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(54) **WORKING TOOL**

(57) [PROBLEMS] To provide a working tool with a rotary tip tool capable of effectively maintaining the synchronous rotation of a drive side rotating member and a driven side rotating member in an integrated state. [MEANS FOR SOLVING PROBLEMS] This working tool comprises the drive side rotating member (121) and the driven side rotating member (123) relatively rotatably fitted to the drive side rotating member in the passed state through the rotating axis of the drive side rotating member. The rotating force of the drive side rotating member is transmitted to the driven side rotating member (123) through the contact state of a power transmission part (121a) on a power receiving part (153). A working tool body (107) comprises a lock member (165) which, when the drive side rotating member and the driven side rotating member are synchronously rotated through the contact state of the power transmission part on the power receiving part, allows the rotation of the driven side rotating member and, when the driven side rotating member is rotated relative to the drive side rotating member, locks the rotation of the driven side rotating member. Also, the working tool body comprises a synchronous rotation holding part (171) which adds a holding force to maintain the synchronous rotations of the drive side rotating member and the driven side rotating member and, when an external force beyond that holding force acts on the driven side rotating member, allows the rotation of the driven side rotating member relative to the drive side rotating member.

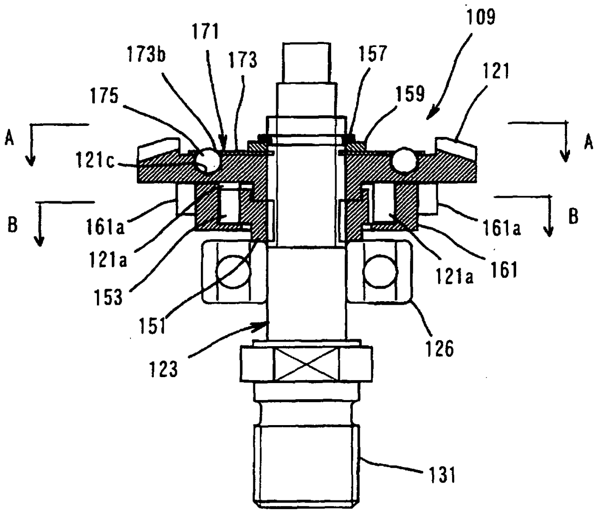

FIG. 2

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Description

Field of the Invention

[0001] The present invention relates to a power tool that performs an operation by utilizing rotation of a tool bit, such as a disc grinder.

Background of the Invention

[0002] Japanese non-examined laid-open Patent Publication No. 11-72122 discloses an electric portable screwdriver having a spindle lock mechanism for facilitating tool change. In this screwdriver, a driving-side rotating member in the form of a driving shaft is connected to a driven-side rotating member in the form of a spindle via a coupling. When a rotating force is inputted from the driving shaft side to the coupling, claws of the driving-side coupling contact claws of the driven-side coupling in the circumferential direction, so that the rotating force of the driving shaft is transmitted to the spindle. On the other hand, when a rotating force (external force) is inputted from the spindle side to the coupling, a lock member is engaged between the driven-side coupling and a lock ring fixed to the housing, so that the driven shaft is locked against rotation. With an electric screwdriver having such a spindle lock mechanism thus constructed, it is not necessary to lock the spindle against rotation at the time of tool change, so that the tool change can be facilitated.

[0003] In the above-mentioned spindle lock mechanism, a braking part is provided which maintains synchronous rotation between the driving-side coupling and the driven-side coupling in order to prevent vibration or noise from being caused by repeated movements of the driving-side coupling and the driven-side coupling moving away from each other and moving toward each other into contact. However, in the above-described known technique, the degree of freedom of design is low in the configuration and the installation position of the braking part, and in this point, further improvement is required.

Disclosure of the Invention

Problems to be solved by the invention

[0004] It is, accordingly, an object of the present invention to provide an effective technique for effectively maintaining synchronous rotation between the driving-side rotating member and the driven-side rotating member, in a power tool having a rotary tool bit.

Means for solving the problems

[0005] In order to solve the above-described problem, the present invention provides a power tool including a driving-side rotating member, a driven-side rotating member, a power receiving part, a power transmitting part, a tool bit, a lock member and a synchronous rotation retaining part. The "power tool" in this invention typically represents a disc grinder which performs a grinding or polishing operation on a workpiece by rotation of a tool bit in the form of a grinding wheel, but it can be widely applied to any power tool which performs a predetermined operation on a workpiece by a rotating tool bit.

[0006] The driving-side rotating member is rotatably disposed within a power tool body. The driven-side rotating member is disposed within the power tool body and inserted through the driving-side rotating member in the direction of the axis of rotation of the driving-side rotating member such that the driven-side rotating member is coaxially and rotatably arranged with respect to the driving-side rotating member. The power receiving part is integrally disposed with the driven-side rotating member. The power transmitting part is integrally disposed with the driving-side rotating member and engages the power receiving part to thereby transmit a rotating force of the driving-side rotating member to the driven-side rotating member. The tool bit is rotationally driven via the driven-side rotating member and thereby performs a predetermined operation. The tool bit can be switched between tool bit driving mode and tool bit replacing mode. In the tool bit driving mode, the rotating force of the driving-side rotating member is transmitted to the driven-side rotating member via the power transmitting part and the power receiving part which are engaged with each other, so that the driving-side rotating member and the driven-side rotating member rotate together. Thus, the tool bit can perform the predetermined operation. In a tool bit replacing mode, a rotating force generated by manual operation for replacing the tool bit is inputted to the driven-side rotating member so that the driven-side rotating member rotates with respect to the driving-side rotating member. As a result, the driven-side rotating member is locked against rotation. Thus, replacement of the tool bit can be facilitated.

[0007] In the tool bit driving mode, the lock member allows the driven-side rotating member to rotate such that the tool bit can perform the predetermined operation. While, in the tool bit replacing mode, the lock member locks the driven-side rotating member against rotation.

[0008] Further, in the tool bit driving mode, the synchronous rotation retaining part maintains synchronous rotation of the driving-side rotating member and the driven-side rotating member. Therefore, even when the driven-side rotating member is caused to rotate faster than the driving-side rotating member by change of the rotational load of the driven-side rotating member, such a faster movement is prevented by the retaining force of the synchronous rotation retaining part. As a result, engagement between the power receiving part and the power transmitting part is reliably maintained, so that synchronous rotation of the driving-side rotating member and the driven-side rotating member is maintained. In this manner, vibration or noise can be prevented from being caused by repeated movements of the power receiving part and the power transmitting part moving away from each other and moving toward each other into contact.

[0009] In the tool bit replacing mode, when a rotating force is manually inputted which releases the engagement between the power receiving part and the power transmitting part, the synchronous rotation retaining part allows the driven-side rotating member to rotate with respect to the driving-side rotating member in a direction that releases the engagement between the power receiving part and the power transmitting part so that the lock member locks the driven-side rotating member against rotation. Therefore, in the tool bit replacing mode, an external force is applied to the driven-side rotating member such that the driven-side rotating member rotates with respect to the driving-side rotating member. Thus, the driven-side rotating member is locked against rotation, so that the mounting and removal of the tool bit can be facilitated.

[0010] Further, in this invention, with the construction in which the driven-side rotating member is inserted through the driving-side rotating member, the installation position of the synchronous rotation retaining part between the driving-side rotating member and the driven-side rotating member can be selected at any position in the axial direction of the driving-side rotating member and the driven-side rotating member. Thus, a higher degree of freedom of design in the installation position of the synchronous rotation retaining part can be ensured. Further, with the construction in which the driven-side rotating member is inserted through the driving-side rotating member, centering of the shafts with respect to each other can be easily performed by fitting the rotating members together.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 is a sectional view showing the entire structure of an electric disc grinder according to an embodiment of the invention.
FIG. 2 is an enlarged sectional view of a power transmitting mechanical part.
FIG. 3 is a sectional view taken along line A-A and line B-B in FIG. 2, showing a rotating force transmitting part, a lock mechanical part and a synchronous rotation retaining part, showing the state during operation in (I), the state at the time of removal of a grinding wheel in (II), and the state at the time of attachment of the grinding wheel in (III).
FIG. 4 is a plan view of a gear.
FIG. 5 is a bottom view of the gear.
FIG. 6 is a sectional view of the gear.
FIG. 7 is a front view of a spindle.
FIG. 8 is a plan view of the spindle, half shown in section.
FIG. 9 is a plan view of a lock cam.
FIG. 10 is a sectional view of the lock cam.
FIG. 11 is a plan view of a lock ring.
FIG. 12 is a sectional view of the lock ring.
FIG. 13 is a plan view of a leaf spring.
FIG. 14 is a sectional view showing a rotating force transmitting part, a lock mechanical part and a synchronous rotation retaining part according to a second embodiment, showing the state during operation by clockwise rotation of the grinding wheel in (I), the state at the time of removal of a grinding wheel in (II), and the state at the time of attachment of the grinding wheel in (III).
FIG. 15 is a sectional view showing the rotating force transmitting part, the lock mechanical part and the synchronous rotation retaining part according to the second embodiment, showing the state during operation by counterclockwise rotation of the grinding wheel in (I), the state at the time of removal of the grinding wheel in (II), and the state at the time of attachment of the grinding wheel in (III).
FIG. 16 is a sectional view showing the entire structure of an electric disc grinder according to a third embodiment of the invention.
FIG. 17 is an enlarged sectional view of a power transmitting mechanical part.
FIG. 18 is a sectional view taken along line A-A and line B-B in FIG. 17, showing a rotating force transmitting part, a lock mechanical part and a synchronous rotation retaining mechanism, showing the state during operation in (I), the state at the time of removal of a grinding wheel in (II), and the state at the time of attachment of the grinding wheel in (III), and showing a retainer in a phantom line.
FIG. 19 is a plan view of a gear.
FIG. 20 is a bottom view of the gear.
FIG. 21 is a sectional view of the gear.
FIG. 22 is a front view of a spindle.
FIG. 23 is a plan view of the spindle, half shown in section.
FIG. 24 is a plan view of a lock cam.
FIG. 25 is a sectional view of the lock cam.
FIG. 26 is a plan view of a lock ring.
FIG. 27 is a sectional view of the lock ring.
FIG. 28 is a sectional view of a retainer.
FIG. 29 is a plan view of the retainer.
FIG. 30 is a sectional view showing the electric disc grinder turned upside down with the grinding wheel facing upward in order to replace the grinding wheel.

Representative embodiment of the invention

(First Embodiment)

[0012] A first embodiment of the present invention is now described with reference to FIGS. 1 to 13. In this embodiment, an electric portable disc grinder which is used for grinding or polishing various kinds of workpiece, such as steel, concrete and stone, is explained as a representative example of a power tool according to the present invention. FIG. 1 is a sectional view showing the entire structure of an electric disc grinder 101. In FIG. 1, part of the rear portion (on the right side as viewed in FIG. 1) is not shown. FIG. 2 is a sectional view showing a power transmitting mechanical part. FIG. 3 shows a sectional structure of the power transmitting mechanical part. FIG. 3 shows the sectional structure in section taken along line A-A and line B-B of FIG. 2 on the upper side and the lower side, respectively. The operating conditions of each of the sectional structure parts are shown in sequence from left to right, in (I) showing the state during operation, (II) showing the state at the time of removal of the grinding wheel, and (III) showing the state at the time of attachment of the grinding wheel. FIGS. 4 to 13 show component parts of the power transmitting mechanical part. FIGS. 4 to 6 show a gear, FIGS. 7 and 8 show a spindle, FIG. 9 and 10 show a lock cam, FIGS. 11 and 12 show a lock ring, and FIG. 13 shows a leaf spring.

[0013] As shown in FIG. 1, the electric disc grinder 101 includes a body 103 having a motor housing 105 and a gear housing 107. The body 103 is a feature that corresponds to the "tool body" according to this invention. The motor housing 105 is generally cylindrical and houses a driving motor 111. The driving motor 111 is a feature that corresponds to the "driving source" according to this invention. The driving motor 111 is arranged such that an axis of rotation of a rotor 113 of the driving motor extends in the longitudinal direction of the electric disc grinder 101. A small bevel gear 117 is mounted on the front end (left end as viewed in the drawing) of a motor shaft 115 of the driving motor 111. Further, a cooling fan 119 is mounted on the motor shaft 115 such that it can rotate together with the motor shaft 115. In this embodiment, the driving motor 111 rotates in one direction.

[0014] A power transmitting mechanical part 109 is housed within the gear housing 107 that is connected to the front end of the motor housing 105. The power transmitting mechanical part 109 transmits the rotating output of the driving motor 111 to a grinding wheel 141. The grinding wheel 141 is a feature that corresponds to the "tool bit" according to this invention. As shown in FIG. 2, the power transmitting mechanical part 109 includes the small bevel gear 117 (see FIG. 1), a gear 121, a spindle 123 and a lock cam 151. The gear 121 and the spindle 123 are features that correspond to the "driving-side rotating member" and the "driven-side rotating member", respectively, according to this invention. The gear 121 is driven by the driving motor 111 and caused to rotate in the direction of the arrow shown in FIG. 3.

[0015] The gear 121 has teeth in the outer circumferential region which engage the small bevel gear 117 (see FIG. 1) all the time. The gear 121 is arranged such that its axial direction coincides with a direction perpendicular to the axis of rotation of the driving motor 111, or the vertical direction. The spindle 123 is coaxially arranged with the gear 121 and fitted through the shaft hole of the gear 121 for relative rotation. The spindle 123 extends vertically and is rotatably supported at its upper and lower ends on the gear housing 107 via bearings 125, 126 (see FIG. 1).

[0016] As shown in FIG. 1, the end (lower end) of the spindle 123 protrudes from the lower surface of the gear housing 107, and a grinding wheel mounting portion 131 having a bolt width and a threaded portion is formed on the protruding end of the spindle 123. The grinding wheel 141 is detachably mounted to the grinding wheel mounting portion 131 in such a manner as to be clamped from above and below via inner (grinding wheel upper surface side) and outer (grinding wheel lower surface side) mounting flanges 133, 135. The inner mounting flange 133 on the upper surface side of the grinding wheel 141 is mounted to the grinding wheel mounting portion 131 via the bolt width such that it cannot rotate with respect to the grinding wheel mounting portion 131. The outer mounting flange 135 on the lower surface side of the grinding wheel 141 is screwed onto the threaded portion in order to mount the grinding wheel 141. The outer mounting flange 135 has a threaded hole and is turned in a direction opposite to the direction of rotation of the spindle in order to be tightened. Specifically, when the grinding wheel 141 is rotated, the screw tightening force acts upon the grinding wheel 141 all the time. The rear half of the grinding wheel 141 is covered by a cover 143.

