DESCRIPTION

GAS-INSULATED SWITCHING APPARATUS

TECHNICAL FIELD

This invention relates to a gas-insulated switching apparatus and, more particularly, to a gas-insulated switching apparatus in which a plurality of vacuum valves are disposed within a gas filled vessel filled with an electrically insulating gas.

BACKGROUND ART

In a conventional gas-insulated switching apparatus in which vacuum valves, provided within a vacuum vessel with a stationary electrode and a movable electrode driven toward and away from the stationary electrode for conducting and interrupting the electric current therethrough by closing and opening the stationary and movable electrodes, are housed within a gas-filled vessel in which an electrically insulating gas such as SF6 gas or the like is filled, the movable electrode of the vacuum valves are connected to a manual operating lever by means of a operating force transmitting mechanism composed of levers, links, connecting rods and the like (see, for example, Japanese Patent Laid-Open No. 02-257536 publication, pages 1 and 2, Fig. 2, in particular).

Also, in a conventional gas-insulated switching apparatus used in a three-phase a. c. interrupter, in which typically three vacuum vessels are disposed in parallel and provided with a interlocking mechanism including a connecting rod for connecting the movable electrode of the respective vacuum valves to simultaneously drive three vacuum valves (see, for example, Japanese Patent Laid-Open No. 2000-283320).

In such gas-insulated switching apparatus, a bellow is provided at the region through which the movable electrode of the vacuum valve extends through the gas-filled vessel wall between the movable electrode and the wall

surface of the gas-filled vessel, for the purpose of sealing therebetween without impeding the forward and backward movement of the movable electrode (See, for example, Japanese Patent Laid-Open No. 02-257536, pages 1 and 2, Fig. 2 in particular).

In the conventional gas-insulated switching apparatus having the structure as just has been described, miniaturization of the apparatus cannot be achieved because of the operating power transmitting mechanism composed of the levers, the links, the connecting rods and the like connected to the movable electrode of the vacuum valve, and such the operating power transmitting mechanism is disadvantageously poor in energy transmission efficiency for the operating power because of large energy losses at the connection portions of the transmission components and the friction losses generated at the rotating components such as links.

Also, in the conventional gas-insulated switching apparatus in which a bellows is used for the purpose of sealing the circumference of the movable electrode, assembling efficiency was disadvantageously poor because the bellows is fragile and particularly weak in twisting motion, requiring that the assembly and the adjustment be carefully achieved.

The present invention has been made in order to solve the above-discussed problems and has as its object the provision of a gas-insulated switching apparatus that can be made compact and light-weight, reduced in energy losses of the operating power and improved in the assembling efficiency even in the one employing the bellows.

DISCLOSURE OF INVENTION

A gas-insulated switching apparatus according to the present invention comprises a vacuum valve including an evacuated vacuum vessel, a stationary electrode disposed within the vacuum vessel and a movable electrode disposed within the vacuum vessel and movable toward and away from the stationary electrode. The vacuum valve achieves the conducting and breaking of the electric current by bringing the movable electrode into contact with and separation from the stationary electrode. The gas-insulated switching apparatus also comprises a gas-filled vessel sealing an electrically insulating gas therein and containing the vacuum valve therein, and an extension rod

having one end connected to the movable electrode and the other end extending to the outside of the gas-filled vessel. The apparatus further comprises an electromagnetic operating mechanism positioned outside of the gas-filled vessel and operated by an external electric signal, the electromagnetic operating mechanism comprising an output shaft connected to the other end of the extension rod and an electromagnetic coil for driving the output shaft by an electromagnetic force to control the opening and closing of the vacuum valve. Therefore, the operating power transmitting mechanism composed of the levers, the links, the connecting rods and the like connected to the movable electrode of the vacuum valve can be reduced to achieve miniaturization and weight reduction of the apparatus. Also, there is no energy losses at the connection portions of the transmission components and the friction losses generated at the rotating components such as links, so that the operating power can be efficiently transmitted and the apparatus is improved in energy efficiency in terms of the operating power.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of the gas-insulated switching apparatus of the present invention, and

Fig. 2 is a perspective view illustrating the details of the gas-insulated switching apparatus of Fig. 1.

BEST MODE FOR CARRYING OUT THE INVENTION

Fig. 1 is a sectional view of the gas-insulated switching apparatus 100 of the present invention. The gas-insulated switching apparatus 100 comprises vacuum valves 1 for conducting and breaking electric current. The vacuum valve 1 has a cylindrical vacuum vessel 2 closed at a bottom end. The vacuum vessel 2 contains therein a stationary electrode 3 and a movable electrode 4. The stationary electrode 3 is secured to one of the end walls 2a. And the stationary electrode 3 has electrically connected thereto an unillustrated main circuit bus bar.

