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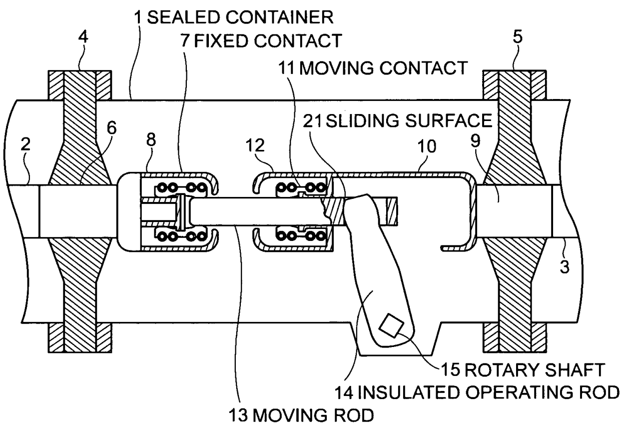
(54) GAS-INSULATED SWITCHING DEVICE

(57) Large-diameter part 16 is formed at the axial-middle part of rotary shaft 15 that rotates driven by operating device. Insulated operating rod 14, the distal end of which makes move in the form of a segment of a circle effected by the rotation of rotary shaft 15, is formed integrally using filler-filled resin over large-diameter part 16 of rotary shaft 15 by cast so that the large-diameter part 15 is embedded into one end of insulated operating rod 14. The contact and connection between insulated operating rod 14 and moving rod 13 is given such sliding surface 21 as is formed for example in an elliptical shape so that the contact occur always at almost one-point on the axis line of the moving rod 13.

FIG. 1



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Description

[Technical Field]

[0001] The present invention relates to such a gas-insulated switchgear that the switching movement of the moving rod thereof is caused by use of an insulated operating rod that rotates around its rotational axis.

[Background Art]

[0002] A gas-insulated switchgear is comprised of a switching device that uses a moving rod the switching movement of which is caused by an operating device. Therefore, if metallic particle are emitted on the high-voltage side relating to the switching movement of the moving rod in the switching device for example, it is probable that the dielectric strength performance of the switching device may be lowered greatly.

[0003] In consideration of measures against that, ideas have been proposed for conventional switching devices. For example, JP 2002-245909 (Patent literature 1) has proposed a mechanism. The mechanism, which is provided on the earthing side, converts a rotational movement into a linear movement using a metallic lever or a gear. A moving rod is driven by the operating of an insulated operating rod through the mechanism. Further for example, JP 2008-176942 (Patent literature 2) and JP H8-298040 (Patent literature 3) have proposed other mechanism as a useful means for repressing emission of metallic particle. The proposed mechanism converts the move in the form of a segment of a circle of an insulated operating rod into a linear movement using a contact and connection with a moving rod.

[0004] Particularly, the later mechanism, which uses the move in the form of a segment of a circle of the insulated operating rod, has such an advantageous feature that reduction of number of constituent parts and simplification of the mechanism are attainable easily. Those insulated operating rods that are of these types of mechanism configuration usually use so-called fiber reinforced plastics (FRP), main constituent of which is glass fiber, as their material. FRP has a high mechanical strength and offers a relatively lower cost.

[0005] However, FRP has problems. The dielectric strength of FRP becomes greatly lowered, if FRP involves follow fibers therein mixed at the manufacturing stage. The dielectric strength of FRP becomes low, because cracked gas damages glass fibers in FRP causing aging degradation thereof. As a consequence of these, the dielectric strength of the insulated operating rod that uses FRP greatly lowers. These problems have been solved by actual use of hollow-fiber-less FRP or by improvement in coating technique.

[0006] However, in the conventional gas-insulated switchgear, a minute gap will be created between the insulated operating rod of FRP and a high-voltage electrode or between such rod and an earthing electrode where the move in the form of a segment of a circle of the insulated operating rod stated above is used in the mechanism working. This minute gap tends to become a weak point in the insulation system of the switchgear because the electric field concentrates at the gap. For improvement to this, it is a common idea to cover around such minute gap with an electric field controlling shield. However, there is a problem in that providing this electric field controlling shield prevents the overall downsizing of the switching device.

[0007] An object of the present invention is to provide a small-sized gas-insulated switchgear with reduced number of constituent parts.

[Disclosure of Invention]

[0008] To attain above-stated object, the present invention provides a gas-insulated switchgear has a sealed container filled with insulating gas; a bar-shaped rotary shaft driven and rotated by an operating device with the sealed container maintained hermetically; an insulated operating rod. The one end of the insulated operating rod is fixed on the bar-shaped rotary shaft and the other end of the insulated operating rod is moved in the form of a segment of a circle by rotation of the bar-shaped rotary shaft. And, the gas-insulated switchgear has a moving rod connected to the other end of the insulated operating rod and driven in an axial direction to perform switching operation. And, the bar-shaped rotary shaft has a large-diameter part formed integrally at the axial-middle part thereof, and the insulated operating rod is cast integrally with the large-diameter part by using filler-filled resin so that the large-diameter part is embedded into one end of the insulated operating rod.

[0009] Preferably, the insulated operating rod has a sliding surface formed on the other end thereof, the sliding surface is formed to slide on the moving rod at roughly one-point on the axis line of the moving rod during the switching operation.

[0010] Preferably further, the large-diameter part on the axial-middle part of the rotary shaft has an elliptical shape, the diameter of the large-diameter part along the axial direction of the insulated operating rod is a long diameter, and the diameter of the large-diameter part along the width direction of the insulated operating rod is a short diameter.

[0011] Preferably still, the material for the resin includes epoxy resin or phenol resin.

[0012] Preferably still further, the filler filled in the resin includes alumina or silica.

[Effect of Invention]

[0013] The gas-insulated switchgear by the present invention provides an insulated operating rod having enhanced dielectric strength compared to the conventional FRP insulated operating rod. This feature is brought about not only from improved abrasion resistance given by the filler filled in the resin but also from greatly enhanced mechanical strength given by increased reinforcement and reduced residual stress. Thereby, the small-sizing of the gas-insulated switchgear and number-reduction of constituent parts therein are realized while reliability of insulation system thereof is assured.
[0014] Further to this, making it elliptical the cross-sectional shape of the large-diameter part, which is provided on the rotary shaft at the axially-middle portion thereof and which is to be molded integrally on one end of the insulated operating rod by cast using filler-filled resin, further improves the dielectric strength of the insulated operating rod.
[0015] Moreover, use of epoxy resin or phenol resin as the material for the molding of the insulated operating rod permits obtaining an insulated operating rod having excellent properties in water resistance and SF6 cracked gas resistance even though coating work that the conventional FRP type rod requires is omitted. Additionally, use of alumina or silica as the filler for the molding resin greatly improves the abrasion resistance and the mechanical strength of the insulated operating rod.
[0016] Furthermore, the gas-insulated switchgear by the present invention provides features as follows. The position of contact between the insulated operating rod and the moving rod on the sliding surface changes its location as the insulated operating rod rotates. However, this contact point falls always approximately on the central axis line of the moving rod as far as the insulated operating rod moves rotationally within the predetermined range of angles. Therefore, when the moving rod is moved toward circuit closing by the rotation of the insulated operating rod, the moving rod smoothly moves linearly on the central axis line.
[0017] When the shape of the sliding surface of the insulated operating rod with the moving rod is made to be circular, the contact point between the insulated operating rod and the moving rod deviates from the central axis line of the moving rod as the insulated operating rod rotates. Transmitting the driving force from the insulated operating rod under this situation produces a component of force perpendicular to the central axis line of the moving rod. This component of force works as an oblique force as a whole with respect to the central axis line of the moving rod and increases frictional drag causing sliding portion to emit metallic particle. In contrast, using the sliding surface having the above-stated shape reduces greatly the sliding frictional drag that is applied to the insulated operating rod and the moving rod made of metal. Thus, the moving rod moves smoothly on its central axis line with emission of metallic particle therefrom reduced.