[0017] As shown in FIGS. 9 and 10, the lock cam 151 has a generally cylindrical shape having a spline hole 151a. The lock cam 151 is mounted on the lower surface side or one axial end of the gear 121 and concentrically arranged with the gear 121. The lock cam 151 is connected to a spline shaft 123a of the spindle 123 by spline fitting and thus rotates together with the spindle 123. As shown in FIG. 2, the gear 121 and the lock cam 151 are prevented from moving in the axial direction by the lower bearing 126 and a washer 159 mounted on the spindle 123 via a circlip 157. The lock cam 151 has two claws 153 and two plane cams 155 on the outer periphery. The claws 153 are spaced apart 180° in the circumferential direction from each other, and the plane cams 155 are spaced apart 90° in the circumferential direction from the claws 153 (or 180° in the circumferential direction from each other). The claws 153 has a predetermined length extending in the radial direction. The plane cams 155 are formed by flat surfaces parallel to each other. The claws 153 of the lock cam 151 receive a rotating force from two claws 121a (see FIGS. 5 and 6) provided on the gear 121 for power transmission and transmits it to the spindle 123. This rotating force transmitting structure will be described below.

[0018] As shown in FIGS. 1, 2 and 3, a circular lock ring 161 is disposed between the gear 121 and the lower bearing 126 and on the outer peripheral side of the lock cam 151. A plurality of projections 161a (see FIGS. 11 and 12) radially extend from the outer periphery of the lock ring 161. The projections 161a engage a recess 107a (see FIG. 1) which is formed in the inner wall surface of the gear housing 107 in such a manner as to correspond to the projections 161 a, so that the lock ring 161 is prevented from moving in the circumferential direction. The lock ring 161 has an inner circumferential surface having an inside diameter slightly larger than the outside diameter of the region of the lock cam 151 including the claws 153. A predetermined clearance 156 is formed between the inner circumferential surface of the lock ring 161 and the outer circumferential surface and the plane cams 155 of the lock cam 151 (see FIG. 3).

[0019] As shown in FIG. 3, a cylindrical rolling element 165 is disposed in the clearance 156 between the inner circumferential surface of the lock ring 161 and each of the plane cams 155 of the lock cam 151. The rolling element 165 is a feature that corresponds to the "lock member" according to this invention. The predetermined clearance 156 defined between the inner circumferential surface of the lock ring 161 and the plane cam 155 of the lock cam 151 has a maximum radial width at the middle of the plane cam 155 in the circumferential direction and a minimum radial width at the ends of the plane cam 155 in the circumferential direction. The rolling element 165 has an outside diameter smaller than the maximum width of the clearance 156 and larger than the minimum width of the clearance 156. Therefore, when the rolling element 165 is located in the maximum width portion of the clearance 156 (in the state shown in (I) of FIG. 3), the rolling element 165 allows the spindle 123 to rotate. On the other hand, when the rolling element 165 is moved away from the maximum width portion via a play region (movement allowed region) of the clearance 156 (in the state shown in (II) and (III) of FIG. 3), the rolling element 165 is engaged between the inner circumferential surface of the lock ring 161 and the plane cam 155 of the lock cam 151. Thus, the lock cam 151 and the lock ring 161 are locked, and the spindle 123 is locked against rotation. Specifically, the lock cam 151, the lock ring 161 and the rolling element 165 form a spindle lock mechanism.

[0020] Four claws 121a, 121b (see FIG. 5) are formed on the underside of the gear 121 and spaced apart 90° around the axis of the gear 121 from each other. Each of the claws 121a, 121b has predetermined lengths in the axial and circumferential directions and has an arcuate section. As shown in FIG. 3, the claws 121a, 121b are fitted into the clearance between the inner circumferential surface of the lock ring 161 and the outer circumferential surface of the lock cam 151 such that the claws are located between the claws 153 of the lock cam 151 and the plane cams 155. Among the four claws 121a, 121b of the gear 121, one circumferential end (the front end in the direction of rotation) of each of the two claws 121a diametrically opposed with respect to the axis of rotation of the gear 121 contacts one circumferential end of the associated claw 153 of the lock cam 151 and applies a rotating force to the lock cam 151 in the direction of the arrow (clockwise), which causes the spindle 123 to rotate in the same direction. Specifically, the claws 121a of the gear 121 and the claws 153 of the lock cam 151 form a rotating force transmitting mechanism for transmitting a rotating force of the gear 121 to the spindle 123. The two claws 121a of the four claws 121a, 121b of the gear 121 which contact the claws 153 of the lock cam 151 are features that correspond to the "power transmitting part", and the lock cam 151 and the claws 153 are features that correspond to the "power receiving part" according to this invention.

[0021] As described above, in the state of synchronous rotation in which the gear 121 and the spindle 123 rotate by contact between the claws 121 a of the gear 121 and the claws 153 of the lock cam 151, one circumferential end of each of the other two claws 121b of the gear 121 contacts the associated rolling element 165. Thus, the rolling element 165 is held in the maximum width portion of the clearance 156 and thereby prevented from being engaged between the lock cam 151 and the lock ring 161. Therefore, synchronous rotation of the gear 121 and the spindle 123 is allowed.

[0022] As shown in FIG. 3, a predetermined clearance (hereinafter referred to as play) is provided between the claws 153 of the lock cam 151 and the claws 121a, 121b of the gear 121 located on the both sides of the claws 153. Specifically, the lock cam 151 is allowed to move in the circumferential direction with respect to the gear 121 within the range of the play. Therefore, during rotation of the spindle 123, the rotational load on the spindle side (the driven side) may change (increase or decrease), and rotation of the spindle 123 may become faster or slower than the gear 121. At this time, the claws 153 of the lock cam 151 and the claws 121 a, 121b of the gear 121 repeat movements of moving away from each other and moving toward each other into contact, which may cause vibration or noise. In order to avoid such an occurrence and retain synchronous rotation of the spindle 123 and the gear 121, a synchronous rotation retainer 171 is provided which provides a retaining force for preventing relative rotation of the spindle 123 and the gear 121.

[0023] The synchronous rotation retainer 171 includes a leaf spring 173 and steel balls 175. The leaf spring 173 and the steel balls 175 are features that correspond to the "first member" and the "second member", respectively, according to this invention. The leaf spring 173 is a plate-like member made of elastic material and having a spline hole 173a (see FIG. 13) in the middle. The leaf spring 173 is disposed oppositely on the upper surface of the gear 121 and connected (see FIG. 3) to the spline shaft 123a of the spindle 123 by spline fitting.

[0024] As shown in FIGS. 1 and 2, the leaf spring 173 is prevented from moving in the axial direction by the washer 159 mounted on the spindle 123 via the circlip 157. The steel balls 175 are retained in ball receiving recesses 121c (see FIG. 6) formed in the upper surface of the gear 121. Further, the steel balls 175 partially engage in ball retaining holes 173b and thereby apply a retaining force (resistance) to prevent the spindle 123 from rotating with respect to the gear 121 (ahead of the gear). In this manner, the claws 121a of the gear 121 and the claws 153 of the lock cam 151 can be held in contact with each other.

[0025] The electric disc grinder 101 according to this embodiment is constructed as described above. Operation and usage of the electric disc grinder 101 is now explained. When the driving motor 111 is driven and thus the motor shaft 115, the small bevel gear 117 and the gear 121 are rotated, as shown on the lower side in (I) of FIG. 3, the two claws 121a of the gear 121 contact the claws 153 of the lock cam 151 and apply a clockwise rotating force to the lock cam 151, which causes the spindle 123 to rotate clockwise. Further, at the same time, the other two claws 121b of the gear 121 contact the rolling elements 165 and retain the rolling elements 165 in the maximum width portions of the clearance 156 between the plane cams 155 of the lock cam 151 and the inner circumferential surface of the lock ring 161, which allows the spindle 123 to rotate together with the gear 121. Therefore, the rolling elements 165 are not engaged between the lock ring 161 and the lock cam 151.

[0026] At this time, as shown on the upper side in (I) of FIG. 3, the steel balls 175 partially engage in the ball retaining holes 173b and retain the claws 121a of the gear 121 and the claws 153 of the lock cam 151 in contact with each other. Therefore, the spindle 123 and the gear 121 are prevented from rotating with respect to each other and thereby kept allowed to synchronously rotate. Thus, such an occurrence of the phenomenon in which the claws 153 of the lock cam 151 and the claws 121 a, 121b of the gear 121 repeat movements of moving away from each other and moving toward each other into contact, can be avoided.

[0027] Removal of the grinding wheel 141 from the spindle 123 is now described. In this case, in the state of rest of the spindle 123, a rotating force is applied clockwise (in the direction of rotation of the spindle 123) to the outer mounting flange 135 in order to loose the outer mounting flange 135 by using a lock nut wrench (not shown). Then the rotating force is transmitted to the leaf spring 173 connected to the spindle 123 via the spline. At this time, the steel balls 175 are located in the ball retaining holes 173b, so that the claws 153 of the lock cam 151 and the claws 121 a of the gear 121 are held in contact with each other. However, since the gear 121 connected to an armature of the driving motor 111 has a rotational load, the leaf spring 173 rotates clockwise together with the spindle 123 with respect to the gear 121. As a result, as shown in (II) of FIG. 3, the steel balls 175 are disengaged from the ball retaining holes 173b by elastic deformation of the leaf spring 173 in the axial direction of the spindle (upward as viewed in FIG. 1). By this relative rotation of the spindle 123 and the gear 121, the lock cam 151 connected to the spindle 123 via the spline rotates, so that the claws 153 of the lock cam 151 move away from the claws 121a of the gear 121. Specifically, the lock cam 151 rotates clockwise with respect to the gear 121. By this relative rotation, the rolling elements 165 move away from the claws 121b of the gear 121 and move within the movement allowed region. At this time, the rolling elements 165 are engaged between the inner circumferential surface of the lock ring 161 and the plane cams 155 of the lock cam 151. Thus, the spindle 123 is locked against rotation. Thereafter, by rotating the mounting flange 135 clockwise with respect to the locked spindle 123, the mounting flange 135 can be removed from the grinding wheel mounting portion 131 of the spindle 123. Then, the grinding wheel 141 can be removed.

[0028] Attachment of the grinding wheel 141 to the spindle 123 is now described. In the state of rest of the spindle 123 (in the state shown in (II) of FIG. 3), the grinding wheel 141 is fitted onto the grinding wheel mounting portion 131 and the mounting flange 135 is turned counterclockwise in order to be tightened. At this time, when a rotating force is applied to the spindle 123 by such tightening, as shown in (III) of FIG. 3, the leaf spring 173 rotates counterclockwise together with the spindle 123 with respect to the gear 121. As a result, the steel balls 175 are fitted in the associated ball retaining holes 173b of the leaf spring 173. At the same time, the lock cam 151 rotates counterclockwise together with the spindle 123 with respect to the gear 121. As a result, the rolling elements 165 are engaged between the inner circumferential surface of the lock ring 161 and the plane cams 155 of the lock cam 151, so that the spindle 123 is locked against rotation. In this state, the mounting flange 135 is tightened with a predetermined torque. In this manner, the grinding wheel 141 can be attached to the spindle 123.

[0029] As described above, according to this embodiment, in removing or mounting the grinding wheel 141 to the spindle 123, when a rotating force (external force) is inputted from the spindle 123, the spindle lock mechanism including the lock cam 151, the lock ring 161 and the rolling elements 165 is actuated. Specifically, the spindle 123 can be locked against rotation without need of additional operation of locking the spindle 123 from the outside. Therefore, ease of operation in removing and mounting the grinding wheel 141 can be enhanced.

[0030] Further, when the driving motor 111 is driven and the grinding wheel 141 is rotated via the power transmitting mechanical part 109, a retaining force is applied to the gear 121 and the spindle 123 via the synchronous rotation retainer 171 so as to prevent relative rotation of the gear 121 and the spindle 123. With this construction, relative rotation of the gear 121 and the spindle 123 which is caused by change of the rotational load on the driven side is prevented. As a result, vibration or noise can be prevented from being caused by the repeated movements of the claws 153 of the lock cam 151 and the claws 121a, 121b of the gear 121 moving away from each other and moving toward each other into contact.

[0031] According to this embodiment, the spindle 123 is inserted through the gear 121, and the both ends of the spindle 123 are supported by the bearings 125, 126. Therefore, transmission of the rotating force between the gear 121 and the spindle 123 can be performed in a stable state. Further, the gear 121 is rotatably supported with

the spindle 123 inserted through the gear 121. With this construction, centering of the spindle 123 and the gear 121 with respect to each other is performed by fitting the spindle 123 and the gear 121 together. Therefore, any additional operation for the centering is not required in assembling the spindle 123 to the gear housing 107. Thus, assembling efficiency can be improved.
Further, with the construction in which the spindle 123 is supported at its both ends, transmission of the rotating force is stabilized, and a force is evenly applied to the gear 121 and the spindle 123. Therefore, the life of component parts involved in transmission of the rotating force, such as the claws 121a of the gear 121, the claws 153 of the lock cam 151 and the rolling element 165, can be increased.

[0032] Further, with the construction in which the spindle 123 is inserted through the gear 121, the synchronous rotation retainer 171 between the gear 121 and the spindle 123 can be placed in any position in the axial direction of the spindle 123. Specifically, according to this embodiment, the synchronous rotation retainer 171 can be disposed by utilizing the gear upper surface region rather than the gear lower surface region in which the mechanism for transmitting the rotating force of the gear 121 to the spindle 123 and the lock mechanism for locking the spindle 123 against rotation are disposed. Therefore, it is not necessary to assemble several kinds of mechanisms in a limited space, so that assembling efficiency as a whole can be effectively enhanced. Further, in this embodiment, in the electric disc grinder 101, a free space originally existing as a dead space on the upper surface of the gear is utilized to dispose the synchronous rotation retainer 171. Thus, the synchronous rotation retainer 171 can be disposed without increasing the size of the electric disc grinder.

