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(54) Vacuum switchgear

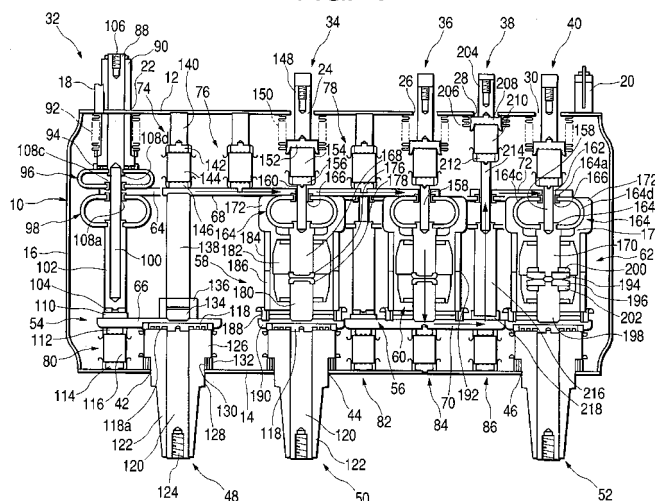
(57) There is disclosed a vacuum switchgear, which comprises a vacuum container (10) to be earthed; a plurality of switches (58,60,62) disposed in the vacuum container. Each of the switches is so constituted that a movable electrode (176,194) supported by a movable electrode rod (168,170) and a fixed electrode (178,196) supported by a fixed electrode rod (180,198) are opposed to each other. One or more bus conductors

(68,72) are connected to the movable electrode rod or the fixed electrode rod of each of the switches.

Each of the switches comprises cylindrical insulating electrode shields (184,186) which are disposed around a conductive shield (182) surrounding the movable electrode and the fixed electrode.

The insulating shield prevents scattering and adhere of metal vapor generated from the movable electrode and the fixed electrode.

FIG. 1



Description

Detailed Description of Invention;

Field of the Invention;

[0001] The present invention relates to a vacuum switchgear, and more particularly to a vacuum switchgear having a plurality of switches disposed in a vacuum container, which is suitable for distribution panels for power transmission systems.

Description of Prior Art;

[0002] Switchgears are installed as one element for a power receiving-distribution facility in a power transmission system. Although air-insulated type switchgears have widely been employed, gas insulated switchgears using SF₆ as an insulating medium are employed. However, SF₆ gas as insulating medium may give adverse affects on ecological atmosphere; there have been proposed vacuum type switchgears using vacuum as an insulating medium in recent years.

[0003] The vacuum switchgears are disclosed in, for example, Japanese Patent Laid-open 2000-268685; the vacuum switchgear is constituted by a plurality of main circuit switches, a fixed electrode and a movable electrode, the electrodes being facing each other and being disposed in a vacuum container, a movable electrode connected to a bus conductor, a fixed electrode connected to a load conductor, wherein each of the main switches is covered with an arc shield, and wherein each of bus conductors is connected through flexible conductors. According to this switchgear, because of vacuum insulation system that makes insulation distance longer, it is possible to make switchgears more compact than the prior art switchgears.

[0004] In the prior art, since each of the main circuit switches is covered with the arc shield, metal vapor is shielded by the arc shield even if metal vapor is generated from each of the electrodes when the movable electrode and the fixed electrode are separated by the action of trip at the time of accident, etc. However, when the vacuum container is earthed and a part of metal vapor scatters through a gap of the shields to adhere the vacuum container, current flows from electrodes through metal vapor and the vacuum container to an earthing point to earth.

[0005] Further, in the prior art, the load conductor is connected to the load side electrode, and a part of the load electrode is projected from the vacuum container, the projected portion being covered with an insulator. One end of the cylindrical insulator is fixed to the wall of the container, and the other end is sealed with a sealing member. A vacuum gap is formed between the cylindrical insulator and the load side electrode. That is, the vacuum gap is formed between the cylindrical insulator and the load side electrode to relieve concentration of

electric field by the difference in dielectric constants between metal and insulator.