The movable electrode 4 is provided in opposition to the stationary electrode 3. The movable electrode 4 is provided to extend through the other end wall 2b of the vacuum vessel 2 and to be movable back and forth. A

bellows 5 is provided at a portion of the end wall 2b through which the movable electrode 4 extends. The bellows 5 expandably seals between the movable electrode 4 and the end wall 2b of the vacuum vessel 2. Interior of the vacuum vessel 2 is maintained evacuated so that an electric arc generated upon the current interruption may be quickly dispersed and extinguished.

As the movable electrode 4 moves forward and backward with respect to the stationary electrode 3, the stationary contact 3a disposed at the tip of the stationary electrode 3 and the movable contact 4a provided at the tip of the movable electrode 4 are brought into contact and separation to open and close the vacuum valve 1. In order to apply a predetermined contact pressure between the stationary contact 3a and the movable contact 4a, a contact pressure spring 6 is disposed at the end portion of the movable electrode 4. The contact pressure spring 6 is disposed in compressed state between the stop plate 7 connected to the end portion of the movable electrode 4 and an insulating rod 8. The stop plate 7 has formed at its center a round hole, through which a shaft member 8a, which extends from the insulating rod 8 toward the vacuum valve 1 and having an outer diameter smaller than that of the central hole in the stop plate 7, extends with a play. The shaft member 8a has a screw 8b thread engaged into its central bore of which head portion prevents the stop plate 7 from disengaged from the shaft member 8a. The stop plate 7 is supported movably along the shaft member 8a and with respect to the insulating rod 8, thereby restricting the amount of expansion of the contact pressure spring 6. The insulating rod 8 is made of epoxy resin and electrically insulates between the vacuum valve 1 and an extension rod 9 which will be described later.

The vacuum valve 1, the contact pressure spring 6, the insulating rod 8 and the stop plate 7 are accommodated within a gas-filled vessel 10. The gas-filled vessel contains therein an electrically insulating gas such as SF_6 gas. One of the end walls of the gas-filled vessel 10 constitutes a base plate 11. The base plate 11 has an opening 11a of a predetermined size, and the extension rod 9 connected at one end to the insulating rod 8 extends at the other end through this opening 11a to outside.

Disposed outside of the gas-filled vessel 10 are electromagnetic operating mechanisms 12. The electromagnetic operating mechanism 12

each is supported by two support members 15 extending from the base plate 11. The electromagnetic operating mechanism 12 comprises at its central portion a cylindrical permanent magnet 16. A first ring-shaped electromagnetic coil 18 is disposed on the vacuum valve side of the permanent magnet 16 in adjacent thereto with its central axis coincided with the axis of the permanent magnet 16. Also a second ring-shaped electromagnetic coil 19 is disposed on the opposite side of the permanent magnet 16 in adjacent thereto with its central axis coincide with the axis of the permanent magnet 16. A cylindrical movable member 20 is disposed to axially movably extend through a central space defined by central holes of the permanent magnet 16, the first electromagnetic coil 18 and the second electromagnetic coil 19 aligned as above described. An output shaft 21 is secured to the movable member 20 on the central axis to extend therethrough.

A thick disc-shaped first yoke 22 is also disposed next to the first electromagnetic coil 18 on the side of the vacuum valve 1. On the other hand, a thick disc-shaped second yoke 23 is also disposed next to the second electromagnetic coil 19 on the side opposite to the vacuum valve 1. The output shaft 21 extends movably back and forth through the central holes of the first yoke 22 and the second yoke 23. The movable member 20, the first yoke 22 and the second yoke 23 are all made of iron.

The electromagnetic operating mechanism 12, the vacuum valves and an extension rod 9 are all disposed on a common straight line. The output shaft 21 of the electromagnetic mechanism 12 and the extension rod 19 are connected by a length adjustment mechanism 24. The length adjustment mechanism 24 is a cylindrical member having an internal thread and having male threads formed on the end portion of the output shaft 21 and the extension rod 9 engaged at both ends. The rotation of the extension rod 9 in one direction with respect to the length adjustment mechanism 24 causes the extension rod 9 to move in the axial direction away from the output shaft 21, thereby decreasing the distance between the insulating rod 8 and the vacuum valve 1. Also, the rotation of the extension rod 9 in the opposite direction with respect to the length adjustment mechanism 24 causes the extension rod 9 and the output shaft 21 come close to each other, thereby increasing the distance between the insulating rod 8 and the vacuum valve 1.