[0033] Further, according to this embodiment, the synchronous rotation retainer 171 is constructed to apply a retaining force when the steel balls 175 are partially fitted (engaged) in the ball retaining holes 173b of the leaf spring 173. The leaf spring 173 and the steel balls 175 which are opposed to each other in the axial direction of the gear 121 are engaged with each other and obtain a retaining force on the engagement surface extending in a direction perpendicular to the axial direction of the gear 121. Thus, compared with the construction in which the engagement surface extends in the axial direction of the gear 121, the length of the synchronous rotation retainer 171 in the axial direction can be effectively shortened.

(Second Embodiment)

[0034] A second embodiment of the present invention is now described with reference to FIGS. 14 to 15. In the second embodiment, the tool bit, for example, in the form of the grinding wheel 141 (see FIG. 1) can be rotated both clockwise and counterclockwise (both in the normal and reverse directions). In this embodiment, when the gear 121 is rotated clockwise by the driving motor (see FIG. 1), among the four claws 121a, 121b of the gear 121, the two claws 121a diametrically opposed with respect to the axis of rotation of the gear 121 serve to transmit clockwise rotating force, and the other two claws 121b serve to retain the rolling elements 165. On the other hand, when the gear 121 is rotated counterclockwise, the claws 121a, 121b serve vice versa. Specifically, the other two claws 121b serve to transmit counterclockwise rotating force, and the two claws 121a serve to retain the rolling elements 165. Further, the leaf spring 173 forming the synchronous rotation retainer 171 includes ball retaining holes 173b for clockwise rotation and ball retaining holes 173c for counterclockwise rotation. The ball retaining holes 173b for clockwise rotation and the ball retaining holes 173c for counterclockwise rotation are spaced a predetermined distance apart from each other in the circumferential direction. The distance corresponds to the circumferential length of the clearance provided between the claws 153 of the lock cam 151 and the claws 121a, 121 b of the gear 121 located on the both sides of the claws 153.

[0035] The construction of this embodiment is the same as the first embodiment except the above-described point. FIG. 14 shows the state in which the gear 121 is driven by the driving motor 111 and rotates clockwise (thus the grinding wheel 141 rotates clockwise). In this case, as shown in (I) of FIG. 14, the two claws 121a of the gear 121 for clockwise rotation contact the associated claws 153 of the lock cam 151. Further, at the same time, the other two claws 121 b of the gear 121 contact the rolling elements 165 and retain the rolling elements 165 in the maximum width portion of the clearance 156 between the plane cams 155 of the lock cam 151 and the inner circumferential surface of the lock ring 161. Therefore, the rolling elements 165 are not engaged between the plane cams 155 of the lock cam 151 and the inner circumferential surface of the lock ring 161. Thus, the gear 121 and the spindle 123 rotate together via contact between the claws 121a of the gear 121 and the claws 153 of the lock cam 151. At this time, in the synchronous rotation retainer 171, the steel balls 175 are engaged in the ball retaining holes 173b of the leaf spring 173 for clockwise rotation and apply a retaining force to prevent relative rotation of the spindle 123 and the gear 121. As a result, despite of change of rotational load on the driven side, the spindle 123 and the gear 121 are kept allowed to synchronously rotate.

[0036] In order to remove the grinding wheel 141 after grinding or polishing operation by clockwise rotation of the grinding wheel 141, in the state of rest of the spindle 123, the mounting flange 135 (see FIG. 1) is turned in the loosening direction (clockwise). At this time, the rotational load of the armature of the driving motor 111 is applied to the gear 121. Therefore, as shown on the upper side in (II) of FIG. 14, the leaf spring 173 rotates together with the spindle 123 with respect to the gear 121. By this rotation, the steel balls 175 retained on the gear 121 side move out of the associated ball retaining holes 173b of the leaf spring 173 while elastically deforming the leaf spring 173 in the axial direction of the spindle (upward as viewed in FIG. 1). Further, by the relative rotation of the spindle 123 and the gear 121, as shown on the lower side in (II) of FIG. 14, the lock cam 151 connected to the spindle 123 via the spline rotates, so that the claws 153 of the lock cam 151 are disengaged from the claws 121a of the gear 121. Specifically, the lock cam 151 rotates clockwise with respect to the gear 121. By this relative rotation, the rolling elements 165 are disengaged from the claws 121b of the gear 121 and move within the movement allowed region. At this time, the rolling elements 165 are engaged between the inner circumferential surface of the lock ring 161 and the plane cams 155 of the lock cam 151. Thus, the spindle 123 is locked against rotation. Thereafter, by rotating the mounting flange 135 clockwise with respect to the locked spindle 123, the mounting flange 135 can be removed from the grinding wheel mounting portion 131 of the spindle 123. Then, the grinding wheel 141 can be removed.

[0037] Attachment of the grinding wheel 141 to the spindle 123 is now described. In the state of rest of the spindle 123 (in the state shown in (II) of FIG. 14), the grinding wheel 141 is fitted onto the grinding wheel mounting portion 131 and the mounting flange 135 is turned counterclockwise in order to be tightened. At this time, when a rotating force is applied to the spindle 123 by such tightening, as shown in (III) of FIG. 14, the leaf spring 173 rotates counterclockwise together with the spindle 123 with respect to the gear 121. As a result, the steel balls 175 are fitted in the associated ball retaining holes 173b of the leaf spring 173. At the same time, the lock cam 151 rotates counterclockwise together with the spindle 123 with respect to the gear 121. As a result, the rolling elements 165 are engaged between the inner circumferential surface of the lock ring 161 and the plane cams 155 of the lock cam 151, so that the spindle 123 is locked against rotation. In this state, the mounting flange 135 is tightened with a predetermined torque. In this manner, the grinding wheel 141 is attached to the spindle 123.

[0038] In (I) of FIG. 15, the grinding wheel 141 is rotated counterclockwise for grinding or polishing operation. In this case, the gear 121 is rotated counterclockwise by the driving motor 111. At this time, when the steel balls 175 are held engaged in the ball retaining holes 173b of the leaf spring 173 for clockwise rotation, the gear 121 rotates counterclockwise with respect to the spindle 123 by the rotational load on the driven side. By this relative rotation, the steel balls 175 move out of the associated ball retaining holes 173b of the leaf spring 173 for clockwise rotation. Then, the steel balls 175 are fitted in the associated ball retaining holes 173c of the leaf spring 173 for counterclockwise rotation (see the upper side of (I) in FIG. 15). At this time, the claws 121b of the gear 121 for counterclockwise rotation contact the associated claws 153 of the lock cam 151, and the other two claws 121a contact the associated rolling elements 165. As a result, the rolling elements 165 are retained in the maximum width portion of the clearance 156 between the plane cams 155 of the lock cam 151 and the inner circumferential surface of the lock ring 161 (See the lower side of (I) in FIG. 15). Therefore, the rolling elements 165 are not engaged between the plane cams 155 of the lock cam 151 and the inner circumferential surface of the lock ring 161. Thus, the gear 121 and the spindle 123 rotate counterclockwise together. At this time, in the synchronous rotation retainer 171, the steel balls 175 are engaged in the ball retaining holes 173c of the leaf spring 173 for counterclockwise rotation and apply a retaining force to prevent relative rotation of the spindle 123 and the gear 121. As a result, despite of change of rotational load on the driven side, the spindle 123 and the gear 121 are kept allowed to synchronously rotate.

[0039] In order to remove the grinding wheel 141 after grinding or polishing operation by counterclockwise rotation of the grinding wheel 141, in the state of rest of the spindle 123, the mounting flange 135 (see FIG. 1) is turned in the loosening direction (clockwise). At this time, as shown in (II) of FIG. 15, the claws 153 of the lock cam 151 are in engagement with the claws 121 b of the gear 121 for counterclockwise rotation. Therefore, an external force (rotating force) exceeding the rotational load of the armature of the driving motor 111 is applied to the gear 121. Then, the lock cam 151 rotates together with the gear 121. As a result, the rolling elements 165 are engaged between the plane cams 155 and the inner circumferential surface of the lock ring 161, so that the spindle 123 is locked against rotation. In this case, the gear 121 and the lock cam 151 rotate together, so that the steel balls 175 are kept engaged in the ball retaining holes 173c of the leaf spring 173 for counterclockwise rotation. Thereafter, by rotating the mounting flange 135 clockwise with respect to the locked spindle 123, the mounting flange 135 can be removed from the grinding wheel mounting portion 131 of the spindle 123. Then, the grinding wheel 141 can be removed.

[0040] In order to attach the grinding wheel 141 to the spindle 123, in the state of rest of the spindle 123 (in the state shown in (II) of FIG. 15), the grinding wheel 141 is fitted onto the grinding wheel mounting portion 131 and the mounting flange 135 is turned counterclockwise in order to be tightened. At this time, when a rotating force is applied to the spindle 123 by such tightening, as shown in (III) of FIG. 15, the leaf spring 173 rotates counterclockwise together with the spindle 123 with respect to the gear 121. As a result, the steel balls 175 move out of the ball retaining holes 173c of the leaf spring 173 for counterclockwise rotation. At the same time, the lock cam 151 rotates counterclockwise together with the spindle 123 with respect to the gear 121. As a result, the rolling elements 165 are engaged between the inner circumferential surface of the lock ring 161 and the plane cams 155 of the lock cam 151, so that the spindle 123 is locked against rotation. In this state, the grinding wheel 141 can be attached to the spindle 123 by tightening the mounting flange 135.

[0041] As described above, according to this embodiment, when the driving wheel 141 is rotated, whether clockwise or counterclockwise, a retaining force of preventing relative rotation is applied to the spindle 123 and the gear 121 via the synchronous rotation retainer 171. As a result, despite of change of rotational load on the driven side, the spindle 123 and the gear 121 can be kept allowed to synchronously rotate. Further, in removing or mounting the grinding wheel 141 to the spindle 123, when a rotating force is inputted from the spindle 123, the spindle 123 can be locked against rotation via the spindle lock mechanism including the lock cam 151, the lock ring 161 and the rolling elements 165, without additional operation of locking the spindle 123 from the outside. Therefore, ease of operation in removing and mounting the grinding wheel 141 can be enhanced. Further, like in the first embodiment, the spindle 123 is inserted through the center of axis of the gear 121, and the effect obtained by this construction is the same as in the first embodiment.

[0042] Further, in this embodiment, the synchronous rotation retainer 171 is disposed on the upper surface side of the gear 121, but it may be disposed on the lower surface side of the gear 121. Specifically, the synchronous rotation retainer 171 may be disposed in the region in which the mechanism for transmitting the rotating force of the gear 121 to the spindle 123 and the lock mechanism for locking the spindle 123 against rotation are disposed. Further, in this embodiment, the rolling elements 165 are cylindrical, but they may comprise steel balls.

[0043] Further, in this embodiment, the synchronous rotation retainer 171 is formed by the leaf spring 173 and the steel balls 175 that engage the ball retaining holes 173b of the leaf spring 173, but it is not limited to this construction. Specifically, it may be any construction which can apply to the gear 121 and the spindle 123 a retaining force that can prevent relative rotation of the gear 121 and the spindle 123. For example, it may be constructed such that the gear 121 and the spindle 123 are connected to each other via an elastic element such as a rubber and a spring, or such that a retaining force is applied by friction contact of two elastically biased members. Therefore, the ball retaining holes 173b of the leaf spring 173 in the first embodiment, or the retaining holes 173b, 173c of the leaf spring 173 for clockwise and counterclockwise rotation in the second embodiment may be omitted, and it may be constructed such that the leaf spring 173 applies a resistance to the steel ball 175 by surface contact by utilizing the spring force of the leaf spring 173.

[0044] Further, in this embodiment, the electric disc grinder 101 for grinding or polishing operation is described as a representative example of the power tool. However, other than the electric disc grinder, this invention can be applied to a power tool which performs a predetermined operation by rotation of a tool bit, such as a screwdriver.

(Third Embodiment)

[0045] A third embodiment of the present invention is now described with reference to FIGS. 16 to 30. Components or elements in the third embodiment which are substantially identical to those in the first embodiment are given like numerals as in the first embodiment and will not be described. FIG. 16 is a sectional view showing the entire structure of the electric disc grinder 101.

[0046] As shown in FIGS. 16, 17 and 18, a circular lock ring 161 is disposed between the gear 121 and the lower bearing 126 and on the outer peripheral side of the lock cam 151. As shown in FIGS. 26 and 27, a plurality of projections 161 a radially extend from the outer periphery of the lock ring 161. The projections 161a engage the recess 107a (see FIG. 16) which is formed in the inner wall surface of the gear housing 107 in such a manner as be assigned to the projections 161a, so that the lock ring 161 is prevented from moving in the circumferential direction. The lock ring 161 has an inner circumferential surface having an inside diameter slightly larger than the outside diameter of the region of the lock cam 151 including the claws 153. The lock ring 161 has a recessed inner circumferential surface 161 b formed along the entire circumference and having a circular arc section. A predetermined clearance 156 is formed between the recessed inner circumferential surface 161b of the lock ring 161 and the outer circumferential surface and recessed cams 155 of the lock cam 151 (see FIG. 18).

[0047] As shown in FIG. 18, a first steel ball 165 is disposed in the clearance 156 between the recessed inner circumferential surface 161b of the lock ring 161 and the recessed cams 155 of the lock cam 151. The first steel ball 165 is a feature that corresponds to the "lock member" according to this invention. The predetermined clearance 156 defined between the recessed inner circumferential surface 161b of the lock ring 161 and the recessed cams 155 of the lock cam 151 has a maximum radial width at the middle of the recessed cams 155 in the circumferential direction and a minimum radial width at the ends of the recessed cams 155 in the circumferential direction. The first steel ball 165 has an outside diameter smaller than the maximum width of the clearance 156 and larger than the minimum width of the clearance 156. Therefore, when the first steel ball 165 is located in the maximum width portion of the clearance 156 (in the state shown in (I) of FIG. 18), the first steel ball 165 allows the spindle 123 to rotate. On the other hand, when the first steel ball 165 is moved away from the maximum width portion via a play region (movement allowed region) of the clearance 156 (in the state shown in (II) and (III) of FIG. 18), the first steel ball 165 is engaged between the recessed inner circumferential surface 161b of the lock ring 161 and the recessed cam 155 of the lock cam 151. Thus, the lock cam 151 and the lock ring 161 are locked, and the spindle 123 is locked against rotation. Specifically, the lock cam 151, the lock ring 161 and the first steel ball 165 form a spindle lock mechanism.