[0006] In order to relieve the concentration of electric field by the vacuum gap between the cylindrical insulator and the load side electrode, the vacuum gap must be sufficiently large. Consequently, a diameter of the total cable head including the load side electrode and the cylindrical insulator becomes large and its occupation space becomes large, too. Working effects becomes worse.

[0007] Further, at the time of switching "on", a shock produced by contacting between the movable electrode and the fixed electrode is given to the sealing member through the load side electrode, thereby to create tension between the cylindrical insulator and the sealing member so that mechanical strength at the connection face between the cylindrical insulator and the sealing member may be lowered.

Summary of the Invention;

[0008] An object of the present invention is to provide a vacuum switchgear having a structure for preventing earthing phenomenon that is caused by metal vapor.

[0009] A vacuum switchgear of the invention is based on a concept that a movable electrode and a fixed electrode disposed in a vacuum container to be earthed are surrounded by an electro-conductive shield, and the conductive shield is surrounded by an insulating shield so that adhering or deposition of metal vapor to the conductive shield is prevented and earthing is also prevented.

Brief Description of Drawings;

[0010]

Fig. 1 is a frontal view of an essential part of a switchgear according to one embodiment of the present invention.

Fig. 2 is a plane view of the vacuum switchgear shown in Fig. 1.

Fig. 3 is a sectional view of an essential part of the vacuum switchgear shown in Fig. 1.

Fig. 4 is a circuit diagram of the vacuum switchgear shown in Fig. 1.

Fig. 5 is a drawing for explaining a method of fabrication of a vacuum switchgear, wherein (a) is a construction of the upper plate having the upper parts, and (b) is a side view of the upper plate having the upper parts fixed thereon.

Fig. 6 is a drawing for explaining a method of fabrication of a vacuum switchgear according to the present invention, wherein (a) is a construction of the lower plate having the lower parts, and (b) is a side view of the lower plate having the lower parts fixed thereon.

Fig. 7 is a drawing for explaining a method of fabri-

cation of a vacuum switchgear according to the present invention, that explains a welding method of the upper plate and the lower plate in inert gas. Fig. 8 is a frontal view of the essential part of the vacuum switchgear after its fabrication.

Fig. 9 is a diagrammatic drawing for explaining another embodiment.

Fig. 10 is a frontal view of an essential part of the vacuum switchgear having three disconnectors and three earth switches to which the present invention is applied.

Fig. 11 is a frontal view of an essential part of the vacuum switchgear having two disconnectors and two earth switches to which the present invention is applied.

Fig. 12 is a frontal view of an essential part of the vacuum switchgear having one disconnector and one earth switches to which the present invention is applied.

Fig. 13 (a) is a frontal view of an essential part of the vacuum switchgear wherein switches for three phases are disposed, and Fig. 13 (b) is a side view of an essential part of the vacuum switchgear wherein switches for three phases are disposed.

Detailed description of the Invention;

[0011] Disconnectors 58, 60 and interrupter 62 are disposed in vacuum container 10. The disconnector 58 is connected to a cable head 50. The interrupter 62 is connected to cable head 52. Electrode shield 182 is arranged around a movable electrode 176 of disconnectors 58, 60 and a fixed electrode 178.

[0012] Insulating shields 184, 186 are disposed around the electrode shield 182. The insulating shield 184 is connected to a shield 172. The insulating shield 186 is inserted into a shield 188.

[0013] Scattering of metal vapor generated from the movable electrode 176 and the fixed electrode is prevented by the electrode shield 182 and the insulating shields 184, 186, thereby to avoid earthing of the vacuum container. It is possible to prevent earthing phenomenon due to generation of metal vapor.