[Brief Description of Drawings]

[0018] Fig. 1 is a sectional view that illustrates the circuit-close state of the gas-insulated switchgear in an embodiment of the present invention.
[0019] Fig. 2 is a sectional view that illustrates the circuit-open state of the gas-insulated switchgear illustrated in Fig. 1.
[0020] Fig. 3 is a perspective view that illustrates a principal part of the gas-insulated switchgear illustrated in Fig. 1.
[0021] Fig. 4 is a property diagram that indicates the relationship between the amount of alumina filled in resin and the abrasion loss.
[0022] Fig. 5 is a property diagram that indicates the relationship between the amount of alumina filled in resin and the strength.
[0023] Fig. 6 is a property diagram that indicates the relationship between the amount of alumina filled in resin and the linear expansion coefficient.
[0024] Fig. 7 is an enlarged view that illustrates dimensional relationship of a principal part of the gas-insulated switchgear illustrated in Fig. 1.
[0025] Fig. 8 is a property diagram that indicates the positional change curve of the movement of the position of contact with respect to the rotational variation of the insulated operating rod.
[0026] Fig. 9 is an enlarged view that schematically illustrates a principal part of the gas-insulated switchgear illustrated in Fig. 1.
[0027] Fig. 10 is a front view that schematically illustrates a principal part of a conventional gas-insulated switchgear.
[0028] Fig. 11 is an enlarged view that illustrates a principal part of the gas-insulated switchgear illustrated in Fig. 1.
[0029] Fig. 12 is an enlarged front view that illustrates a principal part of a conventional gas-insulated switchgear.
[0030] Fig. 13 is an enlarged plan view that illustrates a principal part of the gas-insulated switchgear illustrated in Fig. 1.
[0031] Fig. 14 is an enlarged sectional view that illustrates a principal part of the gas-insulated switchgear illustrated in Fig. 1.
[0032] Fig. 15 is an enlarged plan view that illustrates a principal part of the gas-insulated switchgear in another embodiment of the present invention.
[0033] Fig. 16 is a sectional view that illustrates a principal part of the gas-insulated switchgear illustrated in Fig. 15.
[0034] Fig. 17 is an enlarged plan view that illustrates a principal part of the gas-insulated switchgear in further another

embodiment of the present invention.

[0035] Fig. 18 is a sectional view that illustrates a principal part of the gas-insulated switchgear illustrated in Fig. 17.

[Best Mode for Carrying out the Invention]

[Embodiment 1]

[0036] The following provides an explanation of an embodiment of the present invention referring to drawings.

[0037] Fig. 1 is a sectional view that illustrates a disconnecting switch as the gas-insulated switchgear in an embodiment of the present invention.

[0038] In a sealed container 1 pressurized with insulating media such as nitrogen gas, dry air, and SF6 gas, a high-voltage conductors 2 and 3 are supported in a state electrically insulated by an insulating spacers 4 and 5.

[0039] On a center conductor 6 supported by the insulating spacer 4, a fixed contactor 7 is fixed. On the periphery of the fixed contactor 7, an electric field controlling shield 8 is arranged. On a center conductor 9 supported by the insulating spacer 5, a moving contactor 11 is installed using a moving-side cylindrical conductor 10. On the periphery of the moving contactor 11, the electric field controlling shield 12 is arranged.

[0040] A moving rod 13 that is provided for bridging between the fixed-side contact 7 and the moving-side contact 11 in an openable and closable manner is connected to one end of an insulated operating rod 14, the free end thereof, in a manner of the contact and connection so as to make a switching movement on its central axis line. On the other end of the insulated operating rod 14, a rotary shaft 15, which hermetically leads out to the outside of the sealed container 1, is connected. To the rotary shaft 15, an operating device (not illustrated) is connected.

[0041] Details of the configuration the contact and connection between the moving rod 13 and the insulated operating rod 14 will be described later. Both sides of the free end of the insulated operating rod 14 severally have a contrived curved surface on their parts that contact with the moving rod 13. In contrast, such a part on the moving rod 13 as contacts with the curved surface is a flat plane; therefore, they contact each other almost in one-point contact.

[0042] When the moving rod 13 is driven by the insulated operating rod 14 toward the left side of the figure to close the circuit and when the moving rod 13 is driven by the insulated operating rod 14 toward the right side of the figure to open the circuit, the uniquely designed shape of the curved surface makes the contact point between the moving rod 13 and the insulated operating rod 14 be kept always aligned almost on the central axis line of the moving rod 13.

[0043] When the rotary shaft 15 is rotated by the operating device (not illustrated), the free end of the insulated operating rod 14 integrally formed on the rotary shaft 15 rotates clockwise around its central axis line to drive the moving rod 13, arranged in a manner of the contact and connection, toward the right side, in the circuit opening direction, on its central axis line.

[0044] Then, the distal end of the moving rod 13 separates from the fixed contactor 7 retracting into the inside of the electric field controlling shield 12 to reach the circuit-open state as illustrated in Fig. 2. In contrast, when the rotary shaft 15 is rotated counterclockwise by the operating device (not illustrated) from the circuit-open state as indicated in Fig. 2, the free end of the insulated operating rod 14 integrally formed on the rotary shaft 15 rotates counterclockwise around its central axis. Then, the insulated operating rod 14 drives the moving rod 13 connected thereto in a manner of the contact and connection toward the left side, in the circuit closing direction, on its central axis line. Thus, the distal end of the moving rod 13 contacts with the fixed contactor 7 to establish the circuit-closed state as illustrated in Fig. 1.

[0045] Fig. 3 is an enlarged perspective view that illustrates the joint part between the insulated operating rod 14 and the rotary shaft 15.

[0046] The rotary shaft 15 is a bar-shaped and has an large-diameter part 16 integrally formed at the axially-middle portion thereof, wherein the large-diameter part 16 is given a rounded shape to relax electric field. The integrally formed large-diameter part 16 is given for example such an elliptical shape that the diameter thereof along the axis of the insulative rod 14 is large diameter and that the diameter thereof along the width of the insulative rod 14 is a small diameter. The shape applicable to the large-diameter part 16 of the rotary shaft 15 is not limited to such an elliptical shape as stated above; also an edge-rounded polygon is applicable too.

[0047] Usually, the insulated operating rod 14 made of FRP is used. In the present invention, the insulated operating rod 14 is manufactured integrally by cast involving both end faces 16a and 16b of the large-diameter part 16 on the axial direction with respect to the rotary shaft 15, using filler-filled resin. This practice prevents the appearing of minute gaps on boundaries among the resin and the rotary shaft 15 and the diameter-enlarged part 16 by eliminating gap that may appear between the insulated operating rod 14 and the diameter-enlarged part 16 of the rotary shaft 15 because of resin contraction that occurs while resin curing.