[0048] Four claws 121 a, 121b (see FIG. 20) are formed on the underside of the gear 121 and spaced apart 90° around the axis of the gear 121 from each other. Each of the claws 121a, 121b has predetermined lengths in the axial and circumferential directions and has an arcuate section. As shown in FIG. 18, the claws 121 a, 121b are fitted into the clearance between the recessed inner circumferential surface 161 b of the lock ring 161 and the outer circumferential surface of the lock cam 151 such that the claws are located between the claws 153 of the lock cam 151 and the recessed cams 155. Among the four claws 121a, 121b of the gear 121, one circumferential end (the front end in the direction of rotation) of each of the two claws 121a diametrically opposed with respect to the axis of rotation of the gear 121 contacts one circumferential end of the associated claw 153 of the lock cam 151 and applies a rotating force to the lock cam 151 in the direction of the arrow (clockwise), which causes the spindle 123 to rotate in the same direction. Specifically, the claws 121a of the gear 121 and the claws 153 of the lock cam 151 form a rotating force transmitting mechanism for transmitting a rotating force of the gear 121 to the spindle 123.

[0049] As described above, in the state of synchronous rotation in which the gear 121 and the spindle 123 rotate by contact between the claws 121 a of the gear 121 and the claws 153 of the lock cam 151, one circumferential end of each of the other two claws 121 b of the gear 121 contacts the associated first steel ball 165. Thus, the first steel ball 165 is held in the maximum width portion of the clearance 156 and thereby prevented from being engaged between the lock cam 151 and the lock ring 161. Therefore, synchronous rotation of the gear 121 and the spindle 123 is allowed.

[0050] As shown in FIG. 18, a predetermined clearance (hereinafter referred to as play) is provided between the claws 153 of the lock cam 151 and the claws 121a, 121b of the gear 121 located on the both sides of the claws 153. Specifically, the lock cam 151 is allowed to move in the circumferential direction with respect to the gear 121 within the range of the play. Therefore, during rotation of the spindle 123, the rotational load on the spindle side (the driven side) may change (increase or decrease), and rotation of the spindle 123 may become faster or slower than rotation of the gear 121. At this time, the claws 153 of the lock cam 151 and the claws 121 a, 121 b of the gear 121 repeat movements of moving away from each other and moving toward each other into contact, which may cause vibration or noise. In order to avoid such an occurrence and retain synchronous rotation of the spindle 123 and the gear 121, a synchronous rotation retaining mechanism 181 is provided which prevents relative rotation of the spindle 123 and the gear 121.

[0051] The synchronous rotation retaining mechanism 181 includes a retainer 183 and second steel balls 185. The second steel balls 185 are features that correspond to the "actuating member" according to this invention. The retainer 183 is a plate-like member having a spline hole 183a (see FIGS. 28 and 29) in the middle. The retainer 183 is rotatably disposed on the upper surface of the gear 121 and connected (see FIGS. 16 and 17) to the spline shaft 123a of the spindle 123 by spline fitting. The retainer 183 is prevented from moving in the axial direction by the washer 159 mounted on the spindle 123 via the circlip 157.

[0052] The second steel balls 185 are disposed between two steel ball grooves 187 which are formed in the upper surface of the gear 121 and spaced apart 180° in the circumferential direction from each other, and two steel ball grooves 188 which are formed in the lower surface of the retainer 183 and spaced apart 180° in the circumferential direction from each other. The steel ball grooves 187, 188 are features that correspond to the "guide groove" according to this invention. As shown in FIG. 18, the steel ball grooves 187 of the gear 121 extend obliquely with respect to a radial line perpendicular to the axis of the gear 121. A parallel portion 187a is formed in a radially outer portion of each of the steel ball grooves 187 (on the side remote from the axis). The parallel portion 187a is a feature that corresponds to the "parallel region" according to this invention. The steel ball groove 187 of the gear 121 extends obliquely such that its radially inner portion is located forward and its radially outer portion is located rearward, in the direction of rotation of the gear 121. As shown in FIG. 29, the steel ball grooves 188 of the retainer 183 are formed parallel to a radial line perpendicular to the axis of the gear 121. The steel ball grooves 178, 188 have widths equal to or slightly larger than the diameter of the second steel balls 185, so that smooth rolling movement of the second steel balls 185 is ensured.

[0053] As shown in FIGS. 16 and 17, each of the second steel balls 185 is fitted in the associated oblique steel ball groove 187 of the gear 121 and the associated parallel steel ball groove 188 of the retainer 183 and can move in this state between the radially outer end and the radially inner end of the steel ball grooves 187, 188. Specifically, relative movement of the gear 121 and the retainer 183 is allowed by movement of the second steel ball 185 between the radially outer ends and the radially inner ends of the steel ball grooves 187, 188. In other words, relative movement of the gear 121 and the retainer 183 is not allowed unless the second steel ball 185 moves. The second steel balls 185 are located in the radially outer end portions of the steel ball grooves 187, 188 when the claws 121a of the gear 121 contact the claws 153 of the lock cam 151. When the second steel balls 185 move radially inward from the radially outer end portions of the steel ball grooves 187, 188, the claws 121a of the gear 121 are allowed to be disengaged from the claws 153 of the lock cam 151. The radially outer end portions and the radially inner end portions of the steel ball grooves 187, 188 are features that correspond to the "outer position" and the "inner position", respectively, according to this invention.

[0054] As shown in FIGS. 16 and 17, the upper wall surface of the steel ball groove 188 of the retainer 183 is inclined upward from the radially outer side to the radially inner side. Specifically, the steel ball groove 188 is inclined radially inward away from the grinding wheel 141.

[0055] The electric disc grinder 101 according to this embodiment is constructed as described above. Operation and usage of the electric disc grinder 101 is now explained. When the driving motor 111 is driven and thus the motor shaft 115, the small bevel gear 117 and the gear 121 are rotated, as shown on the lower side in (I) of FIG. 18, the two claws 121 a of the gear 121 contact the claws 153 of the lock cam 151 and apply a clockwise rotating force to the lock cam 151, which causes the spindle 123 to rotate clockwise. Further, at the same time, the other two claws 121b of the gear 121 contact the first steel balls 165 and retain the first steel balls 165 in the maximum width portion of the clearance 156 between the recessed cams 155 of the lock cam 151 and the recessed inner circumferential surface of the lock ring 161, which allows the spindle 123 to rotate together with the gear 121. Therefore, the first steel balls 165 are not engaged between the lock ring 161 and the lock cam 151.

[0056] As described above, each of the second steel balls 185 is located in the radially outer end portions of the associated steel ball groove 187 of the gear 121 and the associated steel ball groove 188 of the retainer 183 when the claws 121a of the gear 121 contact the claws 153 of the lock cam 151. Therefore, when the gear 121 is rotated, as shown on the upper side in (I) of FIG. 18, the second steel ball 185 is located in the radially outer end portions of the steel ball grooves 187, 188. Further, the second steel ball 185 which rotates together with the gear 121 is acted upon by a centrifugal force and retained in the radially outer end portions by this centrifugal force. Specifically, the second steel ball 185 engages the radial side wall of the steel ball groove 187 of the gear 121 and the radial side wall of the steel ball groove 188 of the retainer 183 and thereby prevents relative movement of the gear 121 and the retainer 183 in the circumferential direction. As a result, the claws 121a of the gear 121 and the claws 153 of the lock cam 151 are held in contact with each other. Therefore, the spindle 123 is prevented from rotating ahead of the gear 121 by change of the rotational load on the driven side and thereby kept allowed to rotate together with the gear 121. Thus, such an occurrence of the phenomenon in which the claws 153 of the lock cam 151 and the claws 121 a, 121b of the gear 121 repeat movements of moving away from each other and moving toward each other into contact, can be avoided.

[0057] Removal of the grinding wheel 141 from the spindle 123 is now described. As shown in FIG. 30, replacement of the grinding wheel 141 is performed with the body 103 held upside down (in the inverted position) or with the grinding wheel 141 facing upward. In such an inverted position, the upper wall surface (the bottom as seen in the inverted position) of the steel ball groove 188 of the retainer 183 is inclined downwardly from the radially outer end to the radially inner end. Further, during stop of rotation of the grinding wheel 141, the second steel balls 185 are not acted upon by a centrifugal force. Therefore, each of the second steel balls 185 can easily move within the steel ball grooves 187, 188 from the radially outer end to the radially inner end under its own weight. In this state, when the grinding wheel 141 is held by the hand and rotated intermittently, the second steel balls 185 are pushed by the retainer 183 connected to the grinding wheel 141 in the circumferential direction via the spindle 123 and the spline. As a result, the second steel balls 185 move radially inward under the own weight along the inclined surface of the steel ball grooves 188 of the retainer 183 (see the upper side of (II) in FIG. 18).

[0058] When the second steel balls 185 move radially inward, the second steel balls 185 no longer prevent relative movement of the gear 121 and the retainer 183. Thus, the retainer 183 is allowed to rotate with respect to the gear 121. In this state, when the spindle 123 rotates together with the retainer 183, the lock cam 151 connected to the spindle 123 via the spline rotates, so that the claws 153 of the lock cam 151 are disengaged from the claws 121a of the gear 121. Specifically, the lock cam 151 rotates clockwise with respect to the gear 121. By this relative rotation, the first steel balls 165 move away from the claws 121b of the gear 121 and move within the movement allowed region. At this time, the first steel balls 165 are engaged like a wedge between the recessed inner circumferential surface of the lock ring 161 and the recessed cams 155 of the lock cam 151. Thus, the spindle 123 is locked against rotation (see the lower side of (II) in FIG. 18). Thereafter, by rotating the mounting flange 135 clockwise with respect to the locked spindle 123, the mounting flange 135 can be removed from the grinding wheel mounting portion 131 of the spindle 123. Then, the grinding wheel 141 can be removed.

[0059] Attachment of the grinding wheel 141 to the spindle 123 is now described. In order to attach the grinding wheel 141 to the spindle 123, the grinding wheel 141 is fitted onto the grinding wheel mounting portion 131 and the mounting flange 135 is turned counterclockwise in order to be tightened. During this counterclockwise rotation, as shown on the lower side of (III) of FIG. 18, when the lock cam 151 rotates together with the spindle 123, even if the gear 121 is rotated in the same direction following the rotation of the lock cam 151, the first steel balls 165 are not pushed. Therefore, the first steel balls 165 are engaged between the recessed inner circumferential surface 161b of the lock ring 161 and the recessed cams 155 of the lock cam 151. Specifically, the counterclockwise rotation of the spindle 123 is locked by the first steel balls 165 in any positional relationship of the gear 121 and the spindle 123. As a result, tightening operation of the grinding wheel 141 is allowed and the grinding wheel 141 can be attached to the spindle 123.

[0060] As described above, according to this embodiment, in removing or mounting the grinding wheel 141 to the spindle 123, when a rotating force (external force) is inputted from the spindle 123, the spindle lock mechanism including the lock cam 151, the lock ring 161 and the first steel balls 165 is actuated. Specifically, the spindle 123 can be locked against rotation without need of additional operation of locking the spindle 123 from the outside. Therefore, ease of operation in removing and mounting the grinding wheel 141 can be enhanced.

[0061] Further, in the synchronous rotation retaining mechanism 181 for retaining synchronous rotation of the gear 121 and the spindle 123 according to this embodiment, when the grinding wheel 141 is rotated and the gear 121 and the spindle 123 rotate together via contact of the claws 121 a of the gear 121 and the claws 153 of the lock cam 151, the second steel ball 185 disposed between the steel ball groove 187 of the gear 121 and the steel ball groove 188 of the retainer 183 is located in the radially outer end portions of the steel ball groves 187, 188. The second steel ball 185 is acted upon by a centrifugal force and retained in the radially outer end portions by this centrifugal force. Therefore, despite of change of rotational load on the driven side, the spindle 123 is reliably prevented from rotating ahead of the gear 121. As a result, vibration or noise can be prevented from being caused by the repeated movements of the claws 153 of the lock cam 151 and the claws 121a, 121 b of the gear 121 moving away from each other and moving toward each other into contact.

[0062] Further, according to this embodiment, the parallel portion 187a is formed in the radially outer end portion of each of the steel ball grooves 187. When the gear 121 and the spindle 123 rotate together via contact of the claws 121a of the gear 121 and the claws 153 of the lock cam 151, each of the second steel balls 185 is located in the parallel portion 187a of the associated steel ball groove 187. Further, the steel ball grooves 188 of the retainer 183 extend parallel to the radial direction. Therefore, a force acting upon the second steel balls 185 via the radial wall surface of the steel ball grooves 187, 188 is directed generally toward the center of the second steel balls 185. Specifically, a force is not easily applied to the second steel balls 185 in a direction that moves the second steel balls 185 radially inward. As a result, the second steel balls 185 can be reliably retained in the radially outer portions of the steel ball grooves 187, 188, so that the synchronous rotation retaining effectiveness of the gear 121 and the spindle 123 can be further ensured.

[0063] Further, according to this embodiment, the spindle 123 is inserted through the gear 121, and the both ends of the spindle 123 are supported by the bearings 125, 126. Therefore, transmission of the rotating force between the gear 121 and the spindle 123 can be performed in a stable state.

[0064] Further, the synchronous rotation retaining mechanism 181 according to this embodiment is constructed such that the second steel balls 185 are fitted in the radially extending steel ball grooves 187, 188 formed in the gear 121 and the retainer 183, and the second steel balls 185 engage the radial wall surfaces of the steel ball grooves 187, 188, in order to retain synchronous rotation of the gear 121 and the spindle 123. Specifically, the engagement surface in this construction extends in a direction perpendicular to the axial direction of the gear 121. Thus, compared with the construction in which the engagement surface extends in the axial direction of the gear 121, the length of the synchronous rotation retaining mechanism 181 in the axial direction can be effectively shortened.

[0065] Further, in this embodiment, the synchronous rotation retaining mechanism 181 is disposed on the upper surface side of the gear 121, but it may be disposed on the lower surface side of the gear 121. Specifically, the synchronous rotation retaining mechanism 181 may be disposed in the region in which the mechanism for transmitting the rotating force of the gear 121 to the spindle 123 and the lock mechanism for locking the spindle 123 against rotation are disposed. Further, the first steel balls 165 may be cylindrically formed.

