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Daimon et al.

[11] **3,857,006**

[45] **Dec. 24, 1974**

[54] **GAS INSULATED SWITCHING APPARATUS**

[75] Inventors: **Goro Daimon; Seizo Nakano; Tuneo Kishi,** all of Hitachi, Japan

[73] Assignee: **Hitachi, Ltd.,** Tokyo, Japan

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[21] Appl. No.: **411,055**

[52] **U.S. Cl.**..... **200/148 F,** 200/145 R, 200/148 R

[51] **Int. Cl.** **H01h 33/80**

[58] **Field of Search** ..... 200/148 F, 148 D, 148 R, 200/145 R

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Primary Examiner—Robert S. Macon

Attorney, Agent, or Firm—Craig & Antonelli

[57] **ABSTRACT**

A gas insulated switching apparatus having a simple construction and small size in which a circuit breaker unit is disposed within a closed vessel filled with an insulating gas so as to be movable over a predetermined distance within the closed vessel and is provided with an input side terminal conductor and an output side terminal conductor. In the apparatus, stationary contacts of disconnecting switch means and stationary earthing contacts of earthing switch means are disposed respectively at the extreme positions of the opposite ends of the terminal conductors which move with the circuit breaker unit.

10 Claims, 10 Drawing Figures

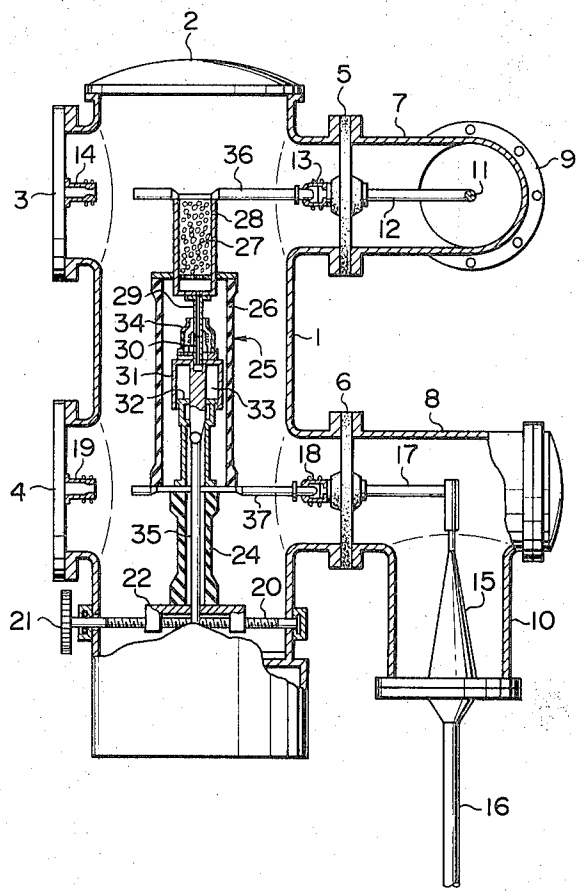


FIG. 1

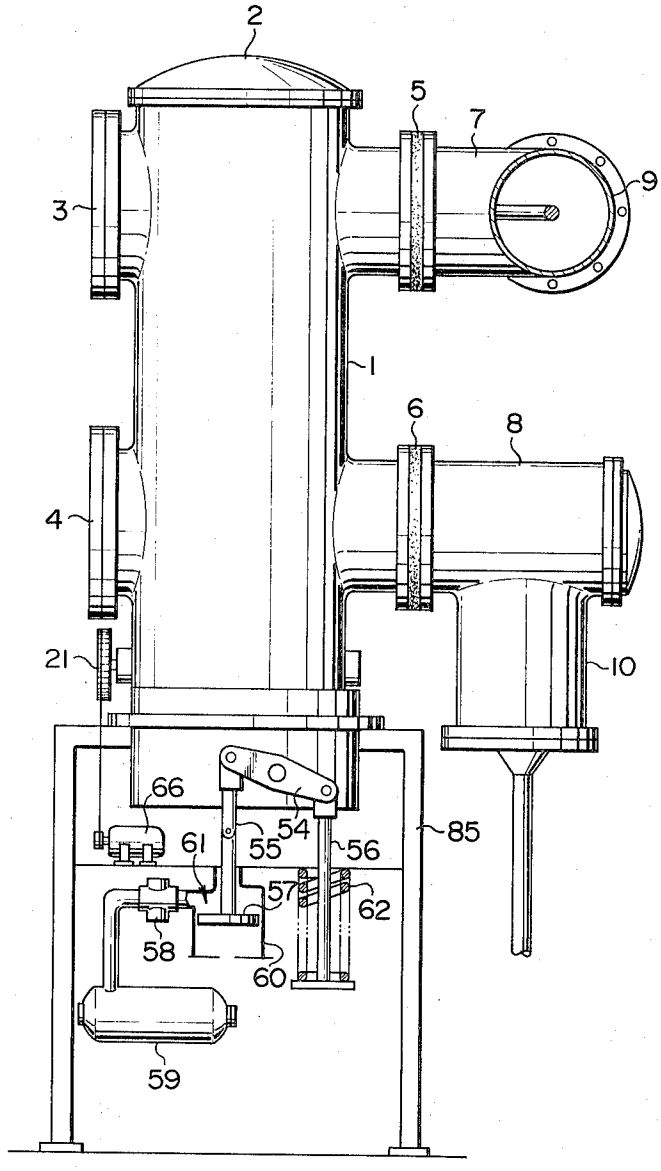


FIG. 2

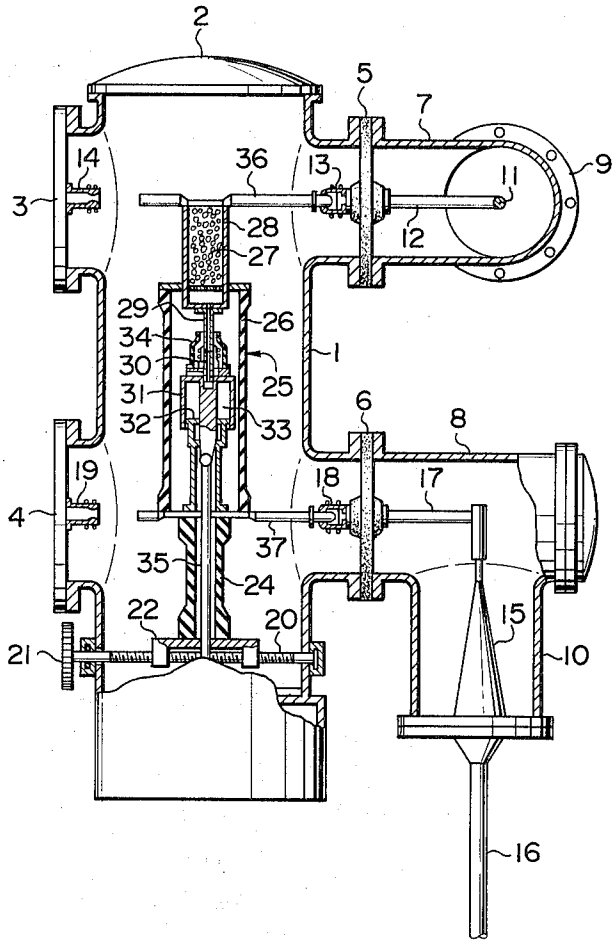

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FIG. 3

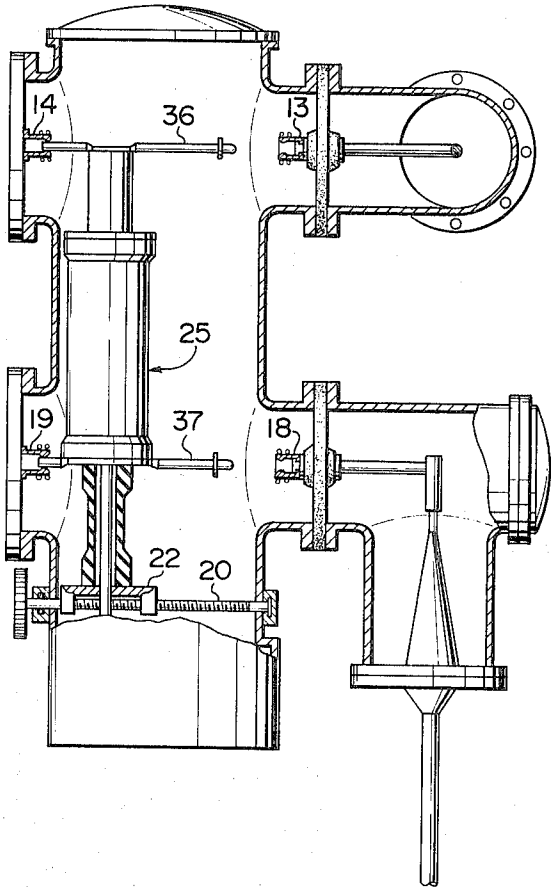


FIG. 4

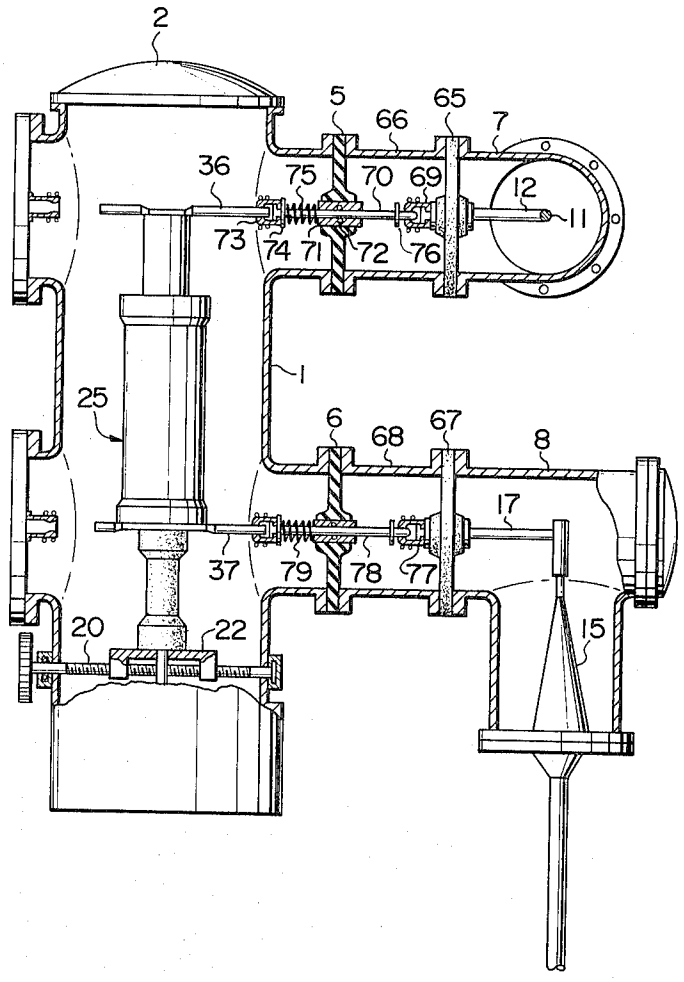

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FIG. 5

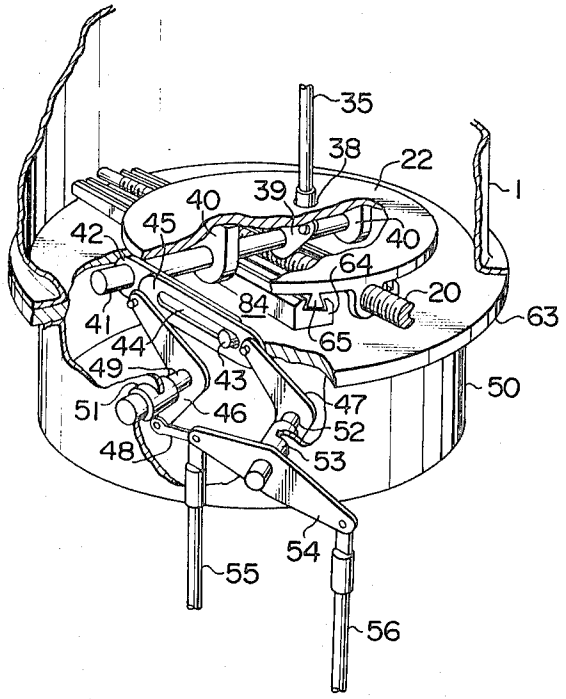