[0048] Fig. 4 is a property diagram that shows the relationship between the amount of filler filled in resin and the abrasion loss, wherein the filler is alumina or silica and the resin is epoxy resin. As can be known from Fig. 4, both the abrasion property curve 17A represented by a solid line, wherein alumina is filled, and the abrasion property curve 17B represented by a dotted line, wherein silica is filled, indicate that the effect such that alumina or silica, the rigidity of which is high, suppresses abrasion of epoxy resin appears more clearly as the filler amount of alumina or silica increases. A practical range of filler amount of alumina or silica as the filler is 45 to 75 wt-%.

[0049] Fig. 5 is a property diagram that shows the relationship between the amount of filler filled in resin and the strength, wherein the filler is alumina or silica and the resin is epoxy resin. As can be known from Fig. 5, the static strength curve 18A and the fatigue strength curve 19A, represented respectively by the thin solid line and the thick solid line, indicate that the static strength and the fatigue strength improve more, when the filler amount of alumina is more than a predetermined amount, compared to those cases where resin is used alone. This is because of that particles of alumina, rigidity of which is high, shares the internal stress inside the resin and therefrom a reinforcing effect appears preventing minute peering-off. Where the resin is filled with silica, the static strength curve 18B and the fatigue strength curve 19B, indicated respectively with the thin dotted line and the thick dotted line, demonstrate similar property behavior.

[0050] Fig. 6 is a property diagram that shows the relationship between the amount of alumina or silica filled in epoxy resin as the filler and the linear expansion coefficient. In Fig. 6, both the linear expansion coefficient curves 20A and 20B, represented respectively by the solid line and the dotted line, indicate that the linear expansion coefficient becomes smaller as the filler amount of alumina in the epoxy resin increases showing coefficient differences from the linear expansion coefficients of iron (1.3 x 10-5/°C) and of aluminum (2.5 x 10-5/°C) come to be small.

[0051] In the case where epoxy resin is used for example, about 50 wt-% of filler amount of alumina can make the linear expansion coefficient to be almost equivalent to that of aluminum. Alumina or silica as the filler for epoxy resin should be used considering the linear expansion coefficient of the filler-filled epoxy resin when combined with aluminum, copper, or iron.

[0052] Therefore, in manufacturing the insulated operating rod 14 having the style illustrated in Fig. 3, it becomes practicable to reduce the residual stress by employing the practice: preparing the filler-filled resin by filling epoxy resin with alumina or silica as the filler so that the linear expansion coefficient of the filler-filled resin will be close to that of the rotary shaft 15 of metal such as iron or copper or aluminum and then integrally forming the insulated operating rod 14 on the rotary shaft 15 by cast using thus prepared filler-filled resin.

[0053] The structure such that the insulated operating rod 14 and the rotary shaft 15 are integrally fabricated with the cast as stated above offers not only an improved abrasion resistance given by the filler but also a greatly enhanced mechanical strength given by increased reinforcement and reduced residual stress. Further, reduction of thickness of the insulated operating rod 14 becomes practicable without loss of mechanical reliability. Moreover, improved performance in dielectric strength, or through-breakdown voltage, of the resin can be expected and thereby the length of the insulated operating rod 14 can be shortened more than the length of the same manufactured with no filler.

[0054] Besides epoxy resin, resin having high resistivity against water or cracked gas like phenol resin is also usable. Usable material as the filler is not limited to alumina but silica is also usable with expectation of the almost same effect as stated above.

[0055] As stated above, the insulated operating rod 14 transfers the switching manipulation power from the operating device to the moving rod 13, which makes switching movement in the disconnecting switch of a gas-insulated switchgear, or an earthing switch and a circuit breaker having a construction similar to the disconnecting switch. Therefore, integrally forming the insulated operating rod 14 on the rotary shaft 15 by cast using filler-filled resin improves the dielectric strength more than that of the insulated operating rod of FRP. Thus thereby, the small-sizing of the gas-insulated switchgear and number-reduction of constituent parts therein are realized while reliability of insulation system thereof is assured.

[0056] Moreover, use of epoxy resin or phenol resin as the material for the molding of the insulated operating rod 14 permits giving an excellent properties in water resistance and SF6 cracked gas resistance to the insulated operating rod 14 even though the coating work which the conventional FRP type rod requires is omitted.

[0057] The following provides an explanation about the structure of the linkage between the free end of the insulated operating rod14 and the moving rod 13. Fig. 7 is an enlarged view that illustrates the linking part between the free end of the insulated operating rod 14 and the moving rod 13.

[0058] As stated above, sliding surfaces 21 on the both sides of the free end of the insulated operating rod 14 that contact with the moving rod 13 and slide on the moving rod 13 are given such a curved surface that the contact always occurs at almost one-point on the central axis line of the moving rod 13. Details are as follows: each of the sliding surfaces 21 on the free end of the insulated operating rod 14 that contacts with the moving rod 13 and slides on the moving rod 13 is given a curved surface having the ellipsoidal curvature. Where the minor axis and the major axis of an ellipse are denoted by a and b respectively, the ellipse on the X-Y plane is expressed by Equation 1 given below.

[0059] The sliding surfaces 21 of the insulated operating rod 14 that contact with the moving rod 13 and slide on the moving rod 13 as illustrated in Fig. 7 may be given a full-ellipsoidal shape as the dotted line in Fig. 7 describes, or instead, may be given a part-of-ellipsoidal shape as the solid line in Fig. 7 describes with the upper part thereof cut off leaving such a part as actually contacts with the moving rod 13.

$$[\text{Equation 1}]\quad b2x2 + a2y2 = a2b2$$

[0060] Assuming for example that the switching movement is caused by the rotation of the insulated operating rod 14 around the rotary shaft 15 over the range of the angle e of right and left with respect to the vertical line, the calculation with Equation 2 indicates that the rotation is equivalent to a rotation of $a\theta/b$ in terms of the move in the form of a segment of a circle when the range of θ is defined as $-45° < \theta < 45°$. Taking this into account, when the radius of rotation, the length of the insulated operating rod 14, is denoted by R, and where the radius of rotation R is sufficiently longer than the minor axis a and the major axis b and $\theta < 20°$, an approximation equation $R \fallingdotseq 6.5\sqrt{}(b2 - a2)$ is valid.

$$[\text{Equation 2}]\quad b^2x^2 + a^2y^2 + (b^2 - a^2)xy \times \sin 2\theta = a^2b^2$$

[0061] With this relationship, where the radius of rotation R of the insulated operating rod 14 is 300 mm with assumption of a = 25 mm and b = 50 mm, the rotation of the free end of the insulated operating rod 14 around the rotary shaft 15 causes the position of the sliding surface 21 contacting with the moving rod 13 to change but a contact point 26, at which the moving rod 13 actually contacts with the insulated operating rod 14, sits always approximately on the central axis line of the moving rod 13. Thus, the displacement of the contact point 26 illustrated in Fig. 9 from the central axis line is controlled within 1 mm.

[0062] From a viewpoint of determination of a practical range, it is realistic to design the dimensional relationship within the range defined by the Equation 3 given below, because such relationship represses the displacement of the contact point 26 within 3 mm from the central axis line of the moving rod 13.

$$[\text{Equation 3}]\quad 6\sqrt{}(b^2 - a^2) < R < 7\sqrt{}(b^2 - a^2)$$

[0063] Fig. 8 indicates, for comparison purpose, the variation of displacement of the contact point 26 for the cases where the shape of the sliding surface 21 of the insulated operating rod 14, which contacts with the moving rod 13, is a circle, and where the shape of the sliding surface 21 is an ellipse.