[0014] The present invention provides a vacuum switchgear, which comprises a vacuum container to be earthed; a plurality of switches disposed in the vacuum container. Each of the switches is so constituted that a movable electrode supported by a movable electrode rod and a fixed electrode supported by a fixed electrode rod are opposed to each other. One or more bus conductors are connected to the movable electrode rod or the fixed electrode rod of each of the switches. A plurality of operating rods is connected to the movable electrode rod of each of the switches. A part of an operating rod is projected outside the container and connected to each of the operation devices outside of the container. A plurality of load side electrodes each is connected to each of the fixed electrodes. A plurality of insulating

bushings each extends through the inside and outside of the container and covers the load side electrodes. Each of the switches is constituted by comprising a cylindrical electrode shield which is disposed around the movable electrode and the fixed electrode for preventing scattering of metal vapor generated from the movable electrode and the fixed electrode. Cylindrical shields each covers each of the electrode shields.

[0015] In constructing the switchgear, the bus conductor is fixed to the vacuum container, and the movable electrode rod of each of the switchgears can be connected to the bus conductor through the flexible conductors.

[0016] In fabricating the switchgears, the following elements may be added.

(1) The flexible conductor is constituted by a pair of fixing portions each being fixed to the bus conductor and the movable electrode rod and a pair of curved portions connected by a curved line through one of the fixing portion to the other portion, and wherein a hole to which the operating rod is inserted is formed in one of the fixing portions that is fixed to the bus conductor.

(2) The pair of curved portions of the flexible conductors is formed by stacking different kinds of metals.

(3) The vacuum switchgear further comprises returning connection conductors connected to one of the bus conductors more than 2, return flexible conductors connected to the connection conductors and to another bus conductor, and return supporting rods for biasing the return connection conductors towards one of the bus conductors, the return supporting rods being connected to the return connection conductors and fixed to the vacuum container. The return flexible conductors each has a pair of fixing portions fixed to the one bus conductors and to the one return connection conductor and a pair of curved portions constituted by a pair of curved lines connecting through the fixing portions. The curved portions are arranged at the both ends of the fixing portions with respect to the axis of the return connection conductors. A hole for inserting the return supporting rod is formed in one of the fixing portion to be fixed to the another bus conductor.

(4) An electro-conductive coating is formed on the surface of each of the insulating bushings that faces the load side electrodes.

(5) The insulating bushings are separated along the axial direction into a movable electrode side and a fixed electrode side with respect to the each of the electrodes.

(6) The operation devices, switches and insulating bushings are aligned in a straight line along the axial direction.

(7) The operation device is of an electro-magnetic type.

Furthermore, in constructing the vacuum switchgear comprising a vacuum container to be earthed; a plurality of switches disposed in the vacuum container, wherein each of the switches is so constituted that a movable electrode supported by a movable electrode rod and a fixed electrode supported by a fixed electrode rod are opposed to each other; one or more bus conductors connected to the movable electrode rod or the fixed electrode rod of each of the switches; a plurality of operating rods connected to the movable electrode rod of each of the switches and a part of an operating rods being projected outside the container and connected to each of operation devices of the container; a plurality of load side electrodes each being connected to each of the fixed electrodes; and a plurality of insulating bushings each extending through the inside and outside of the container and covering the load side electrodes, the following elements can be added to the above basic structure.

(8) The operation devices, switches and insulating bushings are aligned in a straight line along the axial direction.

(9) A conductive coating is formed on the surface of the insulating bushings that face the load side electrodes.

[0017] According to the measures mentioned-above, since the cylindrical electrode shield is disposed around the movable electrode and the fixed electrode and the insulating shield is disposed around the electrode shield. A part of metal vapor that is generated from each of the electrodes and scatters from the gaps between the electrode shield is shielded by the insulating shield. Consequently, adhere of metal vapor to the vacuum container that leads to grounding or earthing due to metal vapor is prevented. This leads to contribution to improvement of reliability.