Description of Numerals

[0066]

101	electric disc grinder (power tool)
103	body
105	motor housing
107	gear housing
107a	recess
109	power transmitting mechanical part
111	driving motor (driving source)
113	rotor
115	motor shaft
117	small bevel gear
119	cooling fan
121	gear (driving-side rotating member)
121a	claw
121b	claw
121c	ball receiving recess
123	spindle (driven-side rotating member)
123a	spline shaft
125	bearing
126	bearing
131	grinding wheel mounting portion
133	inner mounting flange
135	outer mounting flange
141	grinding wheel (tool bit)
143	cover
151	lock cam
151a	spline hole
153	claw
155	plane cam
157	circlip
159	washer
161	lock ring
161 a	projection

165 rolling element
171' synchronous rotation retainer
173 leaf spring
173a spline hole
173b ball retaining hole
173c ball retaining hole
175 steel ball
181 synchronous rotation retaining mechanism
183 retainer
183a spline hole
185 second steel ball (actuating member)
187 steel ball groove (guide groove)
188 steel ball groove (guide groove)

Claims

1. A power tool comprising:

a driving-side rotating member that is rotatably disposed within a power tool body,
a driven-side rotating member that is disposed within the power tool body and inserted through the driving-side rotating member in the direction of the axis of rotation of the driving-side rotating member such that the driven-side rotating member is coaxially and rotatably arranged with respect to the driving-side rotating member,
a power receiving part that is integrally disposed with the driven-side rotating member,
a power transmitting part that is integrally disposed with the driving-side rotating member and engages the power receiving part to thereby transmit a rotating force of the driving-side rotating member to the driven-side rotating member,
a tool bit that is rotationally driven via the driven-side rotating member and thereby performs a predetermined operation and
a lock member which allows the driven-side rotating member to rotate such that the tool bit can perform the predetermined operation, in a tool bit driving mode in which the rotating force of the driving-side rotating member is transmitted to the driven-side rotating member via the power transmitting part and the power receiving part which are engaged with each other so that the driving-side rotating member and the driven-side rotating member rotate together, while locking the driven-side rotating member against rotation in a tool bit replacing mode in which a rotating force generated by manual operation for replacing the tool bit is inputted to the driven-side rotating member so that the driven-side rotating member rotates with respect to the driving-side rotating member,
characterized by a synchronous rotation retaining part that maintains synchronous rotation of the driving-side rotating member and the driven-side rotating member in the tool bit driving mode, while, in the tool bit replacing mode, allowing the driven-side rotating member to rotate with respect to the driving-side rotating member in a direction that releases the engagement between the power receiving part and the power transmitting part so that the lock member locks the driven-side rotating member against rotation, when a rotating force is manually inputted which releases the engagement between the power receiving part and the power transmitting part.

2. The power tool as defined in claim 1, wherein the driven-side rotating member is supported at both ends by respective bearings disposed on the both sides of the driven-side rotating member in the direction of the axis of rotation of the driving-side rotating member.

3. The power tool as defined in claim 1 or 2, wherein:

the power receiving part radially protrudes from the driven-side rotating member and has a driven-side claw that can rotate together with the driven-side rotating member,
the power transmitting part has a driving-side claw that can rotate together with the power transmitting part and can engage the driven-side claw in the direction of rotation of the driving-side rotating member,
in the tool bit driving mode, the driving-side claw rotates while engaging the driven-side claw in the direction of rotation, whereby the driving-side rotating member rotationally drives the driven-side rotating member, and
in the tool bit replacing mode, the driven-side claw rotates in disengagement from the driving-side claw when the driven-side rotating member rotates with respect to the driving-side rotating member.

4. The power tool as defined in any one of claims 1 to 3, wherein:

the power tool body includes a lock ring fixedly mounted to the power tool body,
the driven-side rotating member includes a lock cam that can rotate together with the driven-side rotating member and is fitted in the lock ring,
a clearance is formed between the lock ring and the lock cam and has a maximum width portion and a minimum width portion in the radial direction,
the lock member comprises a rolling element that is disposed in the clearance and, in the tool bit driving mode, the rolling element being locat-

ed in the maximum width portion, thereby allowing the lock cam to rotate with respect to the lock ring, while, in the tool bit replacing mode, being located in the minimum width portion and engaged like a wedge between the lock ring and the lock cam and preventing rotation of the lock cam, thereby locking the driven-side rotating member on the power tool body side.

5. The power tool as defined in claim 4, wherein the rolling element comprises a cylindrical element or a spherical element.

6. The power tool as defined in claim 4 or 5, wherein the power transmitting part further includes a lock member position adjusting claw which, in the tool bit driving mode, contacts the rolling element and retains the rolling element in the maximum width portion, while, in the tool bit replacing mode, allowing the rolling element to move from the maximum width portion to the minimum width portion and then be engaged like a wedge between the lock ring and the lock cam when the driven-side rotating member rotates with respect to the driving-side rotating member.

7. The power tool as defined in claim 6, wherein the tool bit can perform an operation by reverse rotation, and the lock member position adjusting claw retains the rolling element in the maximum width portion even when the operation is performed by reverse rotation of the tool bit.

8. The power tool as defined in any one of claims 1 to 7, wherein the power transmitting part and the power receiving part are disposed on one axial end side of the driving-side rotating member, and the synchronous rotation retaining part is disposed on the other axial end side of the driving-side rotating member.

9. The power tool as defined in any one of claims 1 to 7, wherein the power transmitting part, the power receiving part and the synchronous rotation retaining part are disposed generally on the same plane on one axial end side of the driving-side rotating member.

10. The power tool as defined in any one of claims 1 to 9, wherein the synchronous rotation retaining part includes a driving-side retaining member that is integrally disposed with the driving-side rotating member, a driven-side retaining member that is integrally disposed with the driven-side rotating member and opposed to the driving-side retaining member with respect to the axis of rotation of the driven-side rotating member, and a resistance member that is disposed between the driving-side retaining member and the driven-side retaining member and applies a retaining force of preventing relative rotation of the driving-side retaining member and the driven-side retaining member.

11. The power tool as defined in claim 10, wherein:

the driving-side retaining member has a spherical body disposed on the driving-side rotating member, and the driven-side retaining member has a plate-like member that is disposed on the driven-side rotating member and has a spherical body retaining part recessed to be assigned to the spherical body, and
the spherical body and the spherical body retaining part are engaged with each other so that the retaining force of preventing relative rotation between the driving-side rotating member and the driven-side rotating member is applied.

12. The power tool as defined in any one of claims 1 to 11, wherein the synchronous rotation retaining part includes an actuating member that is disposed between the driving-side rotating member and the driven-side rotating member and can move between an outer position and an inner position in a radial direction of the driving-side rotating member,
in the tool bit driving mode, the actuating member is placed in the outer position by a centrifugal force caused by rotating together with the driving-side rotating member, thereby maintaining the synchronous rotation of the driving-side rotating member and the driven-side rotating member via contact between the power transmitting part and the power receiving part, and
in the tool bit replacing mode, when the actuating member is moved from the outer position to the inner position by user's operation of moving the actuating member, and a rotating force of releasing contact between the power transmitting part and the power receiving part is manually inputted to the driven-side rotating member, the actuating member allows the driven-side rotating member to rotate with respect to the driving-side rotating member in a direction that releases the engagement between the power transmitting part and the power receiving part, whereby the lock member locks the driven-side rotating member against rotation.

13. The power tool as defined in claim 12, wherein:

an axial end surface of the driving-side rotating member and an axial end surface of the driven-side rotating member are arranged opposite to each other, and a radially extending first guide groove is formed in one of the end surfaces of the rotating members, and a second guide groove is formed in the other of the end surfaces and extends radially in a manner of intersecting

with the first guide groove,
the actuating member comprises a spherical body and is fitted in the first and second guide grooves such that the actuating member can move between radially outer ends and radially inner ends of the first and second guide grooves,
the first and second guide grooves are configured such that, in the tool bit driving mode, the spherical body is placed in the radially outer ends of the first and second guide grooves and contacts radial wall surfaces of the guide grooves, thereby preventing relative rotation of the driving-side rotating member and the driven-side rotating member, while, in the tool bit replacing mode, the radial wall surfaces of the first and second guide grooves press the spherical body such that the spherical body is moved radially inward within the first and second guide grooves.

14. The power tool as defined in claim 13, wherein:

at least one of the first and second guide grooves which is remoter from the tool bit is inclined from the outer end to the inner end away from the tool bit, and, when the user turns the power tool body upside down in the state of rest of the driving-side rotating member, the spherical body is moved inward by its own weight along the inclined guide groove.

15. The power tool as defined in claim 14, wherein:

a parallel region is formed in the radially outer end portions of the first and second guide grooves and extends parallel to a radial line passing through the axis of rotation of the driving-side rotating member, whereby, when the driving-side rotating member and the driven-side rotating member rotate together via contact between the power transmitting part and the power receiving part, the radial wall surface of the first or second guide groove contacts the spherical body generally at right angles.

16. A power tool comprising:

a driving-side rotating member that is rotatably disposed within a power tool body,
a driven-side rotating member that is disposed within the power tool body and coaxially and rotatably arranged with respect to the driving-side rotating member,
a power receiving part that is integrally disposed with the driven-side rotating member,
a power transmitting part that is integrally disposed with the driving-side rotating member and engages the power receiving part to thereby transmit a rotating force of the driving-side rotating member to the driven-side rotating member,
a tool bit that is rotationally driven via the driven-side rotating member and thereby performs a predetermined operation,
a lock member which allows the driven-side rotating member to rotate such that the tool bit can perform the predetermined operation, in a tool bit driving mode in which the rotating force of the driving-side rotating member is transmitted to the driven-side rotating member via the power transmitting part and the power receiving part which are engaged with each other so that the driving-side rotating member and the driven-side rotating member rotate together, while locking the driven-side rotating member against rotation in a tool bit replacing mode in which a rotating force generated by manual operation for replacing the tool bit is inputted to the driven-side rotating member so that the driven-side rotating member rotates with respect to the driving-side rotating member, and
a synchronous rotation retaining part that maintains synchronous rotation of the driving-side rotating member and the driven-side rotating member in the tool bit driving mode, while, in the tool bit replacing mode, allowing the driven-side rotating member to rotate with respect to the driving-side rotating member in a direction that releases the engagement between the power receiving part and the power transmitting part so that the lock member locks the driven-side rotating member against rotation, when a rotating force is manually inputted which releases the engagement between the power receiving part and the power transmitting part, wherein:

the synchronous rotation retaining part includes an actuating member that is disposed between the driving-side rotating member and the driven-side rotating member and can move between an outer position and an inner position in a radial direction of the driving-side rotating member,
in the tool bit driving mode, the actuating member is placed in the outer position by a centrifugal force caused by rotating together with the driving-side rotating member, thereby maintaining the synchronous rotation of the driving-side rotating member and the driven-side rotating member via contact between the power transmitting part and the power receiving part, and
in the tool bit replacing mode, when the actuating member is moved from the outer position to the inner position by user's operation of moving the actuating member, and

a rotating force of releasing contact between the power transmitting part and the power receiving part is manually inputted to the driven-side rotating member, the actuating member allows the driven-side rotating member to rotate with respect to the driving-side rotating member in a direction that releases the engagement between the power transmitting part and the power receiving part, whereby the lock member locks the driven-side rotating member against rotation.

17. The power tool as defined in claim 16, wherein:

an axial end surface of the driving-side rotating member and an axial end surface of the driven-side rotating member are arranged opposite to each other, and a radially extending first guide groove is formed in one of the end surfaces of the rotating members, and a second guide groove is formed in the other of the end surfaces and extends radially in a manner of intersecting with the first guide groove,
the actuating member comprises a spherical body and is fitted in the first and second guide grooves such that the actuating member can move between radially outer ends and radially inner ends of the first and second guide grooves,
the first and second guide grooves are configured such that, in the tool bit driving mode, the spherical body is placed in the radially outer ends of the first and second guide grooves and contacts radial wall surfaces of the guide grooves, thereby preventing relative rotation of the driving-side rotating member and the driven-side rotating member, while, in the tool bit replacing mode, the radial wall surfaces of the first and second guide grooves press the spherical body such that the spherical body is moved radially inward within the first and second guide grooves.

18. The power tool as defined in claim 17, wherein:

at least one of the first and second guide grooves which is remoter from the tool bit is inclined from the outer end to the inner end away from the tool bit, and, when the user turns the power tool body upside down in the state of rest of the driving-side rotating member, the spherical body is moved inward by its own weight along the inclined guide grooves.

19. The power tool as defined in claim 18, wherein:

a parallel region is formed in the radially outer end portions of the first and second guide grooves and extends parallel to a radial line passing through the axis of rotation of the driving-side rotating member, whereby, when the driving-side rotating member and the driven-side rotating member rotate together via contact between the power transmitting part and the power receiving part, the radial wall surface of the first or second guide groove contacts the spherical body generally at right angles.

20. The power tool as defined in any one of claims 16 to 19, wherein the driven-side rotating member is inserted through the driving-side rotating member in the direction of the axis of rotation of the driving-side rotating member and supported at both ends by respective bearings disposed on the both sides of the driven-side rotating member in the direction of the axis of rotation of the driving-side rotating member.