[0064] In the former case, the displacement is calculated by the equation $R(1 - \cos\theta)$. Where the radius of rotation R = 300 mm and the rotation angle $\theta = 20°$, the variation of displacement of the contact point 26 caused by the rotation of the insulated operating rod 14 is indicated by the curves 22, 23, and 24 respectively for the radii of the circle of the sliding surface 21 r = 25 mm, 50 mm, and 75 mm.

[0065] In contrast, when the shape of the sliding surface 21 of the insulated operating rod 14, which contact with the moving rod 13, is an ellipse as stated above, the variation of displacement of the contact point 26 is repressed smaller as the displacement variation curve 25 indicates.

[0066] Where the sliding surface 21 is shaped according to Equation 3 as stated above, the displacement of the contact point 26 actually contacting with the moving rod 13 is below 3 mm from the central axis line of the moving rod 13 as indicated in Fig. 9, which means that the contact occurs almost at one-point on the central axis line of the moving rod 13.

[0067] In the case of the sliding surface 21 being shaped in a circle of which radius R = 25 mm in contrast to the above, the contact point that actually contacts with the moving rod 13 deviates from the central axis line of the moving rod 13 as the insulated operating rod 14 rotates as Fig. 10 indicates. As a consequence of this, the deviation occurs from a contact point 26a to a contact point 26b by the amount as much as about 18 mm.

[0068] Next, the following provides an explanation of an application in which the insulated operating rod 14 stated above is used in a switching device.

[0069] As stated above, one end of the insulated operating rod 14 has the rotary shaft 15 secured thereto by cast integrally. The insulated operating rod 14 is arranged so that the other end, i.e., the free end, thereof will rotate around the rotary shaft 15 describing a circular arc and so that the other end will contact with the end face of the moving rod 13 to establish the contact and connection.

[0070] As illustrated in Fig. 13, which is the plan view of such linkage portion, and Fig. 14, which is the enlarged view of the same, a through hole 27, into which the free end on the upper part of the insulated operating rod 14 is inserted, is formed on the linkage end of the moving rod 13. The shape of the through-hole 27 is designed so that a pair of end faces 28a and 28b will be formed perpendicularly to the central axis line of the moving rod 13. The shape of such a part of the insulated operating rod 14 as contacts with the pair of end faces 28a and 28b is given an elliptical shape on both sides thereof to provide the sliding surface 21.

[0071] This means that the ellipse-shaped sliding surface 21 is formed on such a part of the insulated operating rod

14 as contacts with the end faces 28a and 28b so that the counterclockwise rotation of the insulated operating rod 14, which is transmitted as the circuit-closing movement will push the end face 28a of the moving rod 13 and so that the clockwise rotation of the insulated operating rod 14, which is transmitted as the circuit-opening movement, will push the end face 28b of the moving rod 13.

[0072] Although the position of contact with the moving rod 13 on the sliding surface 21 changes as the insulated operating rod 14 rotates, the contact point 26 between them sits always approximately on the central axis line of the moving rod 13 because of the construction of the contact and connection as stated above as long as the rotation angle of the insulated operating rod 14 is within the predetermined range.

[0073] Therefore, the driving of the moving rod 13 toward the circuit-closing direction, in the arrow-indicated direction as illustrated in Fig. 11, by rotating the insulated operating rod 14 causes the moving rod 13 to move linearly on its central axis line. In contrast, when the sliding surface 21 with the moving rod 13 is shaped in a circle as illustrated in Fig. 12 for comparison purpose, the contact point 26 with the moving rod 13 deviates off the central axis line of the moving rod 13 as the insulated operating rod 14 rotates. As a consequence of this, the driving force transmitted from the insulated operating rod 14 to the moving rod 13 produces a component of force perpendicular to the central axis line of the moving rod 13 as the arrow indicates; this component of force works as an oblique force as a whole with respect to the central axis line of the moving rod 13.

[0074] As can be known from these comparisons, the contact and connection having the construction illustrated in Fig. 12 increases the sliding frictional drag that will be impressed on the insulated operating rod 14 of an insulating material and on the moving rod 13 of metallic material. Further, there appears a component of force perpendicular to the central axis line of the moving rod 13 and thereby an excessive uneven force acts on the contactor 13 on every circuit-closing movement.

[0075] In this event, metal-against-metal rubbing occurs between the moving rod 13 and the moving contactor 11 or the fixed contactor 7, which is a cause of the emission of metallic particle. If the uneven force develops to a greater level, there occurs not only the emission of the metallic particle but also a galling or a mal-alignment between the moving rod 13 and the moving contactor 11 or fixed contactor 7. As a consequence of this, it is likely that the situation develops even into occurrence of malfunction of the switching device.

[0076] In contrast in the contacting mechanism configuration illustrated in Fig. 11, the sliding frictional drag that will be impressed on the insulated operating rod 14 of an insulating material and on the moving rod 13 of metallic material is greatly reduced as stated above, because the position of the contact point 26, at which the moving rod 13 contact with the insulated operating rod 14, deviates always little from the central axis line of the moving rod 13. Thus, the moving rod 13 moves smoothly on its central axis line with emission of metallic particle therefrom reduced.

[0077] Unlike other electrical equipment, the gas-insulated switchgear is prone to greatly lower its dielectric strength performance if metallic particle exists within the sealed container 1 inside of which the high-voltage conductor is accommodated. Therefore, gas-insulated switchgears are carefully controlled so that no metallic particle will invade.

[0078] However, there is a possibility of occurrence of emission of metallic particle while the switching motion of a switching device other than the straying of metallic particle thereinto during fabrication. In particular, not only mechanical parts in the switching-movement parts such as levers and gears that work on switching movement but also mutual sliding motion between the moving rod 13, which moves while the switching movement, and the contactors 7 and 11 for maintaining electrical contact with the moving rod 13 will possibly emit metallic particle.

[0079] For example, in a tulip style contactor, in which contacting segments are arranged periphery of the moving rod 13, plural springs 27 are arranged over the contacting segments like the moving contactor 11 illustrated in Fig. 11 so that the contacting force will work on the moving rod 13 for maintaining good electrical contact therewith even while in motion. Therefore, where contactors 7 and 11 are employed, it is preferable to regulate the spring force so that the periphery of the moving rod 13 will receive the spring force evenly.

[0080] In this regard, the spring forces through the fixed contactor 7 and the moving contactor 11 act evenly on the periphery, because the moving rod 13 moves on its central axis line as stated above. Therefore, the emission of metallic particle from such sliding part is repressed.

[0081] Generally, lubricant like grease is applied on a metal-metal sliding portion to make sliding movement smooth for reduction of the frictional drag on such sliding portion. However, if grease is not applied, the frictional drag will increase making it highly possible to invite emission of hair-like or powder-like fragments of metallic particle attributable to scraping. Even though grease has been applied, the sliding portion may be prevented from smooth movement if greasing performance becomes poor because of deterioration or depletion due to long-time use.

[0082] In contrast, such an arrangement that the contact point 26 between the insulated operating rod 14 and the moving rod 13 sits on the central axis line of the moving rod 13 makes a grease-less operation practicable because such configuration reduces the frictional drag on the contact point 26.

[0083] Because the aged deterioration of grease is unavoidable ina greased mechanism as stated above, every equipment checkup is usually followed by grease replenishment for the greased portion. In a gas-insulated switchgear, the switching device is accommodated in the sealed container 1; accordingly, grease replenishment in the gas-insulated switchgear is difficult because opening a metallic container 1 is not a simple operation. Thus, when it is realized to make metal-sliding portion be grease-less configuration, the conventional fashion of overhaul becomes unnecessary with high-reliability of the gas-insulated switchgear maintained for long time.