At the extension opening 11a of the base plate 11, a tubular guide 25 is mounted along the axis of the extension rod 9. The extension rod 9 is guided by this guide 25 and slidable in the axial direction, and a bellows 26 is provided at the outer circumference of the guide 25.

Fig. 2 is a perspective view showing the details of the bellows 26. The bellows comprises an expansion portion 26a which is an expandable cylindrical portion, an outer flange portion 26b outwardly extending from the opening edge, and an inner flange portion 26c inwardly extending from the end portion of the expansion portion opposite to the vacuum valve 1. The bellows 26 is secured at the outer flange portion 26c sandwiched between a retainer plate 27 and the base plate 11. The retainer plate 27 is fastened on the male threads 28 planted in the base plate 11 by nuts 29. The inner flange portion 26c permits the extension rod 9 to extend through its central opening but hermetically seals the clearance between them. That is, the bellows 26 is disposed between the outer circumference portion of the extension rod 9 and the edge portion of the opening 11a of the gas-filled vessel 10 and provides a hermetic seal or a gas-seal therebetween without impeding the forward and backward movements of the extension rod 9. The cylindrical bellows of the expandable portion 26a expands and contract with a very small force.

Referring back to Fig. 1, a single switching unit is composed by the vacuum valve 1, the contact pressure spring 5, the insulating rod 8, the engagement plate 7, the electromagnetic operating mechanism 12, the length adjustment mechanism 24 and the bellows 26, the gas-insulated switching apparatus 100 comprises three parallel-arranged switching units for controlling a three-phase a. c. current. Each electromagnetic operating mechanism 12 of the respective switching units operates according to electric signals from outside, and three vacuum valves 1 are simultaneously operated to open and close, for example. The slight deviation of the timing between the vacuum valves 1 may be adjusted by the length adjustment mechanism 24, for example.

As has been described, the gas-insulated switching apparatus 100 of this embodiment comprises the electromagnetic operating mechanism 12 positioned outside of the gas-filled vessel 10 and operated by an external electric signal and including the output shaft 21 connected to the other end of the extension rod 9 and the first and the second electromagnetic coils 18, 19 for

driving the output shaft 21 by an electromagnetic force to control the opening and closing of the vacuum valve 1. Therefore, the conventional operating power transmitting mechanism composed of the levers, the links, the connecting rods and the like connected to the movable electrode 4 of the vacuum valve 1 can be reduced to achieve miniaturization and weight reduction of the apparatus. Also, there is no energy losses at the connection portions of the transmission components and the friction losses generated at the rotating components such as links, so that the operating power can be efficiently transmitted and the apparatus is improved in energy efficiency in terms of the operating power.

Also, three vacuum valves 1 are arranged in parallel in order to control a three phase a. c. current, and the electromagnetic operating mechanism 12 is provided one for each vacuum valve 1, so that, as compared to the conventional design, the interlock mechanism for interlockingly operate three vacuum valves can be eliminated, allowing a further decrease in the energy losses, realizing an apparatus of further higher energy efficiency. Also, since the interlocking mechanism conventionally used is eliminated, the vacuum valves 1 may not necessarily be arranged in parallel as in this embodiment, the degree of freedom of the layout of the vacuum valves 1 is increased and the restriction on the apparatus configuration is alleviated.

Also, the axis of the movable electrode 4 and the axis of the output shaft 21 are aligned on the common line, so that the conventional operating force transmitting mechanism composed of the levers, the links, the connecting shaft and the like is not necessary, allowing the apparatus to further become small-sized and light-weighted.

Further, the extension rod 9 extends outwardly through an extension opening 11a formed in a wall of said gas-filled vessel 10, and a bellows 26 is provided between an outer circumferential portion of the extension rod 9 and a circumferential portion of the extension opening 11a of the gas-filled vessel 10 for sealing therebetween without impeding the forward and backward movement of the extension rod 9. Therefore, the resistance upon the forward and backward movements of the extension rod 9 is very small and the deviation among the operation of the vacuum valves 1 is reduced. Also, in the apparatus with the provision of a plurality of vacuum valves 1 as in this

embodiment, the deviation in operation of the vacuum valves 1 can be decreased.