FIG. 1

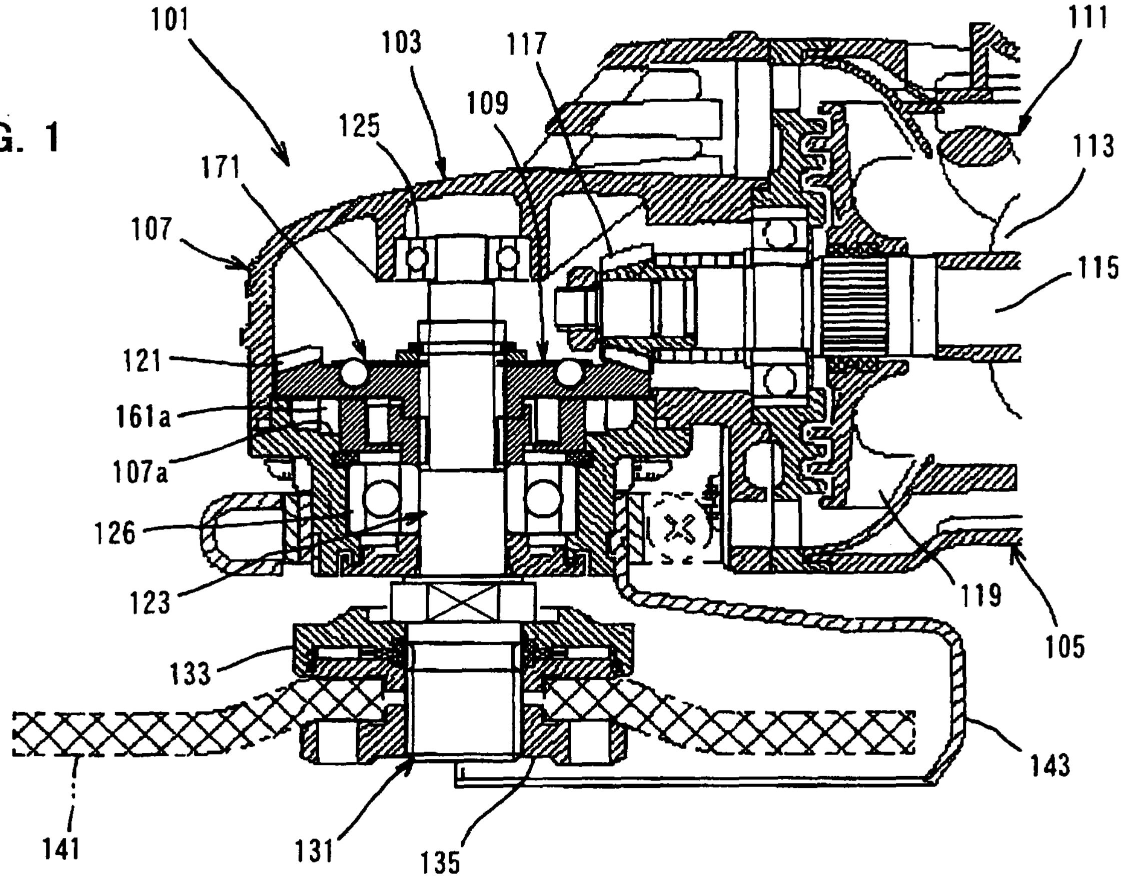
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FIG. 2

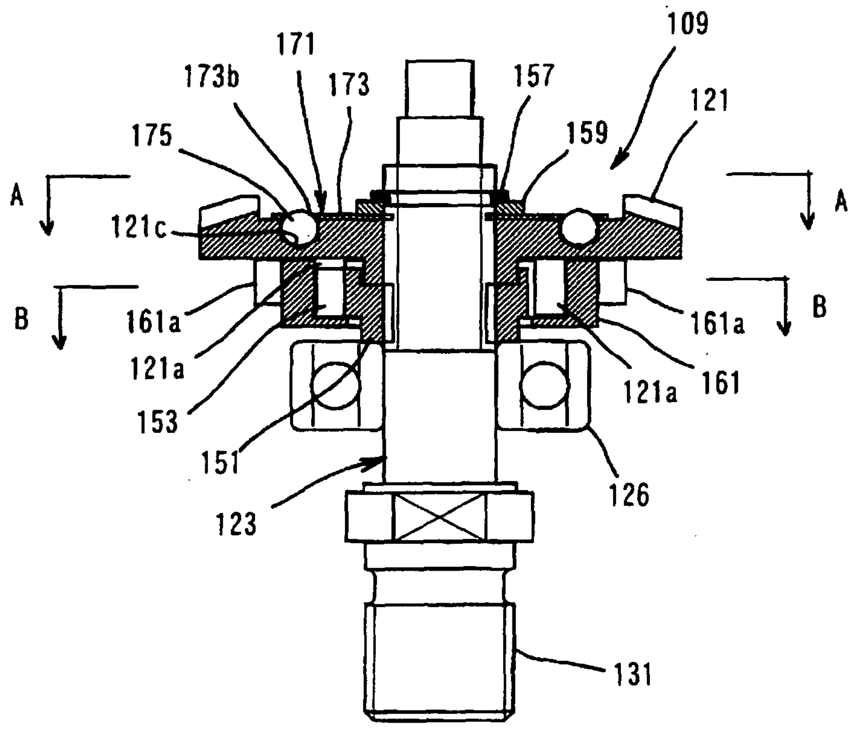
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FIG. 3

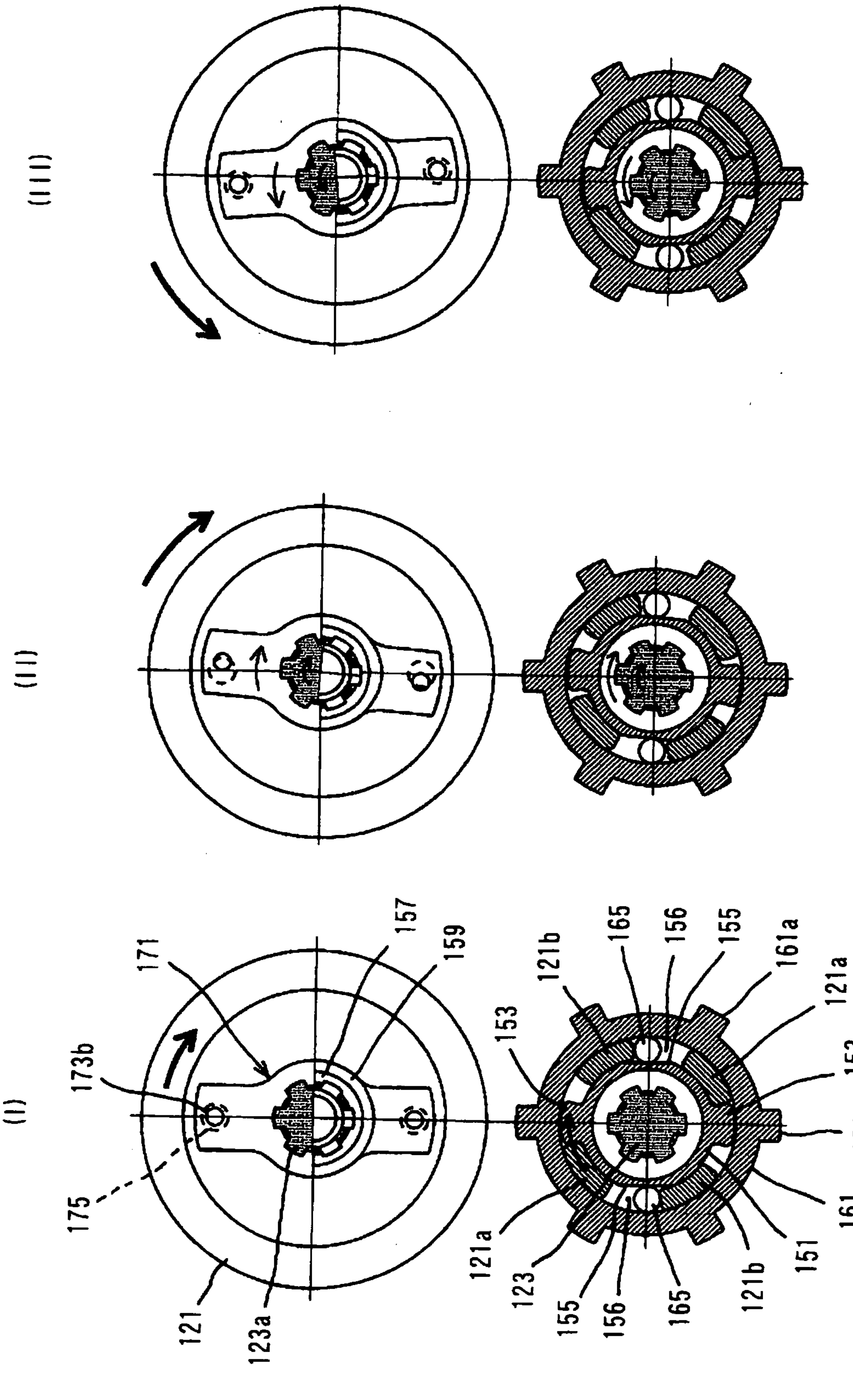
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FIG. 4