[Embodiment 2]

[0084] Fig. 15 and Fig. 16 are the plan view and the sectional view respectively. They illustrate the configuration of the contact and connection between the insulated operating rod 14 and the moving rod 13 in another embodiment.

[0085] The configuration of the sliding surface 21 on the free end of the insulated operating rod 14 is the same as that in the above-stated embodiment. The moving rod 13 has a holder part 29 on the right side to establish the linkage with the insulated operating rod 14 in addition to a conductor portion on the left side for electrical current-carrying. The holder part 29 has the through-hole 27, explained in terms of Fig. 13, which is detachably secured on the conductor portion with a screw 30.

[0086] As can be known from the relationship between the moving rod 13 and the moving contactor 11 illustrated in Fig. 11, no current flows through the holder part 29 that is an element separate from the conductor portion. Therefore, either metallic material or insulating material is applicable as the constituent material of the holder part 29. Where the holder part 29 is formed using insulating material, no metallic particle will be emitted even when the insulated operating rod 14 scrape against the holder part 29, because the portion that contact with the insulated operating rod 14 is the holder part 29 made of insulating material. Thus, the reliability as the gas-insulated switchgear is enhanced more.

[0087] In general, the frictional drag that appears in a sliding motion can be made low by using same material. Therefore, the frictional drag is repressed further-lower by using the same material as the one used in the insulated operating rod 14 stated above for the insulating material of the holder part 29. For example, when the insulated operating rod 14 uses the filler-filled epoxy resin, it is preferable to use the same filler-filled epoxy resin for the holder part 29.

[0088] As another embodiment, a derivation of embodiments illustrated in Figs. 15 and 16, it may be practicable to affix the same material as used in the insulated operating rod 14 on such a portion of the holder part 29 as contacts with the insulated operating rod 14 instead of manufacturing the whole body of the holder part 29 using the same material as used in the insulated operating rod 14. In this configuration, the sliding occurs between same materials with considerably lowered frictional drag. Therefore, such a contact and connection as works smoothly without lubricant like grease can be established.

[Embodiment 3]

[0089] Fig. 17 and Fig. 18 are the plan view and the sectional view respectively. They illustrate the configuration of the contact and connection between the insulated operating rod 14 and the moving rod 13 in another embodiment.

[0090] The configuration of the contact and connection in this embodiment is similar to that in the embodiment illustrated in Figs. 15 and 16, wherein thin films 31a and 31b of solid lubricant are provided on the contacting portion at which the holder part 29 of the moving rod 13 contacts with the insulated operating rod 14. Fluorocarbon resin like polytetrafluoroethylene (PTFE) is applicable as the solid lubricant in this configuration.

[0091] Although it is possible to form the whole body of the holder part 29 using solid lubricant, assuring the mechanical strength of the body is difficult. Therefore, arranging the thin films 31a and 31b only on the contacting portion as illustrated is the most feasible manner. The thin films 31a and 31b of solid lubricant greatly lower the frictional drag, which enables the mechanism to reduce greatly the emission of foreign substance like metallic particle.

[Industrial Applicability]

[0092] The gas-insulated switchgear by the present invention is applicable not only to the disconnecting switch illustrated in Fig. 1 but also to switching devices in other configuration.

Claims

1. A gas-insulated switchgear comprising:

a sealed container filled with insulating gas;
a bar-shaped rotary shaft driven and rotated by an operating device with the sealed container maintained hermetically;
an insulated operating rod, the one end of the insulated operating rod being fixed on the bar-shaped rotary shaft, the other end of the insulated operating rod being moved in the form of a segment of a circle by rotation

of the bar-shaped rotary shaft; and
a moving rod connected to the other end of the insulated operating rod and driven in an axial direction to perform switching operation,
wherein the bar-shaped rotary shaft has a large-diameter part formed integrally at the axial-middle part thereof, and the insulated operating rod is cast integrally with the large-diameter part by using filler-filled resin so that the large-diameter part is embedded into one end of the insulated operating rod.

2. The gas-insulated switchgear according to claim 1, wherein the insulated operating rod has a sliding surface formed on the other end thereof, the sliding surface being formed to slide on the moving rod at roughly one-point on the axis line of the moving rod during the switching operation.

3. The gas-insulated switchgear according to claim 1 or claim 2, wherein the large-diameter part on the axial-middle part of the rotary shaft has an elliptical shape, the diameter of the large-diameter part along the axial direction of the insulated operating rod is a long diameter, and the diameter of the large-diameter part along the width direction of the insulated operating rod is a short diameter.

4. The gas-insulated switchgear according to claims 1 to 3, wherein the material for the resin includes epoxy resin or phenol resin.

5. The gas-insulated switchgear according to claims 1 to 4, wherein the filler filled in the resin includes alumina or silica.

FIG. 1

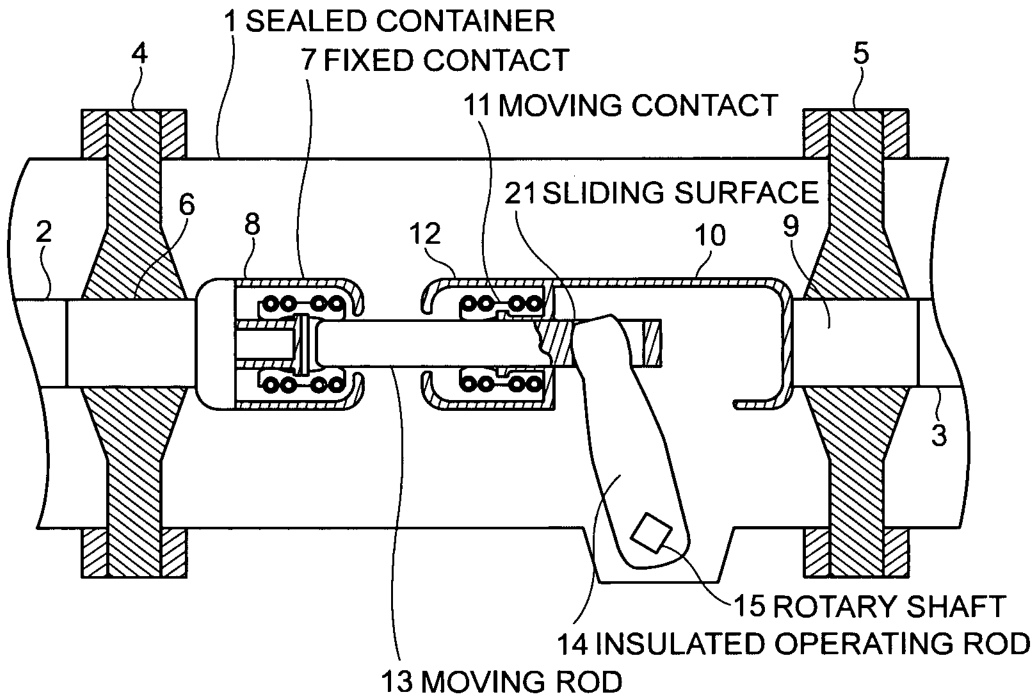

1 SEALED CONTAINER
7 FIXED CONTACT
11 MOVING CONTACT
21 SLIDING SURFACE
4
5
2
6
8
12
10
9
3
15 ROTARY SHAFT
14 INSULATED OPERATING ROD
13 MOVING ROD