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FIG. 6

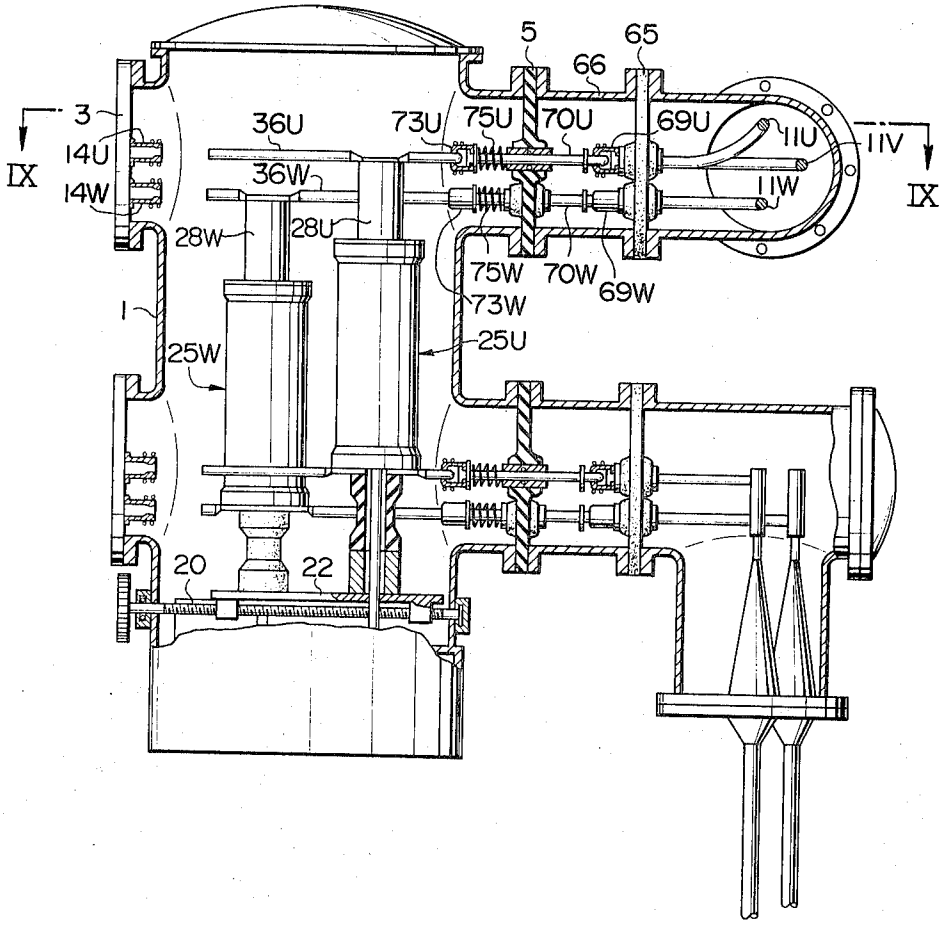

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36U
73U
75U
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69U
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11V
IX
14U
14W
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IX
28W
28U
75W
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69W
73W
1
25U
25W
20
22

FIG. 7

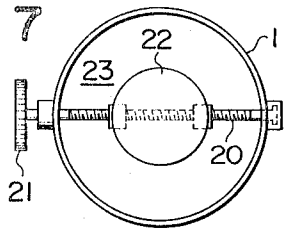


FIG. 8

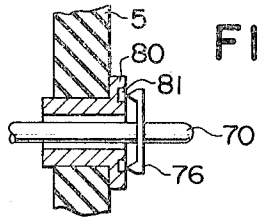


FIG. 9

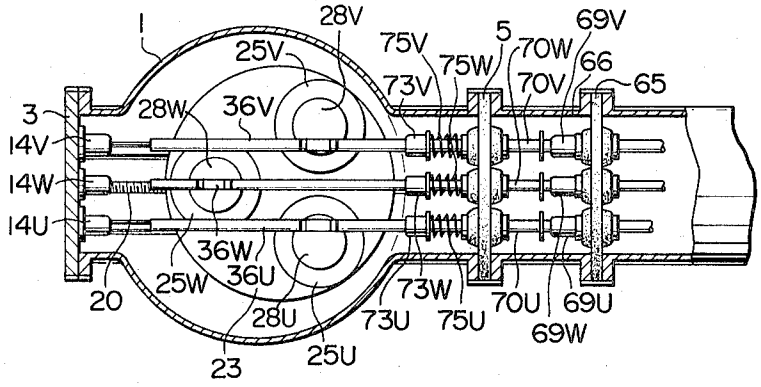
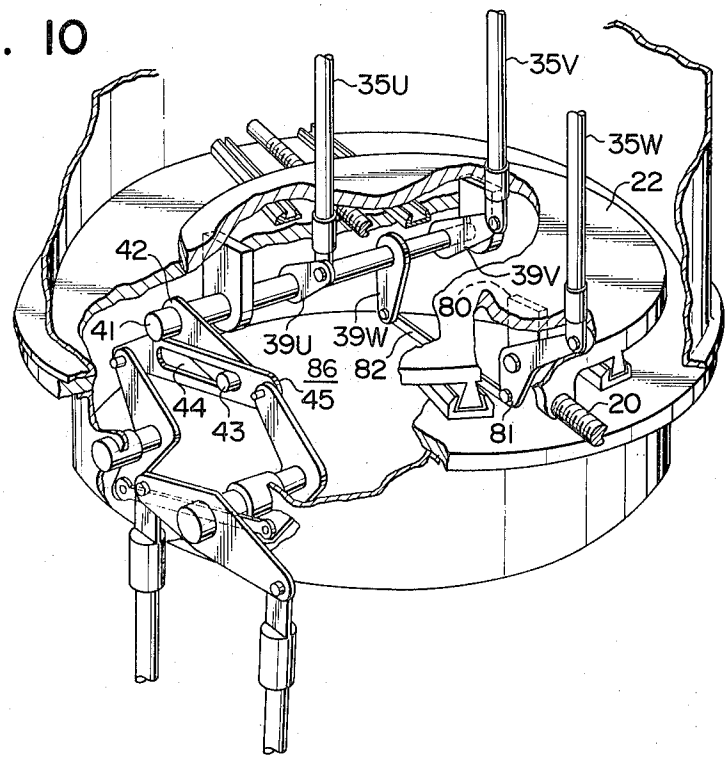


FIG. 10



GAS INSULATED SWITCHING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to gas insulated switching apparatus used in substations and more particularly to improvements in the structure and arrangement of the components of the gas insulated switching apparatus.

With the increase in the transmission voltage and capacity as a result of the abrupt increase in power requirements, switching apparatus in substations tend to become larger in size. In modern substations, gas insulated switching apparatus in which various electrical appliances are housed within a closed vessel, for example, an earthed metallic vessel and an electrical insulating gas at a pressure of several atmospheres is enclosed within the closed vessel for ensuring sufficient electrical insulation between these electrical appliances, are employed from the viewpoints of reductions in the installation area, ease of maintenance, prevention of undesirable damage due to air containing salt, etc.