[0018] Since the insulating shield is divided into the movable electrode side and fixed electrode side, current flow via the insulating shield is prevented to take trip action surely, when a high voltage is applied between the movable electrode and the fixed electrode at the time the movable electrode and the fixed electrode are separated for trip.

[0019] When the flexible conductor is inserted between the movable electrode and the bus conductor of each switch, current flows in the movable electrode rod and the movable electrode from the bus conductor via each of the curved portions when the movable electrode and the fixed electrode are contacted.

[0020] The direction of current flowing in one of the fixed portions is opposite to that of current flowing in the other of the fixed portions. As a result, electro-magnetic forces are generated in opposite directions at the fixed portions, each acting as a force to separate the both ends of the curved portions. Therefore, the connection strength between the flexible conductor and the bus

conductor is increased and the contact force between the movable electrode and the fixed electrode.

[0021] When the return connection conductor, the return flexible conductor and the return supporting rod are disposed, the adjoining switches are directly connected in series with the return connection conductor and the return flexible conductor.

[0022] When an electric conductive coating is formed on the surface of each of the insulating bushings facing each of the load side electrodes, an electric potential between the coating and the load side electrode can be made equal, so that the vacuum gap between the insulating bushing and the load side electrode can be made minimum. That is, the difference in thermal expansion coefficients between ceramic material and metal conductor for the vacuum gap between the insulating bushing and the load side electrode is enough when ceramic material is used for the insulating bushing.

[0023] When each of the operation devices, switches and insulating bushings (cable heads) are aligned in a straight line along the axis, the spaces between the elements can be controlled to be minimum to contribute to downsizing of the switchgears.

25 Description of the Preferred Embodiments;

[0024] In the following, one of the examples of the present invention will be explained.

[0025] Fig. 1 is a front sectional view of an essential part of one example according to the present invention. Fig. 2 is a plane view of the vacuum switchgear shown in Fig. 1. Fig. 3 is a side view of the vacuum switchgear shown in Fig. 1. Fig. 4 is a circuit diagram of the vacuum switchgear shown in Fig. 1.

[0026] In Figs. 1 through 4, the vacuum switchgear has a vacuum container 10 made of stainless steel as an element for power receiving-distribution facilities of a power transmission system. The vacuum container 10 has an upper plate 12, lower plate 14 and side plates 16, each of the peripheries being welded to unite. The side plates 16 are shaped into a corrugate form thereby to strengthen them to withstand vacuum. The vacuum container is earthed together with the facilities. Although three sets of vacuum switchgears for three phases are disposed in the container, only one container for one phase is shown in this example.

[0027] An exhaust pipe 18 and a vacuum sensing terminal 20 are fixed to the upper plate 12, and through-holes 22, 24, 26, 28 are formed therein. An earthing operation rod 32 is inserted into the through-hole 22 in such a manner that the rod can reciprocally move up and down. The switch operation rods 34, 36 are inserted into the through-holes 24, 26 in such a manner that the rods reciprocally move up and down.

[0028] The returning support rod 38 is inserted into the through-hole 28 to make a reciprocal movement (up and down movement). The switch operation rod 40 is inserted into the through-hole 30 to make a reciprocal

movement (up and down movement).

[0029] On the other hand, through-holes 42, 44, 46 are formed in the upper plate 14. #1 Cable head 48 is inserted into the through-hole 42, #2 cable head 50 into through-hole 44, and #3 cable head 52 into through-hole 46.

[0030] The vacuum container 10 is evacuated by means of an exhaust pipe 18, and earth switches 54, 56, disconnectors 58, 60 and an interrupter 62 are disposed in the vacuum container 10. There are also disposed earth bus conductors 64, 66 made of copper and power transmitting bus conductors 68, 70, 72 made of copper. Further, supporting members 74, 76, 78, 80, 84, 86 are disposed in the vacuum container.