FIG. 2

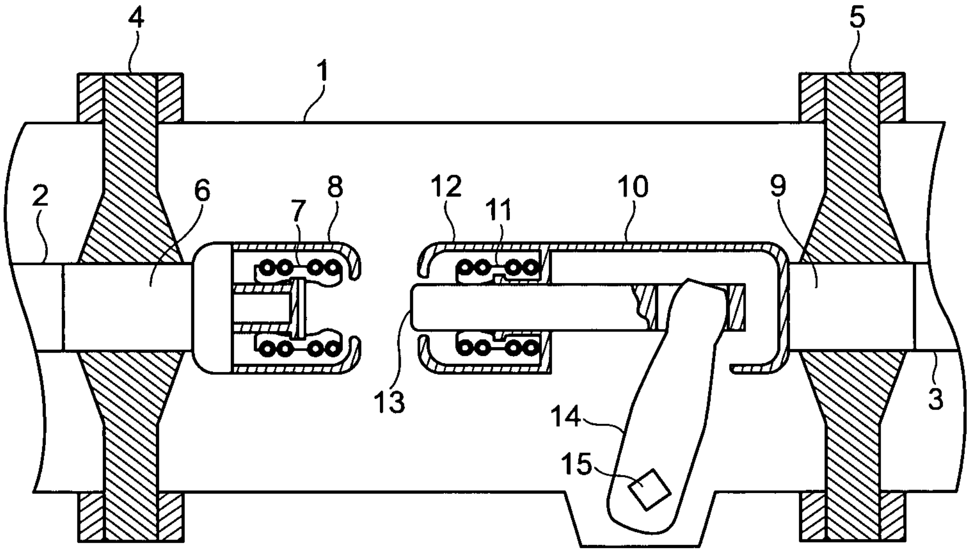

4
5
1
2
6
7
8
12
11
10
9
3
13
14
15

FIG. 3

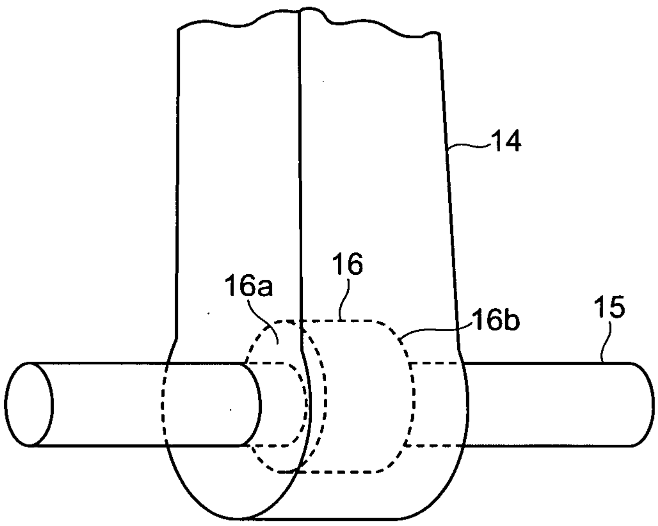

14
16
16a
16b
15

FIG. 4

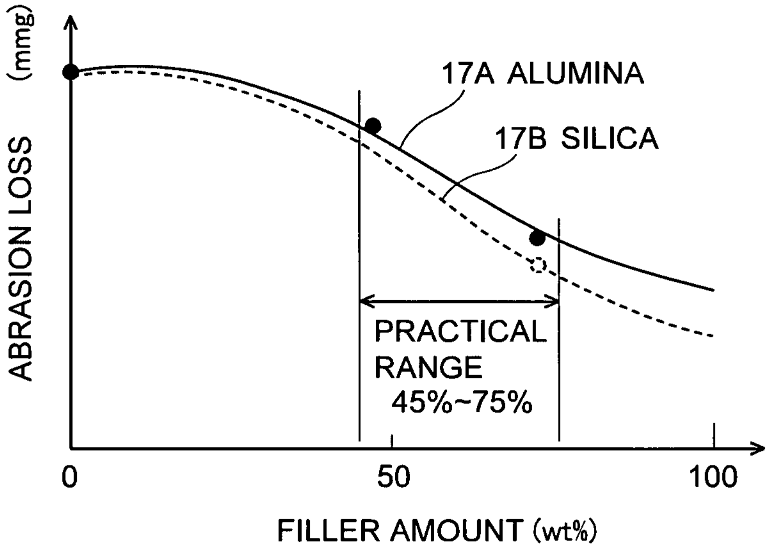

ABRASION LOSS (mmg)
17A ALUMINA
17B SILICA
PRACTICAL RANGE 45%~75%
0
50
100
FILLER AMOUNT (wt%)

FIG. 5

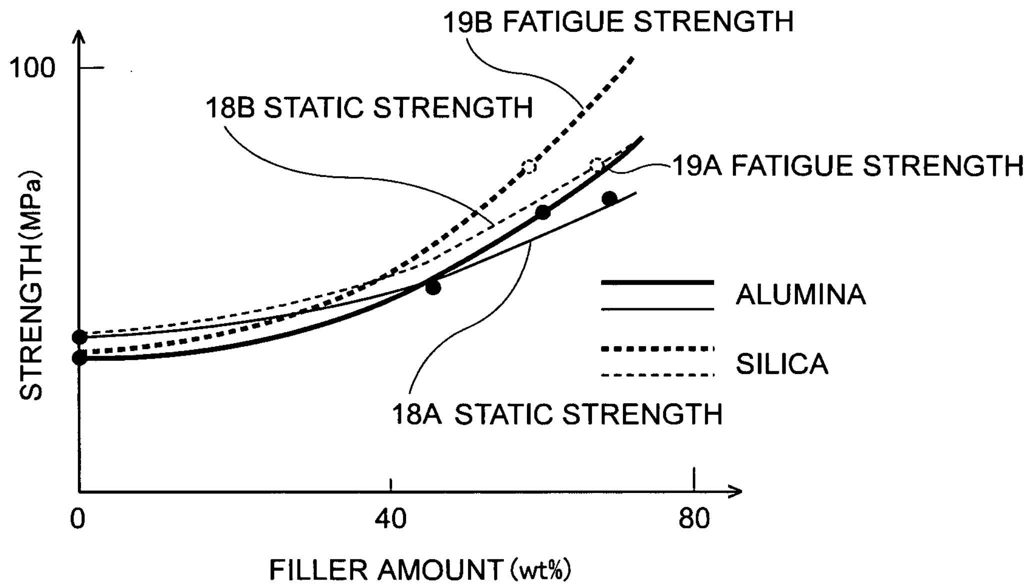

19B FATIGUE STRENGTH
100
18B STATIC STRENGTH
19A FATIGUE STRENGTH
STRENGTH (MPa)
ALUMINA
SILICA
18A STATIC STRENGTH
0
40
80
FILLER AMOUNT (wt%)