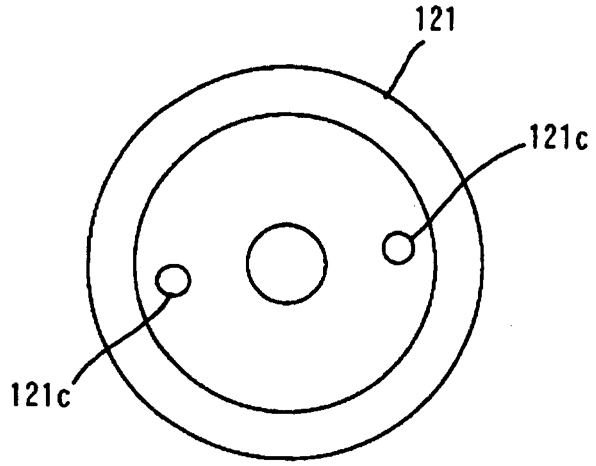

FIG. 5

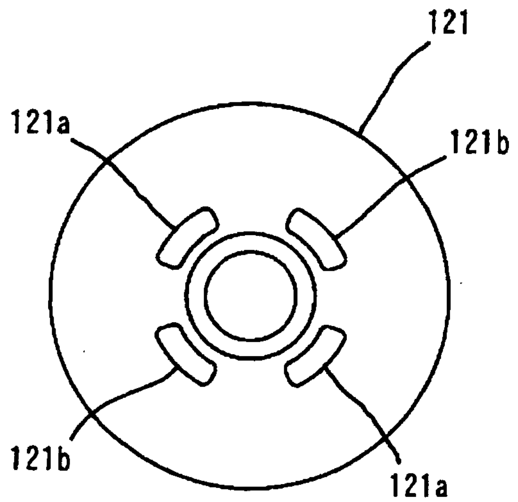

FIG. 6

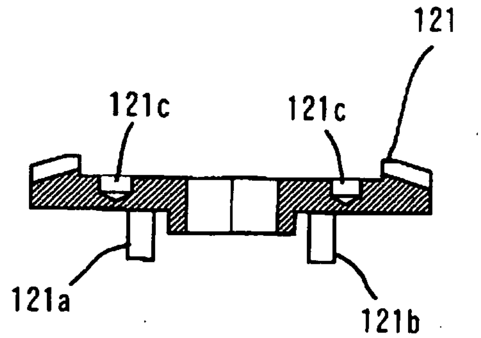

FIG. 7

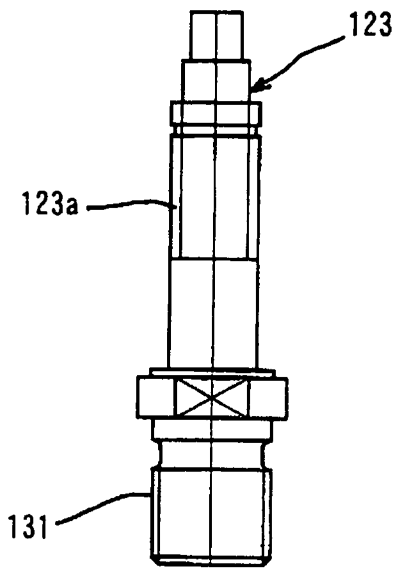

FIG. 8

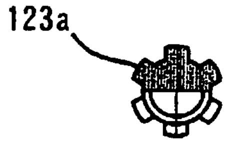

FIG. 9

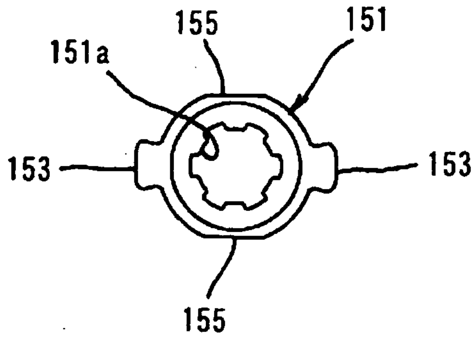

FIG. 10

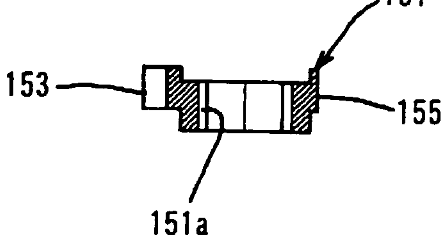

FIG. 11

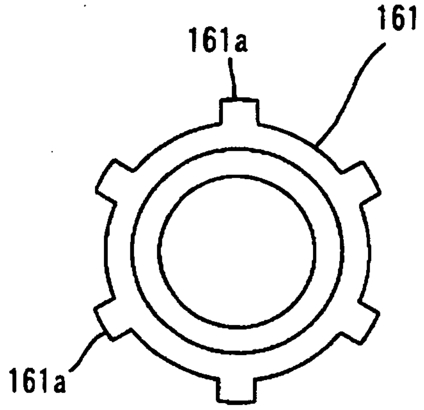

FIG. 12

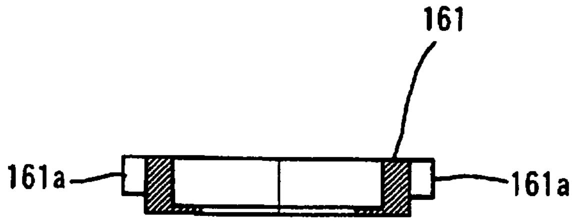

FIG. 13

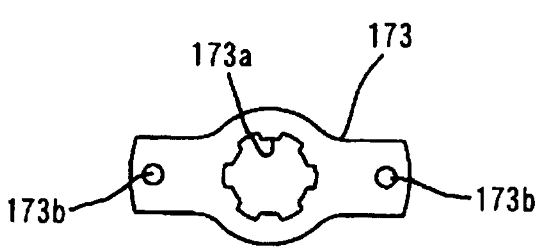

FIG. 14

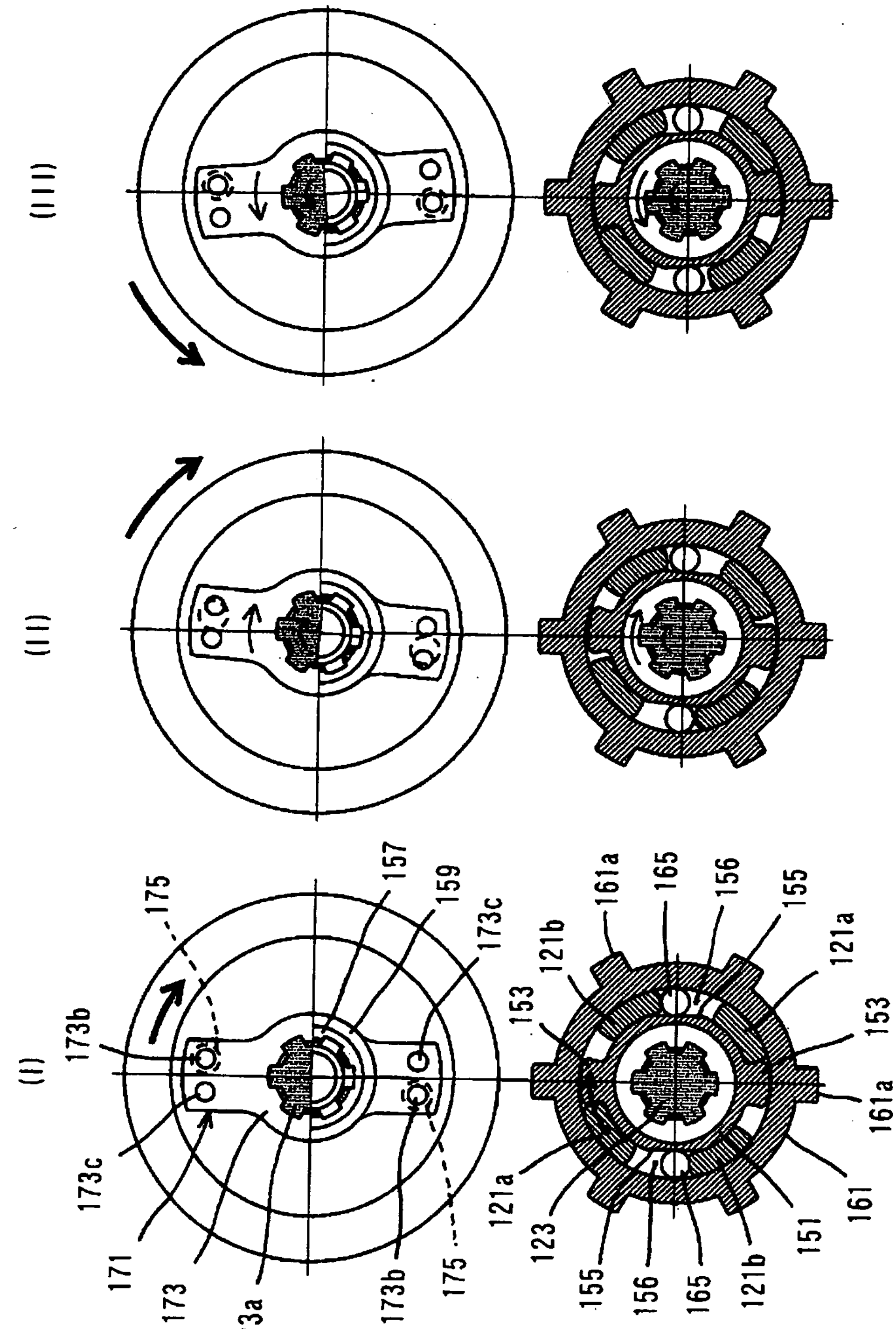
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FIG. 15

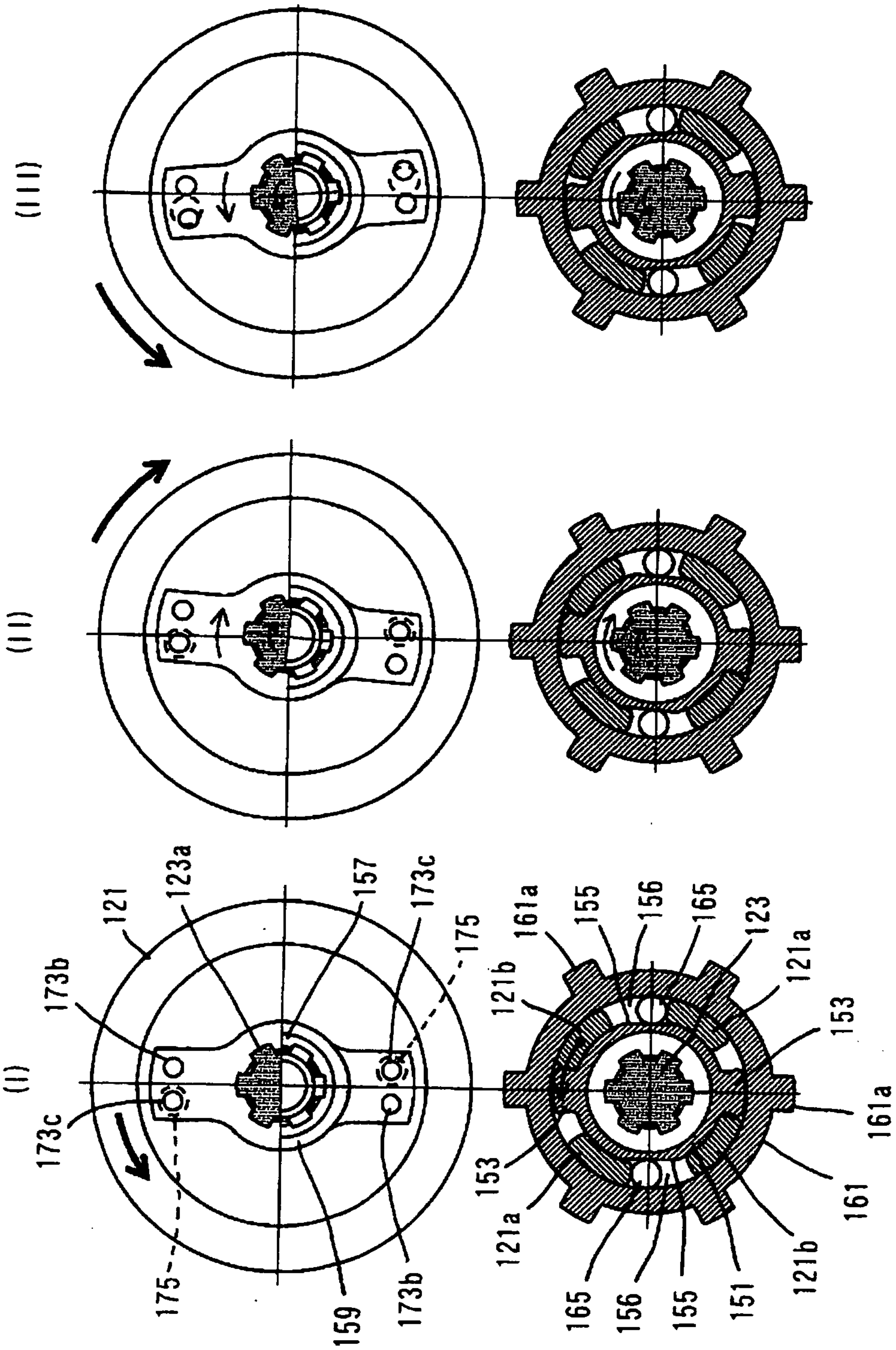
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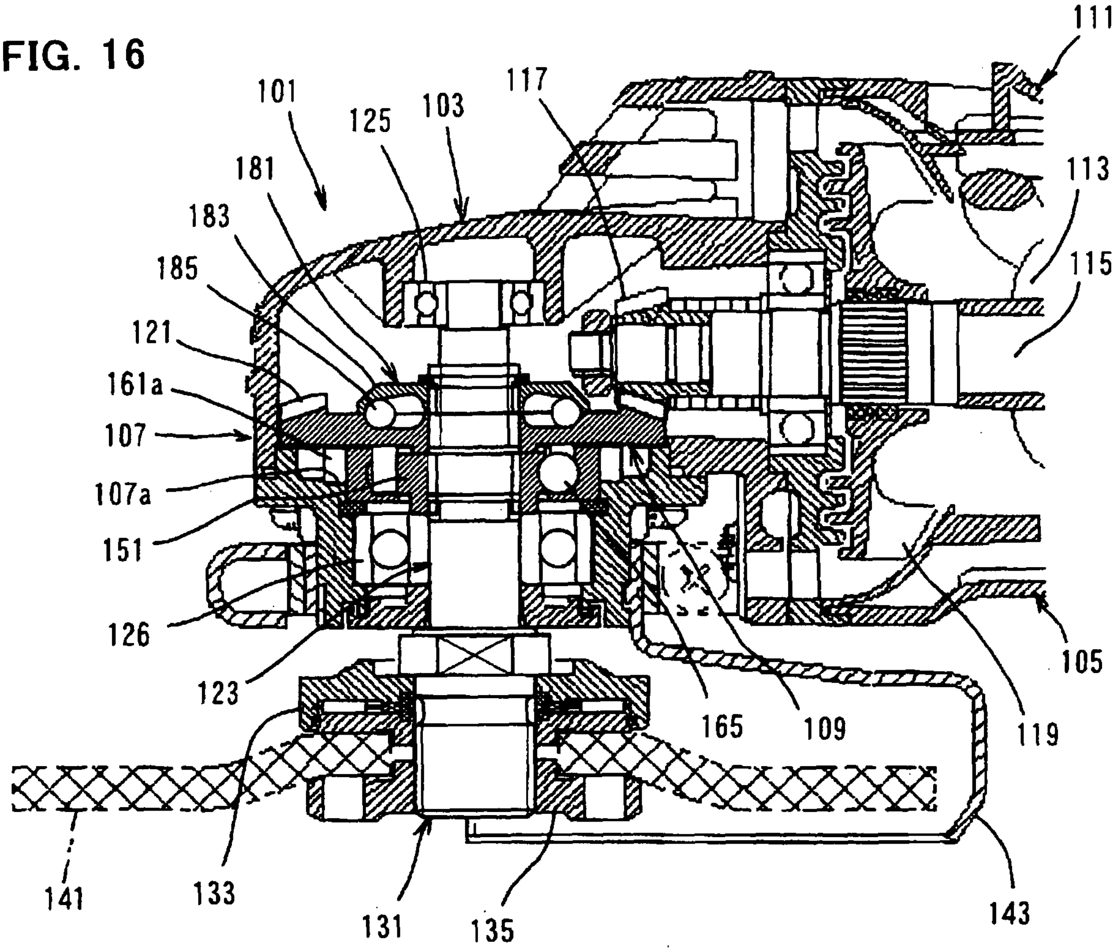
FIG. 16



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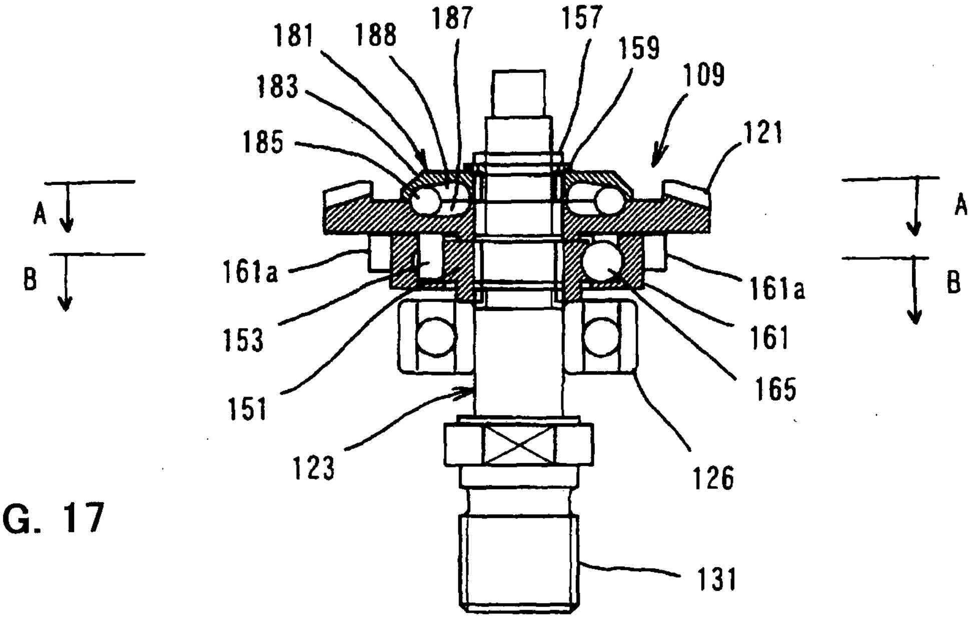