Generally, a gas insulated switching apparatus of the kind above described comprises a circuit breaker disposed in a main circuit connected to a transmission line and disconnecting switch means disposed on opposite sides of the circuit breaker, and the circuit breaker is urged to the open position for breaking the electrical path in the event of trouble. In the case of inspection of the circuit breaker, the disconnecting switch means are opened to isolate the circuit breaker from the electrical path and the conductor in the circuit breaker is earthed by earthing switch means.

The disconnecting switch means and earthing switch means are separately actuated by individual actuators provided therefor and an interlocking mechanism is associated with these actuators so as to satisfy the condition that the earthing switch means is closed after opening of the disconnecting switch means and the disconnecting switch means are closed after opening of the earthing switch means.

Due to the fact that the disconnecting switch means employed in the gas insulated switching apparatus are commonly of the linear make-break type in which movable contacts are moved along the axial direction for making and breaking the electrical path, the movable contacts are provided with sliding electrical connections. Because of the provision of such sliding electrical connections, the position of the actuators for the disconnecting switch means are limited to the neighborhood of the disconnecting switch means and it is also difficult to provide a common actuator for both these connecting switch means. Thus, the prior art gas insulated switching apparatus has been complex in overall construction and expensive.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a gas insulated switching apparatus in which a simplified actuator is provided for actuating the disconnecting switch means and which is small in overall size.