FIG. 6

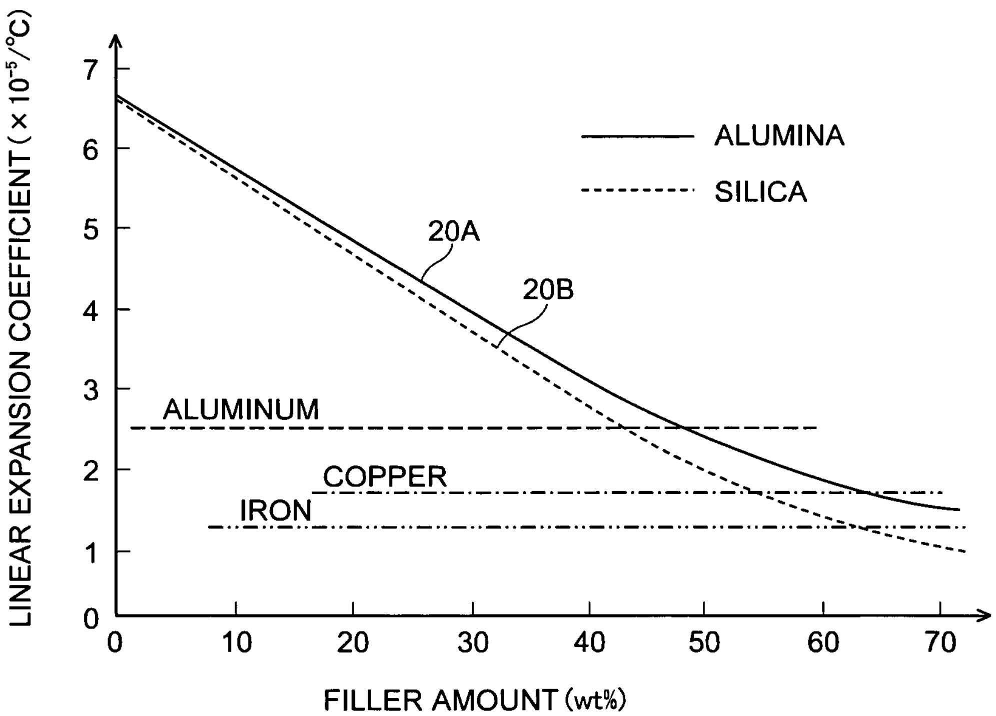

LINEAR EXPANSION COEFFICIENT (×10⁻⁵/°C)
7
6
5
4
3
2
1
0
ALUMINA
SILICA
20A
20B
ALUMINUM
COPPER
IRON
0
10
20
30
40
50
60
70
FILLER AMOUNT (wt%)

FIG. 7

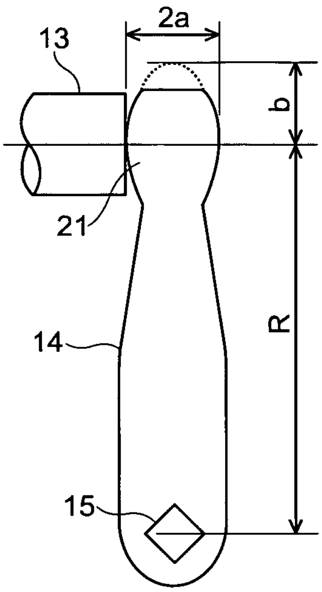

2a
13
b
21
R
14
15

FIG. 8

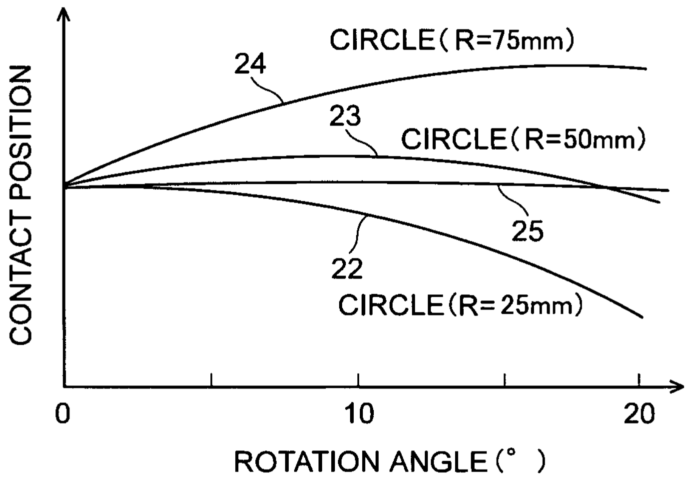

CONTACT POSITION
CIRCLE(R=75mm)
24
23
CIRCLE(R=50mm)
25
22
CIRCLE(R=25mm)
0
10
20
ROTATION ANGLE(°)