[0031] One ends of the supporting members 74, 76, 78 are fixed to the upper plate 12, and the other ends are fixed to the bus conductor 68 to support the bus conductor 66. One end of the supporting member 80 is fixed to the lower plate 14, and the other to the bus conductor 66 to support it. One ends of the supporting members 82, 84, 86 are fixed to the lower plate 14, and the other ends to the bus conductor 70 to support it.

[0032] The earth operation rod 32 for operating the earth switch 54 is constituted by a cylindrical earth terminal 88, a cylindrical air ceramic movable rod 90, a bellows 92, a disc base plate 94, flexible conductors 96, 98, a connecting rod 100 made of stainless steel, a connecting rod 102 made of copper and a movable electrode 104 made of copper.

[0033] A screw 105 is formed in the earth terminal 88, and the earth operation device (not shown) for earthing is fixed to the screw 106 to make the earth terminal 88 earthed. The bellows 92 is fixed to the upper plate 12, and the movable rod 90 is connected to the opening side of the bellows 92. The base plate 94 is fixed to one end of the movable rod 90 in the axial direction. That is, the earth terminal 88 is air-tightly surrounded with the base plate 94, the movable rod 90 and the bellows 92. The movable rod 90 is connected to the flexible conductor 96 together with the base plate 94. The base plate 94 is connected to the earth conductor 64.

[0034] The flexible conductor 98 is connected to the earth bus conductor 64 and to the connecting rod 102. A connecting rod 100 is inserted into the axis center of the connecting rod 102. The connecting rod 100 is slidably inserted into rod insert holes 108 a to d that penetrate the flexible conductor 98, the bus conductor 64 and the flexible conductor 96, and its one end in the axial direction is connected to the earth terminal 88.

[0035] When the earth terminal 88 reciprocates (up and down movement), the connecting rod 100 slides in the rod insert holes 108a to d, the movable electrode 104 makes contact with and separates from the fixed electrode 110 connected to the bus conductor 66. In this case, the flexible conductors 96, 98 curve in accordance with reciprocation of the earth terminal 88.

[0036] The operating rod (its part is shown) is constituted by the same elements as those of the operating

rod 32, and the movable electrode 104 makes contact with the fixed electrode 110 connected to the bus conductor 70.

[0037] The supporting members 80, 82, 84, 86 comprise supporting bases 112, 114 made of copper and a columnar insulating rod 116 made of ceramics, and the supporting bases 112, 114 are bonded to both ends of the insulating rod 116. The supporting base 112 of the supporting member 80 is bonded to the bus conductor 66, and the supporting base 114 of each of the supporting members 82, 84, 86 is bonded to the lower plate 14.

[0038] #1 Cable head 48 is bonded to one end of the bus conductor 66 through a disc shape supporting base 118, and concentric circular grooves 118a in the face of the supporting base 118 on the # 1 cable head 48 are formed. The #1 cable head 48 is constituted by the columnar load conductor 120 made of copper and the cylindrical insulating bushing 122 made of ceramics.

[0039] A screw 124 is formed at the axial end of the load side electrode 120. A cable for power transmission system is screwed to the screw 124, and the insulating part of the cable is coupled to the outer periphery of the insulating bushing 122. The axial ends of the load side electrode 118 and insulating bushing 122 are bonded to the supporting base 126. The insulating bushing has a step 126 and another step 128 having a smaller diameter than the former.

[0040] Bonded portions of the load side electrode 120 and the insulating bushing 122 are disposed in the vacuum container 10, and their parts are projected from the vacuum container 10. A supporting ring 130, which is in contact with the step 126 and the lower plate 14 is provided to the outer periphery of the step 128 so that the bottom portion of the step 126 is supported by the supporting ring 130. Further, a cylindrical shield 132 made of stainless steel is arranged around the periphery of the supporting ring 130 and the step 126.