The operation will now be described. When the first electromagnetic coil 18 of the electromagnetic operating mechanism 12 is energized by an electric power supplied from the outside, the first electromagnetic coil 18 generates an electromagnetic force to attract the movable member 20. This causes the movable member 20 to move in the direction of an arrow A shown in Fig. 1. Then, the attracting force of the first electromagnetic coil 18 pushes the output shaft 21 toward the vacuum valve 1, causing the stationary contact 3a and the movable contact 4a of the vacuum valve 1 to contact with each other to close the vacuum valve 1. At this time, the contact pressure spring 6 is compressed by a predetermined length to apply a predetermined contact pressure on the stationary contact 3a and the movable contact 4a.

When the movable member 20 reaches to the closed position side, the end face of the movable member 20 on the side of the vacuum valve 1 is moved toward the first yoke 22 with a slight clearance defined therebetween. When the movable member 20 moves close to the yoke 22, a magnetic path extending from the permanent magnet 16 to first yoke 22 via the movable yoke 20 is defined and the movable member 20 is attracted by this magnetic path to the first yoke 22. Since this attraction force is larger than the return force of the contact pressure spring 6, the vacuum valve 1 is maintained in the closed position even after the first electromagnetic coil 18 is ceased to be energized.

On the other hand, when the second electromagnetic coil 19 of the electromagnetic operating mechanism 12 is energized by the externally supplied electric power, the second electromagnetic coil 19 generates an electromagnetic force which attracts the movable member 20. Then the movable member 20 is moved in the direction of the arrow B shown in Fig. 1. The attractive force of the second electromagnetic coil 19 dominates the attractive force between the movable member 20 and the first yoke 22 and pulls the output shaft 21 in the direction opposite to the vacuum valve 1. At this time, the contact pressure spring 6 is restricted at a predetermined amount of elongation by the engagement plate 7 and, since this amount of elongation is shorter than the distance of movement of the movable member 20, the stationary contact 3a and the movable contact 4a of the vacuum valve 1

separate to open the vacuum valve 1.

When the movable member 20 is thus moved to the open position side, the end surface of the movable member 20 opposite to the vacuum valve 1 is brought in the vicinity of the second yoke 23 with a small gap therebetween. When the movable member 20 comes close to the second yoke 23, a magnetic path from the permanent magnet 16 to the second yoke 23 via the movable member 20 is completed, and this magnetic path causes the movable member 20 to be attracted to the second yoke 23. Therefore, after this, even when the energization of the second electromagnetic coil 19 is removed, the vacuum valve 1 is maintained to be opened. The permanent magnet 16, the movable member 20, the first yoke 22 and the second yoke 23 together constitute a permanent magnet holding device for holding the vacuum valve 1 in the closed position or the closed position by the magnetic force of the permanent magnet 16.

Thus, in the gas-insulated switching apparatus 100 of this embodiment, the electromagnetic operating mechanism 12 comprises the first electromagnetic coil 18 for urging the movable electrode 4 of the vacuum valve 1 to the closed position side via the output shaft 21, and the second electromagnetic coil 19 for urging the movable electrode 4 to the open position side, so that the movable electrode 4 of the vacuum valve 1 is driven by the electromagnetic force of the electromagnetic coils 18 or 19 when it is moved to either of the closed position side or the open position side, whereby the operation can be made stable and the reliability can be improved.

Also, the electromagnetic operating mechanism 12 includes the permanent magnet holding device acting on the output shaft 21 for holding the movable electrode 4 of the vacuum valve 1 in either the closed position or the open position, so that the movable electrode 4 is maintained in the closed position or the open position by means of the permanent magnet 16, whereby the holding mechanism can be made with a simple structure and the number of parts can be decreased to reduce the cost and the size.

The permanent magnet holding device comprises the movable member 20 secured to the output shaft 21, the permanent magnet 16 surrounding the movable member 20, the first yoke 22 that comes close to the movable member 20 when the movable member 20 is moved to the closed position side to

provide the magnetic path in cooperation with the movable member 20 and the permanent magnet 16, and the second yoke 23 that comes close to the movable member 20 when the movable member 20 is moved to the open position side to provide the magnetic path in cooperation with the movable member 20 and the permanent magnet 16, so that the above mentioned holding mechanism can be provided with a single permanent magnet 16, permitting a further reduction in cost.