Another object of the present invention is to provide a gas insulated switching apparatus which is simple in construction and inexpensive by virtue of the fact that individual exclusive actuators for the disconnecting switch means and earthing switch means are unnecessary.

Still another object of the present invention is to provide a gas insulated switching apparatus in which the circuit breaker unit can be easily taken out for inspection from a closed vessel containing the circuit breaker unit therein.

Yet another object of the present invention is to prevent an undesirable reduction of the intercontact dielectric strength in the disconnecting switch means even when the circuit breaker unit is taken out of the closed vessel.

A further object of the present invention is to facilitate mounting and detachment of the earthing switch means and to simplify the structure of the earthing switch means.

A still further object of the present invention is to provide an effective arrangement in a gas insulated switching apparatus of the three-phase en-bloc type in which individual electrical appliances for a three-phase a.c. system are arranged compact within a common closed vessel.

A yet further object of the present invention is to provide a circuit breaker actuator which is most switable for use in a gas insulated switching apparatus of this kind.

The present invention provides a gas insulated switching apparatus which is featured by provision of a circuit breaker unit disposed within a closed vessel filled with an electrical insulating gas, the circuit breaker unit being capable of reciprocating movement within the closed vessel and provided with an input side terminal conductor and an output side terminal conductor, and disconnecting switch means adapted to be urged to one of the closed and open positions depending on the movement of the terminal conductors which move with the circuit breaker unit.

Therefore, the disconnecting switch means disposed on opposite sides of the circuit breaker unit can be opened and closed by a single driving unit provided for driving the circuit breaker unit so that the structure and cost of the gas insulated switching apparatus can be simplified and reduced. Further, due to the fact that the position of the driving unit is not restricted by the position of the disconnecting switch means, the driving unit can be located at the most switable position for maintenance and inspection.

The above and other objects, features and advantages of the present invention will be apparent from the following detailed description of preferred embodiments thereof taken in conjunction with the accompanying drawing. However, it is to be understood that the embodiments are described for illustrative purposes only and the present invention is in no way limited to such specific embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an external view of an embodiment of the apparatus according to the present invention in its operating state.

FIG. 2 is a longitudinal sectional view of parts of the apparatus shown in FIG. 1.

FIG. 3 is a view similar to FIG. 2 but showing the state in which the circuit breaker unit is disconnected from the circuit.

FIG. 4 is a longitudinal sectional view of parts of another embodiment of the present invention in its operating state.

FIG. 5 is a partly cut-away perspective view of the circuit breaker actuator shown in FIG. 4.

FIG. 6 is a longitudinal sectional view of parts of a further embodiment of the present invention in its operating state.

FIG. 7 is a plan view of the drive means shown in FIG. 2.

FIG. 8 is a partial sectional view showing a partial modification of the arrangement shown in FIG. 4.

FIG. 9 is a sectional view taken on the line IX—IX in FIG. 6.

FIG. 10 is a partly cut-away perspective view of the circuit breaker actuator shown in FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows a switching apparatus associated with one phase in a three-phase a.c. system. Referring to FIG. 1, a closed vessel 1 of metal material having an earth potential is fixedly supported on a supporting frame 85 disposed on the foundation, and an electrical insulating gas is filled within this closed vessel 1. In a most preferred form, the closed vessel 1 is substantially cylindrical in shape and a gas-tight end cover 2 is detachably fixed to an opening formed at the axially upper end of the closed vessel 1. A pair of gas-tight end covers 3 and 4 are detachably fixed to a pair of openings bored in one side wall portion of the closed vessel 1 respectively. These openings are spaced apart from each other by a distance which is determined by the axial length of a circuit breaker unit housed within the closed vessel 1 as will be described later. Another pair of openings are bored in another side wall portion of the closed vessel 1 in axially aligned relation with the first pair of openings, and an input conduit 7 and an output conduit 8 are connected gas-tight to these openings with electrical insulating members 5 and 6 such as electrical insulating spacers interposed therebetween respectively. The input conduit 7 is formed integral with a bus conduit 9, and the output conduit 8 is formed integral with a cable conduit 10. An electrical insulating gas similar to that filled within the closed vessel 1 is filled within the input conduit 7, output conduit 8, bus conduit 9 and cable conduit 10, and the insulating members 5 and 6 serve to isolate the gas space in the closed vessel 1 from the gas spaces in the conduits 7, 8, 9 and 10.

Switch means are disposed within the closed vessel 1 as shown in FIG. 2. A branch conductor 12 branched from a bus 11 in the bus conduit 9 extends through and is supported by the insulating member 5 and is provided with a stationary contact 13 at the left-hand side of the insulating member 5 so as to provide an input side electrical path. On the diameter of the closed vessel 1 passing through the stationary contact 13 there is a stationary earthing contact 14 which is fixed to the inner wall surface of the end cover 3. One end of a cable head 15 in the cable conduit 10 extends outwardly as an insulated cable 16, while a branch conductor 17 connected to the other end of the cable head 15 extends through and is supported by the insulating member 6 and is provided with a stationary contact 18 at the left-hand side of the insulating member 6 so as to provide an output side electrical path. On the diameter of the closed vessel 1 passing through the stationary contact 18 there is a stationary earthing contact 19 which is fixed to the inner wall surface of the end cover 4. The stationary contacts 13, 18 and the stationary earthing contacts 14, 19 are arranged in the same direction as shown.

A threaded rod 20 is disposed along the above-mentioned diametral direction in a lower portion of the closed vessel 1 and one end of the threaded rod 20 carrying a sprocket 21 thereon extends outwardly in gas-tight relation through the side wall of the closed vessel 1 so that the threaded rod 20 can be rotated by the rotation of the sprocket 21. A movable supporting block 22 is in threaded engagement with the threaded rod 20 as will be described in detail later so that it can be advanced and retracted along the axis of the threaded rod 20 as the threaded rod 20 is rotated. As shown in FIG. 7, the movable supporting block 22 is normally situated at the central portion of the closed vessel 1 and cooperates with the threaded rod 20 to constitute a drive means having a screw type propelling means 23 so that the supporting block 22 can be moved to a position adjacent to the inner wall of the closed vessel 1. This drive means serves as an actuator for disconnecting switch means as will be apparent from the later description.