[0041] The connecting rod 134 made of copper and the supporting rod 136 are bonded to the other end of the bus conductor 66, and the connecting rod 138 is bonded to the connecting rod 136. The other end of the connecting rod 138 is bonded to the bus conductor 68.

[0042] The supporting members 74, 76, 78 that are bonded to the bus conductor 68 are constituted by a cylindrical supporting rod 140, a supporting base 142 made of copper, an insulating rod 144 made of ceramics and a supporting base 146 made of copper. The supporting bases 142, 146 are bonded to the both axial ends of the insulating rod 144. The supporting rod 140 is bonded to the supporting base 142, and the axial end of the supporting rod 146 is bonded to the upper plate 12. The supporting base 146 is bonded to the bus conductor 144. That is, the supporting members 74, 76, 78 support the bus conductor 68 to the upper plate 12 through the insulating rod 144.

[0043] Operating rods 34, 36, 40 for making "on" and "off" of the disconnectors 58, 60 and the interrupter 62 are constituted by a cylindrical movable rod 148, a bel-

lows 150, a supporting base 152, an insulating rod 154 made of ceramics, a supporting base 156 made of copper and a cylindrical connecting rod 158 made of stainless steel. A screw 160 is formed at the axial end of the movable rod 148 to which the operation device is connected.

[0044] The cylindrical supporting base 152 made of copper is bonded to the axial end of the movable rod 148, and the bellows 150 is connected to the outer periphery of the supporting base 152. The axial end of the bellows 150 is fixed to the upper plate 12 in such a manner that the movable rod 148 and the supporting base 152 are capable of reciprocating movement (up and down movement) with respect to the bellows 150.

[0045] The insulating rod 154 made of ceramics is bonded to the supporting base 152, and the supporting base 152 made of copper is bonded to axial one end of the insulating rod 154. The connecting rod 158 is inserted in reciprocative relation into a rod insert hole 160, or a rod insert hole 162 formed in the bus conductor 72, or a rod insert hole 166 formed in the flexible conductors of the disconnectors 58, 60 or the interrupter 62 so as to make a reciprocative movement (up and down movement). The axial end thereof is bonded to the fixed electrode rods 168, 170 of the disconnectors 58, 60 and the interrupter 62.

[0046] The disconnectors 58, 60 are constituted by a flexible conductor 164, a cylindrical shield 172 made of stainless steel for preventing scattering of arc or metal vapor, a disc shield 174 made of stainless steel which has a dish plate like form, a movable electrode rod 168 made of copper, a movable electrode 176, a fixed electrode made of copper, a cylindrical shield 182 made of stainless steel, a cylindrical insulating shields 184, 186 made of ceramics which surrounds the electrode shield 182 and a substantially cylindrical shield 188 made of stainless steel.

[0047] The shield 158 of the disconnector 58 is bonded to the fixed electrode rod 180 and the disc-connecting base 190, and the shield of the disconnector 188 is bonded to the bus conductor together with the fixed electrode rod 180.

[0048] The upper part of the shield 172 is bonded to the bus conductor 68, and the bottom side is inserted into the inner periphery of the insulating shield 184. One end of the flexible conductor 164 is bonded to the bus conductor 68, and the other to the movable electrode rod 168.

[0049] The shield 174 is disposed between the electrode shield 182 and the flexible conductor 164 thereby to prevent scattering of metal vapor generated from the movable electrode 176 and the fixed electrode 178.

[0050] The movable electrode 176 is supported by bonding it to the axial one end of the movable electrode rod 168, and the fixed electrode 178 is supported by bonding it to the axial end of the fixed electrode 178. An electrode shield 182 for preventing scattering of metal vapor generated from the movable electrode 176 and

the fixed electrode 178 is disposed around the electrodes.

[0051] A flange 192 is formed at the outer periphery of the axial direction center of the electrode shield 182, which is sandwiched by the insulating shields 184, 186 disposed around the electrode shield 182. The insulating shields 184, 186 are divided along the axial direction of the movable electrode 176 and the fixed electrode 178 into two parts, a movable electrode side and fixed electrode side.

