するものではなく、発明の原理又は理論の理解のために引用するもの
「X」特に関連のある文献であって、当該文献のみで発明の新規性又は進歩性がないと考えられるもの
「Y」特に関連のある文献であって、当該文献と他の1以上の文献との、当業者にとって自明である組合せによって進歩性がないと考えられるもの
「&」同一パテントファミリーの文献

IV. 認　証

国際調査を完了した日	国際調査報告の発送日
16. 09. 92	06.10.92
国際調査機関	権限のある職員
日本国特許庁（ISA/JP）	特許庁審査官　亀井学志 ㊞　3D7146

様式PCT/ISA/210(第2ページ)（1981年10月）

第2ページから続く情報

	(III欄の続き) 18. 3月 1957 (18. 03. 57), (ファミリーなし)	
Y	JP, B1, 32-1751 (横山良次), 18. 3月 1957 (18. 03. 57)	3-5
X	DE, A1, 2619098 (Wienker, Ulrich - Wilhelm), 24. 11月 1977 (24. 11. 77), (ファミリーなし)	1-2, 6

V. □ 一部の請求の範囲について国際調査を行わないときの意見

次の請求の範囲については特許協力条約に基づく国際出願等に関する法律第8条第3項の規定によりこの国際調査報告を作成しない。その理由は、次のとおりである。

1. □ 請求の範囲_____は、国際調査をすることを要しない事項を内容とするものである。

2. □ 請求の範囲_____は、有効な国際調査をすることができる程度にまで所定の要件を満たしていない国際出願の部分に係るものである。

3. □ 請求の範囲_____は、従属請求の範囲でありかつPCT規則6.4(a)第2文の規定に従って起草されていない。

VI. □ 発明の単一性の要件を満たしていないときの意見

次に述べるようにこの国際出願には二以上の発明が含まれている。

1. □ 追加して納付すべき手数料が指定した期間内に納付されたので、この国際調査報告は、国際出願のすべての調査可能な請求の範囲について作成した。
2. □ 追加して納付すべき手数料が指定した期間内に一部分しか納付されなかったので、この国際調査報告は、手数料の納付があった発明に係る次の請求の範囲について作成した。
   請求の範囲_____
3. □ 追加して納付すべき手数料が指定した期間内に納付されなかったので、この国際調査報告は、請求の範囲に最初に記載された発明に係る次の請求の範囲について作成した。
   請求の範囲_____
4. □ 追加して納付すべき手数料を要求するまでもなく、すべての調査可能な請求の範囲について調査することができたので、追加して納付すべき手数料の納付を命じなかった。

追加手数料異議の申立てに関する注意

□ 追加して納付すべき手数料の納付と同時に、追加手数料異議の申立てがされた。
□ 追加して納付すべき手数料の納付に際し、追加手数料異議の申立てがされなかった。