FIG. 9

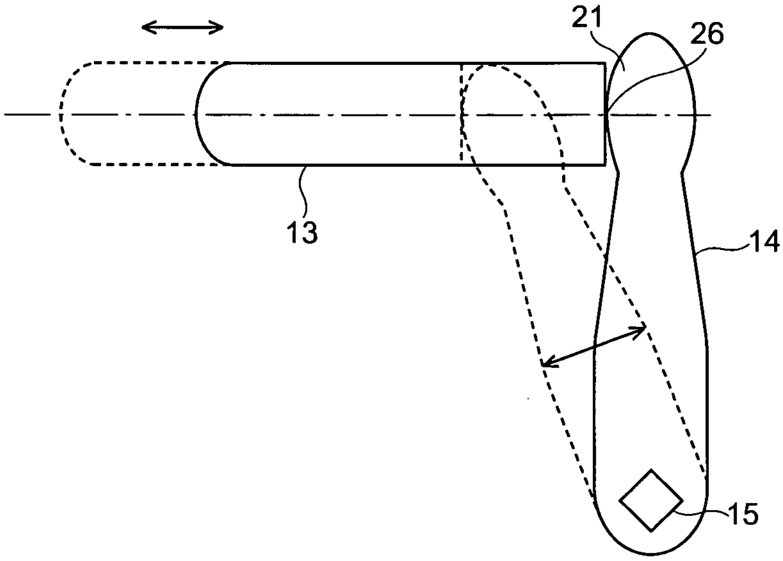


FIG. 10

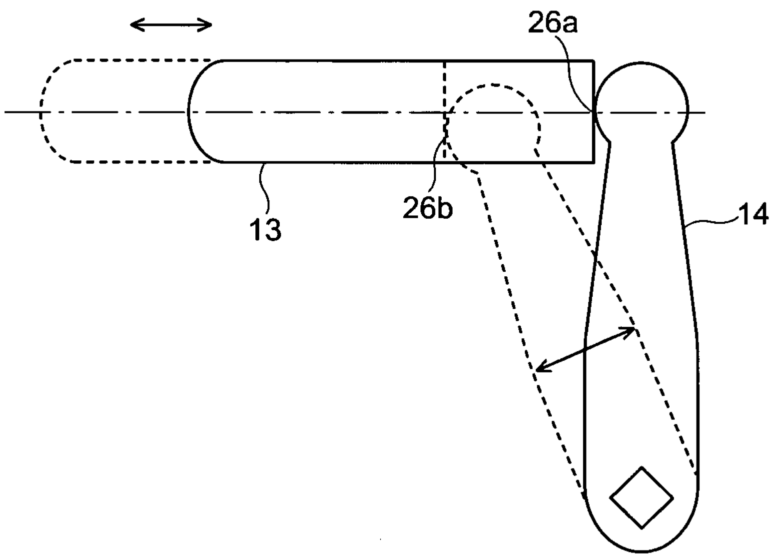


FIG. 11

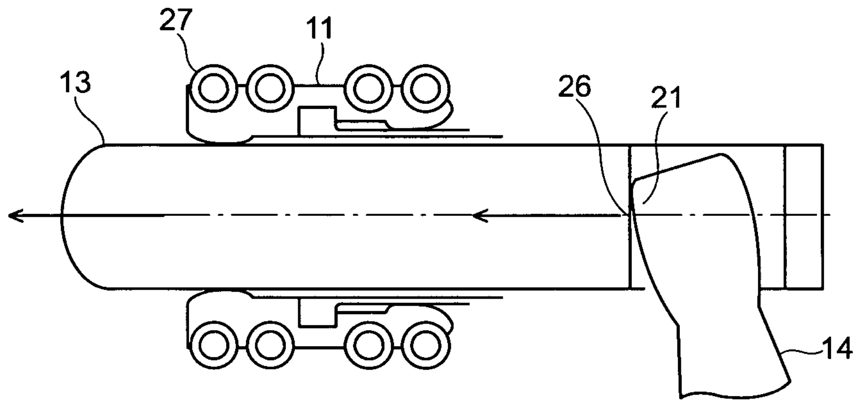


FIG. 12

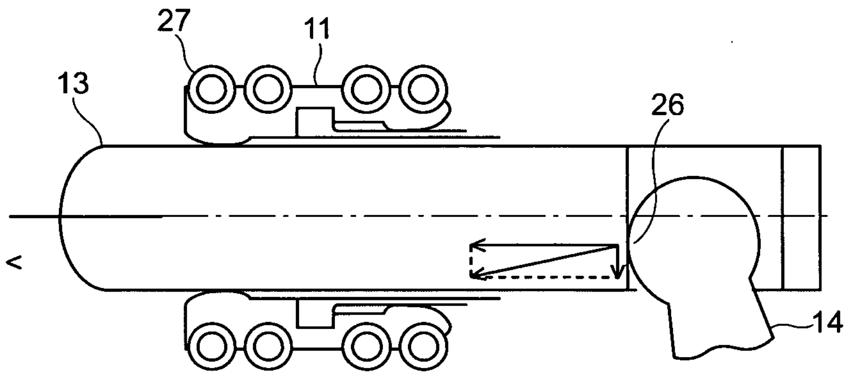


FIG. 13

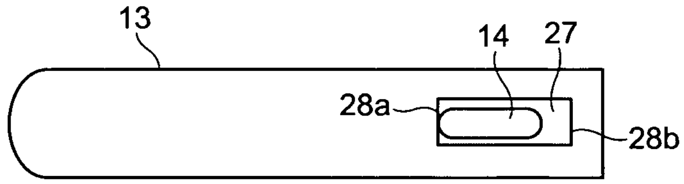


FIG. 14

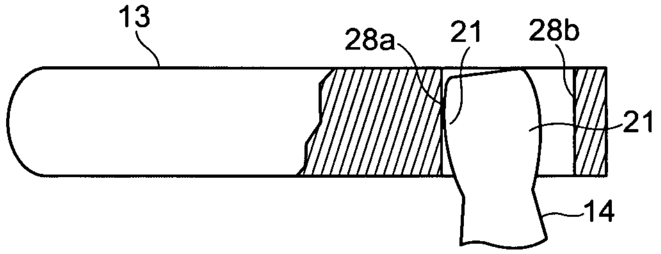


FIG. 15

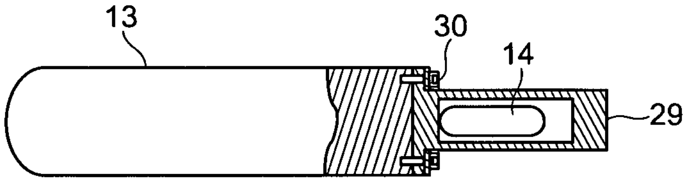


FIG. 16

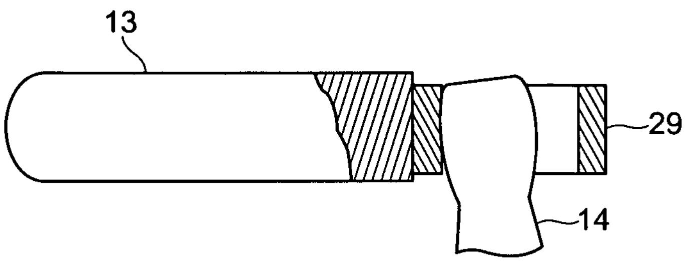


FIG. 17

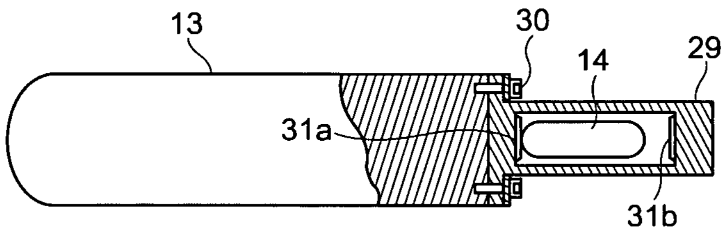
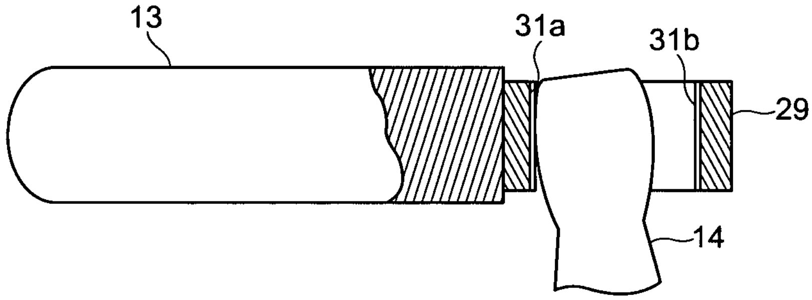


FIG. 18



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/069676

A. CLASSIFICATION OF SUBJECT MATTER
H02B13/02(2006.01)i, *H01H33/64*(2006.01)i

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)
H02B13/02, H01H33/64, H01H31/32, H01H33/12, H01H33/42, H01H33/66

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	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

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.
A	JP 2007-27023 A (Hitachi, Ltd., Japan AE Power Systems Corp.), 01 February 2007 (01.02.2007), paragraph [0015]; fig. 1, 2 & CN 1901124 A	1-5
A	JP 4-359821 A (Mitsubishi Electric Corp.), 14 December 1992 (14.12.1992), paragraphs [0026] to [0028]; fig. 12, 14, 15 (Family: none)	1-5

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search 10 December, 2009 (10.12.09)	Date of mailing of the international search report 22 December, 2009 (22.12.09)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/069676

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 28362/1972(Laid-open No. 103862/1973) (Tokyo Shibaura Electric Co., Ltd.), 04 December 1973 (04.12.1973), fig. 2, 4 (Family: none)	2
A	JP 9-28011 A (Fuji Electric Co., Ltd.), 28 January 1997 (28.01.1997), paragraphs [0003] to [0005]; fig. 8 to 10 (Family: none)	1-5
A	JP 5-114337 A (Fuji Electric Co., Ltd.), 07 May 1993 (07.05.1993), paragraph [0016]; fig. 6 (Family: none)	1-5
A	JP 1-161633 A (Fuji Electric Co., Ltd.), 26 June 1989 (26.06.1989), entire text; fig. 1 to 3 (Family: none)	1-5
A	JP 37-10934 Y2 (Matsushita Electric Industrial Co., Ltd.), 21 May 1962 (21.05.1962), entire text; fig. 1 to 3 (Family: none)	1
A	JP 6-84431 A (Fuji Electric Co., Ltd.), 25 March 1994 (25.03.1994), fig. 1, 2, 4 (Family: none)	1-5

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Patent documents cited in the description

- JP 2002245909 A **[0003]**
- JP 2008176942 A **[0003]**
- JP H8298040 B **[0003]**