A circuit breaker unit 25 is mounted on the movable supporting block 22 through a cylindrical supporting member 24 of electrical insulator. The circuit breaker unit 25 comprises a cylindrical member 26 of electrical insulator and a container 28 containing an absorbent 27 therein, and the internal space of the cylindrical member 26 communicates with the interior of the closed vessel 1 through the adsorbent 27 in the container 28. The breaker portion in the cylindrical member 26 is shown as a puffer type by way of example and a puffer cylinder 31 is connected to a movable contact 30 disposed opposite to a stationary contact 29 connected to the container 28. A piston 32 which is normally maintained in a fixed position is slidably disposed within the puffer cylinder 31 and a puffer chamber 33 is defined between the puffer cylinder 31 and the piston 32. Therefore, with the parting movement of the movable contact 30 away from the stationary contact 29, the insulating gas within the puffer chamber 33 is compressed by the puffer cylinder 31 and this compressed insulating gas is forced through a nozzle member 34 of electrical insulator defining a gas passage thereby effectively extinguishing the arc jumping across the contacts. The cylindrical member 26 and container 28 are not essentially required, and the stationary contact 29 and the movable contact 30 may be mechanically connected by any suitable means. The movable contact 30 and puffer cylinder 31 are mechanically connected by an actuating rod 35 of electrical insulator extending through the movable supporting block 22 to circuit breaker actuating means which will be described in detail later. An input side terminal conductor 36 is connected to one of the axially opposite ends of the circuit breaker unit 25 for electrical connection to the stationary contact 29, while an output side terminal conductor 37 is connected to the other axial end of the circuit breaker unit 25 for electrical connection to the movable contact 30. These terminal conductors 36 and 37 are arranged on the respective lines connecting the stationary contacts 13 and 18 with the stationary earthing contacts 14 and 19. In the state in which the stationary contacts 13 and 18 are in contact with the respective terminal conductors 36 and 37, a distance required for ensuring electrical isolation is maintained between the

stationary earthing contacts 14, 19 and the terminal conductors 36, 37.

In this embodiment, the stationary contact 13 and input side terminal conductor 36 constitute an input side disconnecting switch means, the stationary contact 18 and output side terminal conductor 37 constitute an output side disconnecting switch means, and the stationary earthing contacts 14, 19 and terminal conductors 36, 37 constitute an earthing switch means. Thus, the terminal conductors 36 and 37 serve also as common movable contacts of the disconnecting switch means and earthing switch means.

In the operating state shown in FIG. 2, the disconnecting switch means and circuit breaker unit are in the closed position, while the earthing switch means is in the open position, and an electrical path is formed which is traced from the bus 11 — branch conductor 12 — stationary contact 13 — input side terminal conductor 36 — container 28 — stationary contact 29 — movable contact 30 — puffer cylinder 31 — piston 32 — output side terminal conductor 37 — stationary contact 18 — branch conductor 17 — cable head 15 to the insulated cable 16.

The drive means and circuit breaker actuating means will be described with reference to FIG. 5. Referring to FIG. 5, the actuating rod 35 of electrical insulator extends downward through an opening 38 of the movable supporting block 22 to be connected at the lower end thereof to a lever 39 which is fixed to a crankshaft 41 rotatably supported by a pair of supporting pieces 40 fixed to the lower surface of the movable supporting block 22. A link 42 is secured at one end thereof to the crankshaft 41 and a pin 43 at the other end of the link 42 is received in an elongated slot 44 of a horizontal link 45 extending along the moving direction of the movable supporting block 22 so that the link 42 and horizontal link 45 are mechanically connected to each other to constitute a link means 86. Even when the movable supporting block 22 is moved along the axis of the threaded rod 20 by the operation of the screw type propelling means 23, the pin 43 moves merely in the elongated slot 44 of the horizontal link 45 and the mechanical connection between the links 42 and 45 is maintained. A pair of L-shaped levers 46 and 47 are pivoted at one end thereof to opposite ends respectively of the horizontal link 45 and are mechanically connected to each other by a connecting lever 48 at the other end thereof. The central axis 49 of the L-shaped lever 46 is rotatably suported in a rotary sealing means 51 fixed to a cashing 50 disposed beneath the closed vessel 1. Similarly, the central axis 52 of the L-shaped lever 47 is rotatably supported in another rotary sealing means 53. The central axis 52 of the L-shaped lever 47 extending outwardly from the casing 50 is secured to the center of a rocking lever 54, and a pair of driving rods 55 and 56 are pivoted to opposite ends respectively of the rocking lever 54. Referring to FIG. 1 again, a piston 57 is connected to the driving rod 55, and air under high pressure contained in a tank 59 is charged into a charging chamber 61 defined by the piston 57 and a cylinder 60 when a three-way valve 58 is actuated so that the driving rod 55 acts to cause counter-clockwise rocking movement of the rocking lever 54. On the other hand, the driving rod 56 is connected to a spring 62 which acts to normally maintain the circuit breaker unit in the closed position. The parts above described constitute the circuit breaker actuating means.

The movable supporting block 22 in the drive means described with reference to FIG. 7 is provided with a rail engaging projection 65 which engages with and moves along a rail 64 fixed as by welding to a supporting plate 63 interposed between the casing 50 and the closed vessel 1 as shown in FIG. 5. Therefore, the movable supporting block 22 is urged in either direction along the rail 64 with the rotation of the threaded rod 20 imparting driving force to the movable supporting block 22. This threaded rod 20 is rotated by a reversible motor 66 through the sprocket 21 as shown in FIG. 1, but it may be manually rotated. The rotation of this threaded rod 20 is controlled by a known inter-locking mechanism not shown so that the threaded rod 20 may not be rotated until the circuit breaker unit 25 is urged to the open position by the circuit breaker actuating means.

The circuit breaker unit 25 is disconnected from the electrical path in a manner as described below. At first, a circuit breaking instruction signal is applied to actuate the three-way valve 58 shown in FIG. 1. Air under high pressure is charged into the charging chamber 61 in response to the actuation of the three-way valve 58 and the rocking lever 54 is urged to swing counter-clockwise against the force of the spring 62. As a result of the counter-clockwise swinging movement of the rocking lever 54 causing rotation of the central axis 52 of the L-shaped lever 47 shown in FIG. 5, the L-shaped lever 47 is urged to swing counter-clockwise to cause counter-clockwise swinging movement of the L-shaped lever 46 which is mechanically connected to the L-shaped lever 47 by the connecting lever 48. The rotating force of these two L-shaped levers 46 and 47 is imparted to the pin 43 through the horizontal link 45 to cause clockwise swinging movement of the link 42 and clockwise rotation of the crankshaft 41. Therefore, the lever 39 is also swung clockwise to urge the movable contact 30 and puffer cylinder 31 downward in FIG. 2 through the actuating rod 35. The arc produced due to the parting of the movable contact 30 from the stationary contact 29 is extinguished by the compressed insulating gas jetted out of the puffer chamber 33 and the circuit breaker unit 25 is placed in the open position. As a result, the interlocking mechanism (not shown) is released to permit the operation of the disconnecting switch actuating means or drive means.

The motor 66 is operated to cause rotation of the sprocket 21 and propelling force is imparted to the movable supporting block 22 to urge same toward the left in FIG. 2. Since the circuit breaker unit 25 is fixedly mounted on the movable supporting block 22, the terminal conductors 36 and 37 are moved away from the respective stationary contacts 13 and 18 with the movement of the movable supporting block 22 until finally the terminal conductors 36 and 37 are spaced from the respective stationary contacts 13 and 18 by a distance which is required for maintaining electrical isolation between these elements as shown in FIG. 3. In other words, when the disconnecting switch means are placed in the open position, the terminal conductors 36 and 37 are brought into contact with the respective stationary earthing contacts 14 and 19 to place the earthing switch means in the closed position. Therefore, the conductors providing the electrical path in the circuit

breaker unit **25** are connected to earth and the circuit breaker unit **25** can be safely inspected.