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FIG. 17

FIG. 18

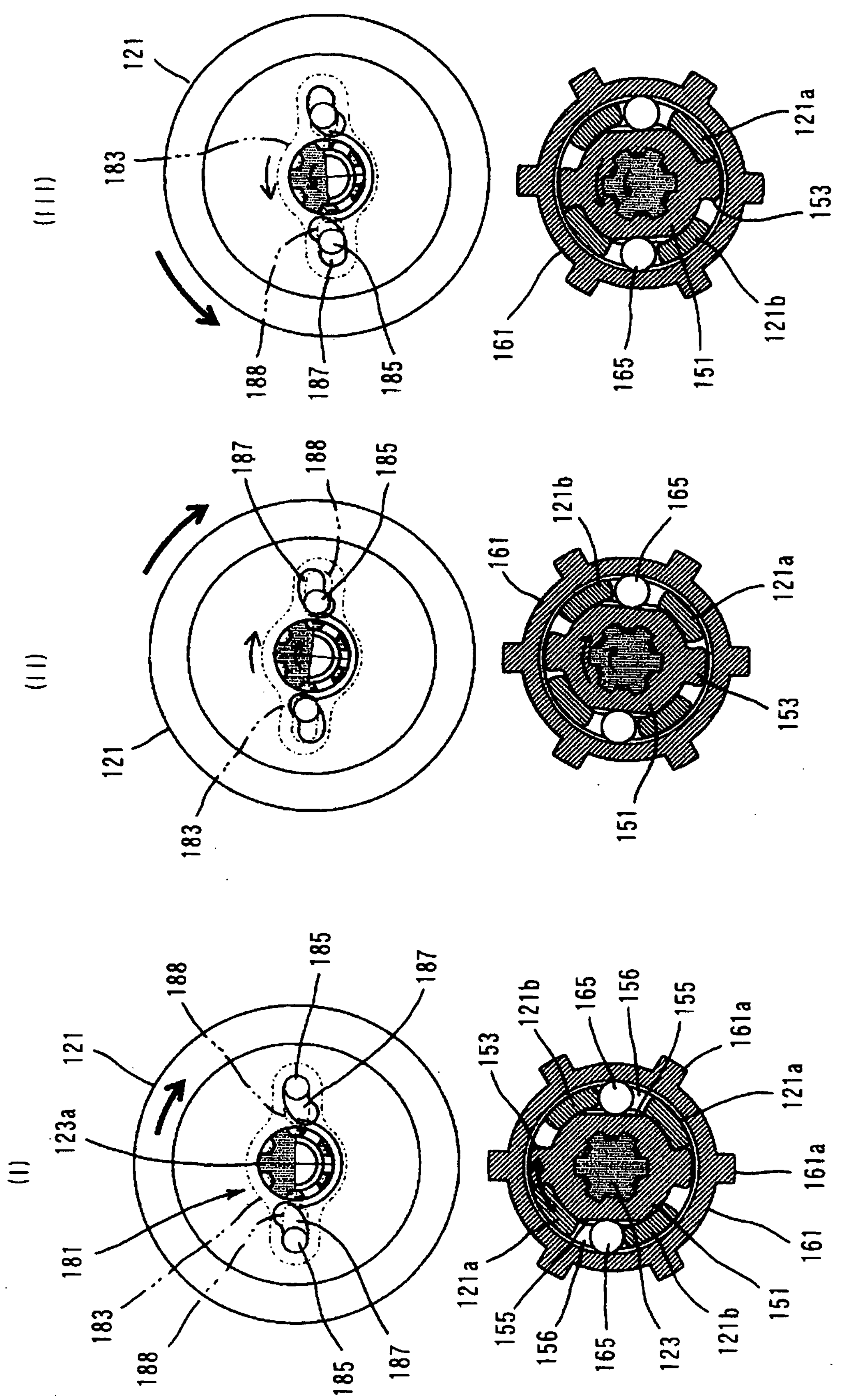
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FIG. 19

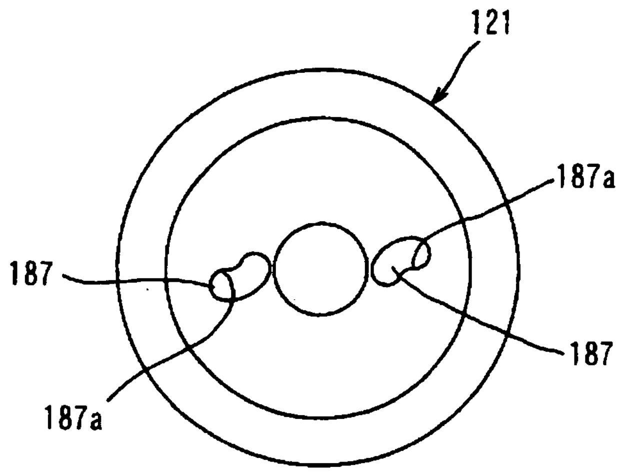


FIG. 20

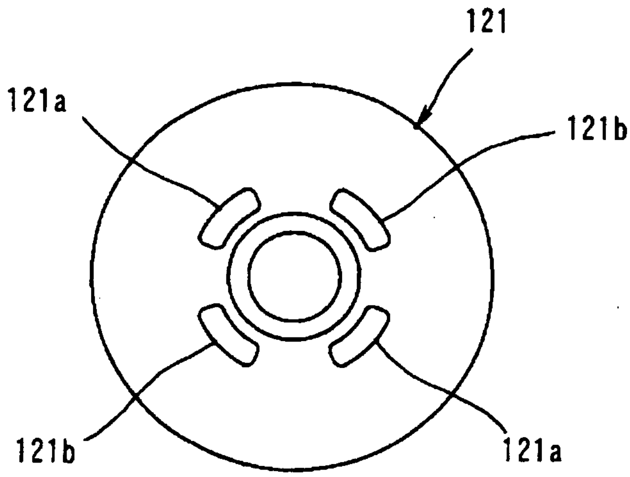


FIG. 21

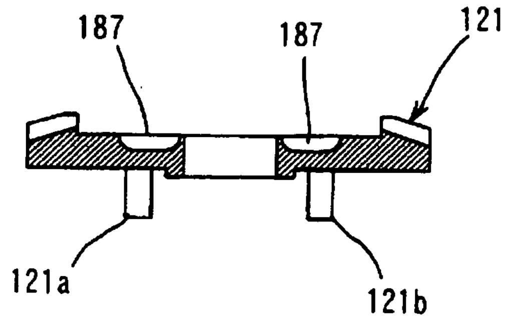


FIG. 22

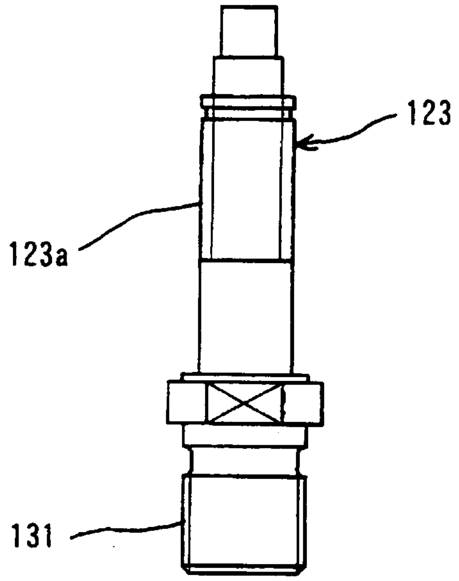


FIG. 23

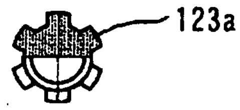


FIG. 24

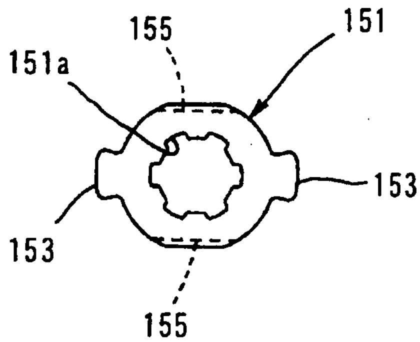


FIG. 25

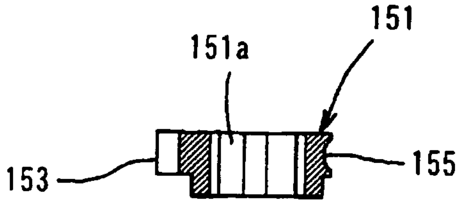


FIG. 26

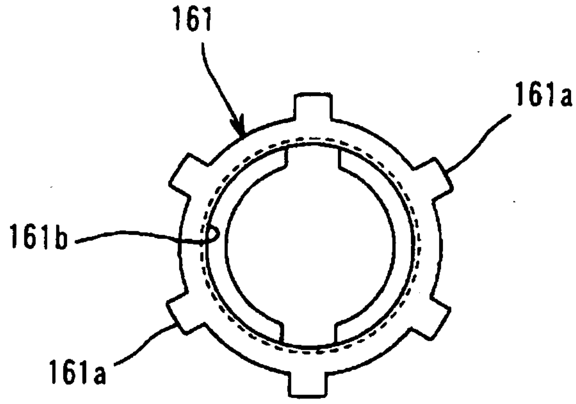


FIG. 27

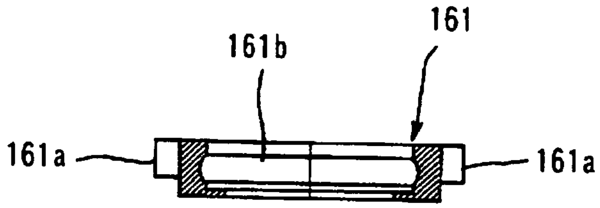


FIG. 28

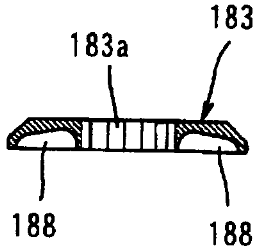


FIG. 29

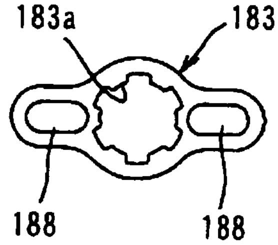
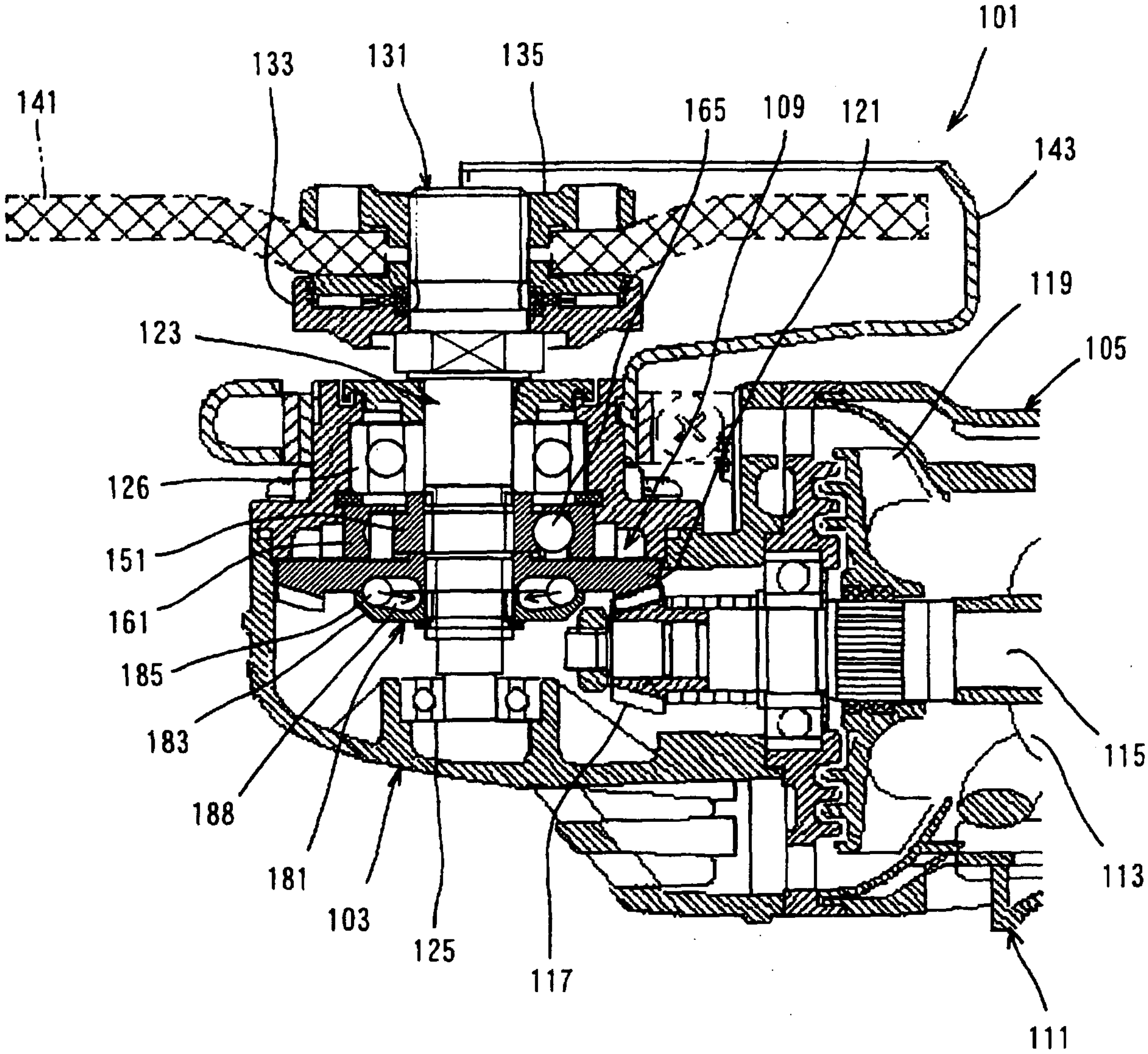


FIG. 30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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/305286

A. CLASSIFICATION OF SUBJECT MATTER
B24B47/12(2006.01), *B24B23/00*(2006.01), *B25B21/00*(2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B24B41/00-51/00, B24B23/00-23/08, B25B21/00, F16D3/14, F16D3/12, F16F15/139

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2006
Kokai Jitsuyo Shinan Koho	1971-2006	Toroku Jitsuyo Shinan Koho	1994-2006

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 3-251374 A (Matsushita Electric Works, Ltd.), 08 November, 1991 (08.11.91), Page 3, upper right column, line 16 to page 4, upper left column, line 8; Figs. 1 to 6 (Family: none)	1-7,9 8,12-20
Y A	JP 11-72122 A (Scintilla AG.), 16 March, 1999 (16.03.99), Par. Nos. [0024], [0029], [0030]; Figs. 1, 2 & GB 2327254 A	1-7,9 8,12-20

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent 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 when the document is taken alone
"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

Date of the actual completion of the international search 22 May, 2006 (22.05.06)	Date of mailing of the international search report 30 May, 2006 (30.05.06)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/305286

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 60-39075 A (Black & Decker Inc.), 28 February, 1985 (28.02.85), & EP 0129348 A2	1-7,9 8,12-20
Y A	JP 1-193164 A (C.& E. FEIN GmbH. & Co.), 03 August, 1989 (03.08.89), & EP 0319813 A2	1-7,9 8,12-20
Y A	JP 7-205053 A (Robert Bosch GmbH.), 08 August, 1995 (08.08.95), & GB 2285003 A	1-7,9 8,12-20

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/305286

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

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

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

2. ☒ Claims Nos.: 10, 11
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:
The resistance material in Claim 10 specifies the invention based on the results obtained. However, since it is not specifically described in the specification, it lacks the disclosure of the description in the meaning
(continued to extra sheet)

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

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.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ 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 claims Nos.:

Remark on Protest the

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee..

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/305286

Continuation of Box No.II-2 of continuation of first sheet(2)

of PCT Article 5, and also inadequately supported by the disclosure of the description in the meaning of PCT Article 6. Also, even if common general technical knowledge at the time of application is taken into account, it lacks the requirement of clarity in PCT Article 6. It is also applicable to Claim 11 dependent on only Claim 10.

Form PCT/ISA/210 (extra sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 11072122 A **[0002]**