Then the method for adjusting the length of the extension rod 9 during the assembly of the gas-insulated switching apparatus 100 of this embodiment will now be described. The extension rod 9 can be moved out from and into the output shaft 21 by rotating the extension rod 9 with respect to the output shaft 21 of the electromagnetic operating mechanism 12. Then, this allows the adjustments of the distance between the insulating rod 8 and the vacuum valve 9 and, therefore, the separation distance between the stationary contact 3a and the movable contact 4a. At this time, if the extension rod 9 is rotated, the bellows 26 attached to the extension rod 9 too is rotated together. Therefore, the nut 29 should be loosened beforehand to remove the holding force on the holder plate 27 against the outer flange portion 26b of the bellows 26, then the bellow 26 is permitted to freely rotate, thereby to eliminate the fear of deformation of the fragile bellows 26.

In other words, the bellows 26 of this embodiment comprises the expandable portion 26a of a substantially accordion cylinder, the inner flange portion 26c inwardly extending from one end portion of the expandable portion 26a and sealingly secured to the extension rod 9 at its inner-most portion, and the outer flange portion 26b outwardly extending from the other end portion of the expandable portion 26a, and wherein the outer flange portion 26b is secured by being sandwiched between a wall of the gas-filled vessel 10 and the holder plate 27 fastened to the wall. Therefore, the length of the extension rod 9 can be adjusted without twisting the bellows 26, eliminating the possibility of deforming the bellows 26.

Also, the length adjusting mechanism 24 is provided between the extension rod 9 and the output shaft 21, so that the distance between the vacuum valve 1 and the electromagnetic operating mechanism 12 can be easily adjusted and, particularly, in the gas-insulated switching apparatus of this

embodiment in which a plurality of vacuum valves 1 are provided, timing adjustment operation among each vacuum valve 1 can be easily achieved.

INDUSTRIAL APPLICABILITY

The gas-insulated switching apparatus of this invention can be used as a gas-insulated switchgear installed in an electrical station such as a power plant, a power distribution station and the like and particularly suitable as a gas-insulated switching apparatus for controlling a three-phase a. c. current.

CLAIMS

1. A gas-insulated switching apparatus comprising;

a vacuum vessel and a movable electrode disposed within the vacuum vessel and movable toward and away from the stationary electrode for conducting and breaking electric current by bringing the movable electrode into contact with and separation from the stationary electrode;

a gas-filled vessel sealing an electrically insulating gas therein and containing said vacuum valve therein;

an extension rod having one end connected to said movable electrode and the other end extending to the outside of said gas-filled vessel; and

an electromagnetic operating mechanism positioned outside of said gas-filled vessel and operated by an external electric signal, said electromagnetic operating mechanism comprising an output shaft connected to said the other end of said extension rod and an electromagnetic coil for driving said output shaft by an electromagnetic force to control the opening and closing of said vacuum valve;

wherein said extension rod extends outwardly through an extension opening formed in a wall of said gas-filled vessel;

a bellows is provided between an outer circumferential portion of said extension rod and a circumferential portion of said extension opening of said gas-filled vessel for sealing therebetween without impeding the forward and backward movement of said extension rod;

said bellows comprises:

an expandable portion of a substantially accordion cylinder;

an inner flange portion inwardly extending from one end portion of said expandable portion and sealingly secured to said extension rod at its inner-most portion;

an outer flange portion outwardly extending from the other end portion of said expandable portion;

said outer flange portion is secured by being sandwiched between a wall of said gas-filled vessel and a holder plate fastened to said wall; and

wherein a length adjustment mechanism is provided between said extension rod and said output shaft.

2. The gas-insulated switching apparatus as claimed in claim 1, wherein said vacuum valve comprises a plurality of vacuum valves each provided with one of said electromagnetic operating mechanism.

3. The gas-insulated switching apparatus as claimed in claim 2, wherein said movable electrode and said output shaft have axes that are on the common line.

4. The gas-insulated switching apparatus as claimed in claim 1, wherein said electromagnetic operating mechanism comprises a first electromagnetic coil for urging said movable electrode of said vacuum valve toward a closed position via said output shaft and a second electromagnetic coil for urging said movable electrode toward an open position.

5. The gas-insulated switching apparatus as claimed in claim 4, wherein said electromagnetic operating mechanism further comprises a permanent magnet holder for holding said movable electrode of said vacuum valve by the action on said output shaft in two positions of the closed and open positions.

6. The gas-insulated switching apparatus as claimed in claim 5, wherein said permanent magnet holder comprises:

a movable member secured to said output shaft,

a permanent magnet surrounding said movable member;

a first yoke disposed to be close to said movable member when said movable member moves to said closed position to define a magnetic path together with said permanent magnet and hold said movable member in said closed position; and

a second yoke disposed to be close to said movable member when said movable member moves to said open position to define a magnetic path together with said permanent magnet and hold said movable member in said open position.