The operating state can be restored by rotating the threaded rod **20** in a direction opposite to that above described thereby opening the earthing switch means and then closing the disconnecting switch means. Subsequently, the interlocking mechanism for the drive means and circuit breaker actuating means is released and the three-way valve **58** is restored to the original position thereby discharging air under high pressure from the charging chamber **61.** As a result, the spring **62** imparts the force to the rod **56** thereby causing rotation of the crankshaft **41** in a direction opposite to that above described.

Disconnecting switch means of the kind in which movement of a circuit breaker unit is utilized for disconnectably connecting two terminal conductors of the circuit breaker unit with an input side electrical path and an output side electrical path, are known as a drawer type circuit breaker in a metal-clad type switchgear. However, in spite of the fact that this drawer type circuit breaker is used in a system of relatively low voltage, drive means therefor is extremely large in size since this drawer type circuit breaker constitutes a unit which is provided with a circuit disconnecting function. When this concept is applied to a gas insulated switching apparatus of the kind to which the present invention is applied, the arrangement may be such that the circuit breaker unit **25** may be fixed within the closed vessel **1,** the supporting frame **85** may be provided with running means such as wheels and the insulating members **5** and **6** may be separably fixed to the closed vessel **1** so that the circuit breaker unit **25** can be moved together with the closed vessel **1** for breaking the electrical connections between the terminal conductors **36, 37** and the stationary contacts **13, 18.** After all, this arrangement resorts still to the concept of the metal-clad type switchgear resulting in a large size of drive means.

However, the disconnecting switch means in the embodiment of the present invention are most suitable for use in gas insulated switching apparatus in that the circuit breaker unit **25** in the closed vessel **1** is solely moved within the closed vessel **1** to open and close the disconnecting switch means.

Instead of causing linear movement of the circuit breaker unit **25** as described in the embodiment of the present invention, the circuit breaker unit **25** may, for example, be adapted to rotate around its vertical axis. Employment of drive means for causing such rotating movement of the circuit breaker unit **25** is preferable in that alignment of the stationary earthing contact **14,** input side terminal conductor **36** and stationary contact **13** as well as alignment of the stationary earthing contact **19,** output side terminal conductor **37** and stationary contact **18** is unnecessary, and the stationary contacts **13, 18** and stationary earthing contacts **14, 19** for contact with the respective terminal conductors **36, 37** may be disposed at the opposite extreme ends of the rotary movement of the circuit breaker unit **25.** However, in view of the increase in the current capacity, the stationary contacts **13** and **18** are preferably in the form of a tulip, and in this respect, the illustrated arrangement of the embodiment is advantageous over the modified arrangement.

According to the present invention, the input side disconnecting switch means and output side disconnecting switch means can be simultaneously opened and closed with the movement of the circuit breaker unit **25.** Thus, the gas insulated switching apparatus is inexpensive and simple in construction due to the fact that exclusive drive means is not required for each of these two disconnecting switch means unlike prior art apparatus of this kind. Further, due to the fact that only one drive means is required for driving the two disconnecting switch means, this drive means can be disposed in the best position for maintenance and inspection. Furthermore, due to the fact that movement of the circuit breaker unit **25** within the closed vessel **1** can simply carry out opening and closing of the disconnecting switch means, slidable electrical connections which have been essentially required in view of the structure of prior art disconnecting switch drive means are utterly unnecessary.

In the present invention, the stationary earthing contacts **14** and **19** are provided so that they can engage the respective terminal conductors **36** and **37** when the disconnecting switch means are urged to the open position by the circuit breaker unit **25.** Thus, the gas insulated switching apparatus is inexpensive because the drive means for the disconnecting switch means serves also as an actuating means for the earthing switch means. Further, the disconnecting switch means and earthing switch means are arranged so as to satisfy the conditions in which the disconnecting switch means are opened prior to closing of the earthing switch means and the earthing switch means are opened prior to closing of the disconnecting switch means. Thus, any especial interlocking mechanism is not required for these switch means.

Furthermore, by virtue of the arrangement in which the stationary earthing contacts **14** and **19** in the earthing switch means are mounted to the inner wall surface of the respective detachable end covers **3** and **4** for the closed vessel **1,** these contacts **14** and **19** can be very easily mounted in position and detached from position without being adversely affected by other elements.

Generally, a circuit breaker unit must be so constructed that it can be actuated for inspection or testing even in a position disconnected from the electrical path. To this end, the apparatus according to the present invention is provided with the link means **86** in the actuating force transmission path for maintaining the mechanical connection between the links **42** and **45** even in the opposite extreme positions of the movable circuit breaker unit **25.** More precisely, the elongated slot **44** is formed in the horizontal link **45** in the moving direction of the movable supporting block **22** and the pin **43** of the link **42** is situated at substantially the opposite ends of the elongated slot **44** in the opposite extreme positions of the movable supporting block **22** so that the circuit breaker unit **25** can be actuated for inspection or testing irrespective of the position thereof.

In the switching apparatus, the circuit breaking portions, especially the stationary and movable contacts must be inspected periodically or when large current such as short-circuit current is cut off by the circuit breaker unit. Since the circuit breaker unit is housed within the closed vessel in the gas insulated switching apparatus, the internal space of the closed vessel is too narrow to carry out inspection of the circuit breaking portions and the circuit breaker unit is generally taken out of the closed vessel for inspection. Anyway, the in-

sulating gas contained within the closed vessel must be replaced with air for the purpose of inspection of the circuit breaking portions. In the embodiment of the present invention above described, the contact parting distance in the disconnecting switch means must be sufficiently large and air must also participate in maintaining the electrical isolation between the contacts.

A modification or improvement of the first embodiment of the present invention is shown in FIG. 4. Referring to FIG. 4, an electrical insulating member 65 such as an electrical insulating spacer is disposed on the left-hand end surface of the input conduit 7 shown in FIG. 2, and a cylindrical member 66 for containing therein an input side disconnecting switch means is disposed between this insulating member 65 and the insulating member 5, the cylindrical member 66 being connected gas-tight to the closed vessel 1 and input conduit 7 at opposite ends thereof. Similarly, an electrical insulating member 67 is disposed on the right-hand end surface of the output conduit 8, and another cylindrical member 68 for containing an output side disconnecting switch means is disposed between this insulating member 67 and the insulating member 6, the cylindrical member 68 being connected gas-tight to the closed vessel 1 and output conduit 8 at opposite ends thereof. The branch conductor 12 branched from the bus 11 extends through the insulating member 65 and is provided with a stationary contact 69 on the left-hand side of the insulating member 65. A movable contact 70 is disposed opposite to this stationary contact 69 and is normally in contact with the latter. The movable contact 70 is slidably received at its intermediate portion in a tubular fitting 71 molded in the axial central portion of the insulating member 5 and is sealed gas-tight by a sealing member 72, and a contact 73 is supported on the left-hand end thereof by a supporting member 74 on the left-hand side of the insulating member 5. The branch conductor 12 and contacts 69, 70 and 73 constitute an input electrical path. A compression spring 75 is interposed between the contact supporting member 74 and the tubular fitting 71 so as to normally bias the movable contact 70 away from the stationary contact 69. The parting between these contacts 69 and 70 by the force of the compression spring 75 is prevented by the input side terminal conductor 36 which engages with the contact 73 when the circuit breaker unit 25 is in the operating position so that the movable contact 70 is normally maintained in contact with the stationary contact 69. The final position of the movable contact 70 is limited by a stopper 76. Thus, the input side disconnecting switch means composed of the stationary contact 69 and movable contact 70 is confined within the closed space defined by the cylindrical member 66 and insulating members 5 and 65, and the movable contact 70 is urged away from the stationary contact 69 by the force of the compression spring 75 with the movement of the circuit breaker unit 25 to the left from the position shown in FIG. 4.

The output side disconnecting switch means is also confined within the closed space defined by the cylindrical member 68 and insulating members 6 and 67 and has the same construction as the input side disconnecting switch means. Briefly speaking, a stationary contact 77 is provided on the branch conductor 17 connected to the cable head 15 in the output electrical path and cooperates with a movable contact 78 to constitute the output side disconnecting switch means, and the movable contact 78 is urged away from the stationary contact 77 by the force of a compression spring 79 with the movement of the circuit breaker unit 25 to the left from the position shown in FIG. 4. Other elements in the modification shown in FIG. 4 are the same as those described in the first embodiment and any detailed description is unnecessary.

In the operating state shown in FIG. 4, an electrical path is established which is traced from the bus 11 — branch conductor 12 — stationary contact 69 — movable contact 70 — contact 73 — input side terminal conductor 36 — conductor in circuit breaker unit 25 — output side terminal conductor 37 — movable contact 78 — stationary contact 77 — branch conductor 17 to the cable head 15.

The circuit breaker unit 25 can be disconnected from the electrical path by placing the circuit breaking portions in the open position and then causing rotation of the threaded rod 20 to cause leftward movement of the movable supporting block 22 by the propelling force of the propelling means 23 as in the first embodiment. Due to this movement of the circuit breaker unit 25, restriction exerted on the compression springs 75 and 79 is gradually released and the movable contacts 70 and 78 are urged leftward by the force of these compression springs 75 and 79. In the final position of the movable supporting block 22, the contact parting distance required for electrical isolation is established between the movable contacts 70, 78 and the stationary contacts 69, 77 and the terminal conductors 36 and 37 are brought into contact with the respective stationary contacts 14 and 19. It will be understood that the arrangement shown in FIG. 4 satisfies the conditions required for the disconnecting switch means and earthing switch means.

Even when the insulating gas within the closed vessel 1 is replaced by air for the purpose of inspection of the circuit breaker unit 25, the closed spaces containing the input side disconnecting switch means and output side disconnecting switch means can be maintained gas-tight and the contact parting distance of these switch means can be selected to be the minimum which is determined by the properties of the insulating gas.

In order to meet the demand of this kind, the terminal conductors 36 and 37 may be mechanically connected to the respective movable contacts 70 and 78. In such a case, however, it is unable to employ the common inspection procedure in hich the end cover 2 is removed and the circuit breaker unit 25 is taken out of the closed vessel 1 for inspection. Thus, it is necessary that the terminal conductors 36 and 37 include a connecting portion which can be mechanically released within the range of the diameter of the upper end opening closed by the end cover 2. The connecting means or contact 73 connecting the contact 70 with the input side terminal conductor 36 serves as such connection. The electrical connecting means or contact 73 is sufficiently suitable for this purpose due to the fact that the connection is attained by the compression springs 75 and 79 which urge normally the movable contacts 70 and 78 in the contact parting direction.

In the embodiment shown in FIG. 4, the sealing members 72 are used to maintain the closed spaces gas-tight in spite of the movement of the movable contacts 70 and 78 in the input side disconnecting switch means and output side disconnecting switch means. However,

as shown in FIG. 8, a packing 81 may be mounted in the right-hand end surface of a molded tubular member 80 fitted in the central axial opening of the insulating member 5 and a stopper 76 may be mounted on the movable contact 70 so that the stopper 76 can be pressed against the packing 81 when the movable contact 70 is parted from the stationary contact 69. This arrangement is advantageous in that the stopper 76 is forced to the left by the insulating gas in the closed space when the insulating gas in the closed vessel 1 is exhausted, and thus, the reliability of sealing means constituted by the stopper 76 and packing 81 can be improved.

In modern gas insulated switching apparatus, a three-phase en-bloc type is known in which all the required elements associated with the individual phases are contained in a single vessel from the viewpoints of reduction in the installation space and ease of maintenance and inspection. FIGS. 6 and 9 show an embodiment of the three-phase en-bloc type. In this embodiment, all the elements disposed in the electrical paths of the individual phases, U, V and W are the same as those shown in FIG. 4 so as to exhibit the advantages of the present invention. Since the output side electrical paths are the same as the input side electrical paths, no description will be given as to the output electrical paths.

In the three-phase en-bloc type, buses 11U, 11V and 11W for the individual phases are disposed at the vertexes of an isosceles triangle so as to prevent undesirable reductions of interphase dielectric strength at the branched portions. In order to ensure interphase insulation in circuit breaker units 25U, 25V and 25W too, input side terminal conductors 36U and 36V among three terminal conductors 36U, 36V and 36W are disposed in the same horizontal plane so that these three input side terminal conductors 36U, 36V and 36W are disposed at the vertexes of an isosceles triangle in which the straight line connecting between the input side terminal conductors 36U and 36V is the base. It is therfore possible to prevent undesirable reductions of dielectric strength due to, for example, conductive portions such as containers 28U, 28V and 28W in the respective circuit breaker units 25U, 25V and 25W.

The circuit breaker units 25U, 25V and 25W associated with the individual phases are fixedly supported on a common movable supporting block 22. As shown in FIG. 7, this movable supporting block 22 is in threaded engagement with a threaded rod 20 rotatably disposed in a closed vessel 1 and is moved along the axis of the threaded rod 20 by being thrusted by the rotating threaded rod 20.

In a closed space defined by a cylindrical member 66 and insulating members 5 and 65, there are disposed input side disconnecting switch means which are constituted respectively by stationary contacts 69U, 69V and 69W connected to the buses 11U, 11V and 11W and movable contacts 70U, 70V and 70W slidably extending through the insulating member 5 while maintaining gas-tight relation therebetween. The movable contacts 70U, 70V and 70W are normally urged away from the stationary contacts 69U, 69V and 69W by compression springs 75U, 75V and 75W respectively, and the movement of these movable contacts 70U, 70V and 70W in the contact parting direction by the force of the compression springs 75U, 75V and 75W is restricted by the input side terminal conductors 36U, 36V and 36W engaging with contacts 73U, 73V and 73W provided on the movable contacts 70U, 70V and 70W respectively.

Therefore, with the leftward movement of the movable supporting block 22 due to the thrust imparted by the rotating threaded rod 20, the movable contacts 70U, 70V and 70W are urged away from the stationary contacts 69U, 69V and 69W by the force of the compression springs 75U, 75V and 75W respectively until finally the movable contacts 70U, 70V and 70W are parted from the respective stationary contacts 69U, 69V and 69W by the contact parting distance required for maintaining electrical isolation. In the final position of the movable supporting block 22, the input side terminal conductors 36U, 36V and 36W are brought into contact with respective stationary earthing contacts 14U, 14V and 14W which are mounted on the inner wall surface of an end cover 3 closing gas-tight an opening bored in the side wall of the closed vessel 1. By virtue of such arrangement, various advantages of the embodiments shown in FIGS. 1 to 5 can also be exhibited in the embodiment shown in FIGS. 6 and 9.

FIG. 10 shows a circuit breaker actuating means for use in the three-phase en-bloc type and this actuating means is an improvement of the actuating means in the single-phase type shown in FIG. 5. In FIG. 10 which is a back view of FIG. 6, three levers 39U, 39V and 39W are fixed to a crankshaft 41 and actuating rods 35U and 35V of electrical insulator for actuating the circuit breaker units 25U and 25V are pivoted to the respective levers 39U and 39V. The lever 39W is connected by a connecting rod 82 to one end of an L-shaped lever 81 supported rotatably by a supporting piece 80 fixed to the lower surface of the movable supporting block 22, and an actuating rod 35W of electrical insulator for actuating the circuit breaker unit 25W is connected to the other end of the L-shaped lever 81.

Therefore, with the rotation of the crankshaft 41, the actuating rods 35U, 35V and 35W are urged in their axial direction so that the circuit breaking portions for the individual phases can be simultaneously actuated. By virtue of the fact that the circuit breaker actuating means of simple construction can actuate the circuit breaker units associated with the individual phases, the overall size of the gas insulated switching apparatus of the three-phase en-bloc type can be reduced.

In a link means 86 consisting of a horizontal link 45 having an elongated slot 44 and a link 42 having a pin 43 engaging with the elongated slot 44 of the horizontal link 45, the mechanical connection between these links 42 and 45 can be maintained at the opposite extreme positions of the movable supporting block 22 which is urged to such positions by the rotation of the threaded rod 20. Thus, the circuit breaker units 25U, 25V and 25W can be actuated for inspection or testing when the disconnecting switch means are in the open position.

We claim:

1. A gas insulated switching apparatus comprising a closed vessel filled with an electrical insulating gas, a circuit breaker unit disposed within said closed vessel and provided with an input side terminal conductor and an output side terminal conductor, drive means for causing reciprocating movement of said circuit breaker unit within said closed vessel, actuating means for actuating said circuit breaker unit for making and breaking the circuit, and disconnecting switch means connected to an input side electrical path and an output side electrical path respectively and adapted to be urged to one

of the closed and open positions depending on the movement of said terminal conductors due to the movement of said circuit breaker unit.

2. A gas insulated switching apparatus comprising a closed vessel filled with an electrical insulating gas, a circuit breaker unit disposed within said closed vessel and provided with an input side terminal conductor and an output side terminal conductor extending in the same direction in parallel with each other, drive means for causing linear reciprocating movement of said circuit breaker unit, actuating means for actuating said circuit breaker unit for making and breaking the circuit, and disconnecting switch means connected to an input side electrical path and an output side electrical path respectively and adapted to be urged to one of the closed and open positions depending on the movement of said terminal conductors due to the movement of said circuit breaker unit.

3. A gas insulated switching apparatus as claimed in claim 1, wherein said closed vessel is substantially cylindrical in shape and has an axial end opening closed gas-tight by a detachable end cover, and connecting means are provided so as to electrically and mechanically release said terminal conductors within the range of the diametral size of said opening.

4. A gas insulated switching apparatus as claimed in claim 1, wherein a pair of stationary earthing contacts are provided in said closed vessel so that said terminal conductors can be brought into contact with the respective stationary earthing contacts when said disconnecting switch means are urged to the open position due to the movement of said circuit breaker unit.

5. A gas insulated switching apparatus as claimed in claim 1, wherein a pair of stationary earthing contacts are disposed so that said terminal conductors can be brought into contact with the respective stationary earthing contacts when said disconnecting switch means are urged to the open position due to the movement of said circuit breaker unit, and said stationary earthing contacts are mounted on the inner wall surface of a detachable end cover closing gas-tight an opening bored in the side wall of said closed vessel.

6. A gas insulated switching apparatus as claimed in claim 2, wherein a link means consisting of a plurality of links is disposed in the transmission path of the actuating force of said actuating means and the mechanical connection between said links can be maintained within the range in which said circuit breaker unit is moved by said drive means.

7. A gas insulated switching apparatus as claimed in claim 2, wherein said drive means comprises a movable supporting block fixedly supporting said circuit breaker unit thereon, a threaded rod in threaded engagement with said movable supporting block for linearly driving said circuit breaker unit over a predetermined distance within said closed vessel, and a rail for guiding said movable supporting block in a predetermined direction along the axis of said threaded rod.

8. A gas insulated switching apparatus as claimed in claim 2, wherein each said disconnecting switch means comprises a pair of electrical insulating members defining an insulating gas space surrounding the disconnecting portion, a movable contact extending through one of said insulating members, a resilient means for normally biasing said movable contact in a parting direction, a sealing means for maintaining gas-tight the closed space defined by said insulating members regardless of movement of said movable contact, and a contact disposed outside of said closed space for establishing an electrical connection between said movable contact and said terminal conductor which engages with said movable contact to restrict the movement of said movable contact away from said stationary contact against the force of said resilient means.

9. A gas insulated switching apparatus comprising a closed vessel filled with an electrical insulating gas, three circuit breaker units disposed within said closed vessel, each said circuit breaker unit being provided with an input side terminal conductor and an output side terminal conductor, drive means for causing reciprocating movement of said circuit breaker units, within said closed vessel, actuating means for actuating said circuit breaker units for making and breaking the circuit, and a disconnecting switch provided for each said circuit breaker unit and adapted to be urged to one of the closed and open positions depending on the movement of said terminal conductors due to the movement of the associated circuit breaker unit, said terminal conductors of individual phases being disposed at the vertexes of an isosceles triangle, and those terminal conductors disposed at the vertexes of the base of the isoceles triangle being arranged to lie in the same horizontal plane.

10. A gas insulated switchigng apparatus comprising a closed vessel filled with an electrical insulating gas, three circuit breaker units disposed within said closed vessel, each said circuit breaker unit being provided with an input side terminal conductor and an output side terminal conductor, a common movable supporting block for fixedly supporting said circuit breaker units thereon, drive means for causing linear reciprocating movement of said movable supporting block, actuating means for actuating said circuit breaker units for making and breaking the circuit, and three disconnecting switches associated with said three circuit breaker units respectively, each said disconnecting switch being adapted to be urged to one of the closed and open positions depending on the movement of said terminal conductors due to the movement of the associated circuit breaker unit.

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