[0052] The insulating shields 184, 186 together with the shields 172, 188 are arranged so as to surround the outer area of the electrodes 176, 178 so that scattering of metal vapor that is generated from the electrodes 176, 178 through gaps between the shields is prevented. Further, the insulating shields 184, 186 are constituted so as to prevent current flow through the insulating shields 184, 186 and to make assured opening of the circuit, when the movable electrode 176 and the fixed electrode 178 are separated to create potential difference between the electrodes 176, 178.

[0053] On the other hand, the interrupter 62 comprises a movable electrode 194 and a fixed electrode 196 disposed in an opposing relation to the electrode 194, and the movable electrode 194 is supported by bonding it to the axial one end of the movable electrode rod 170. The fixed electrode 196 is bonded to the axial one end of the fixed electrode rod 198.

[0054] A shield 200 made of stainless steel is bonded to the movable electrode 170 to adjoin the movable electrode 194, and a stainless steel shield 202 is bonded to the fixed electrode rod 198 to adjoin the fixed electrode 198.

[0055] Spiral grooves for confining arc are formed in the surfaces of the movable electrode 194 and the fixed electrode 196.

[0056] Other constructions of the interrupter 62 are the same as the disconnector 58. That is, the shield 172 is bonded to the bus conductor 72, and the shield 188 is bonded to the connecting base 190 together with the fixed electrode rod 198. The #2 cable head 50 is constituted by the same elements as those of #3 cable head 48.

[0057] The insulating shields 184, 186 are arranged around the electro-magnetic shield 182 in the interrupter 62. Since current flow is prevented by means of the insulating shields 184, 186 to perform trip action surely, even if the movable electrode 194 and the fixed electrode separate at the time of trip to create a potential difference between the electrodes.

[0058] On the other hand, the returning support rod 38 that connects the disconnector 60 and the interrupter 62 in series is constituted by a movable rod 204, a bellows 206, a supporting base 208 made of copper, an insulating rod 210 made of ceramics, a copper support base 212 and a stainless steel connection rod 214. The supporting base 208 is bonded to the axial one end of the movable rod 208, and a bellows 206 is connected

to the outer periphery of the supporting base 208.

[0059] An axial one end of the insulating rod 210 is bonded to the supporting base 208. The connecting rod 214 is bonded to the supporting base 212. The connecting rod 214 is inserted into the rod insert hole 162 formed in the bus conductor 72, a rod insert hole 166 formed in the flexible conductor 164 in such a manner that the connecting rod 214 can make a reciprocative movement (up and down movement), the tip of the rod 214 being connected to the copper connecting rod 216. The axial one end of the connecting rod 216 is bonded to the supporting base 218, and the supporting base 218 is bonded to the bus conductor 70.

[0060] The bus conductor 70 and the bus conductor 72 are connected by means of the supporting base 218, the connecting rod 216 and the flexible conductor 164. In this case, the supporting base 218 and the connecting rod 216 work as returning connecting conductors, the flexible conductor 164 works as a return flexible conductor, and the supporting rod 38 works as a return supporting rod for biasing the supporting rod 38 and the supporting base 218 towards the bus conductor 70.

[0061] Each of the flexible conductors 164 (96, 98) is constituted by a pair of fixing portions 164a, 164b and a pair of curved portions 164c, 164d, and the rod insert through-hole 166 is formed in the fixing portion 164a. The fixing portion 164a is bonded to the bus conductor 68 or 72, and the fixing portion 164b is bonded to the movable electrode rod 168 or 170.

[0062] Each of the curved portions 164c, 164d is constituted by stacking plates of different metals such as copper and stainless steel, and each of the curved portions 164c, 164d is arranged at each side of the movable electrode rods 168 and 170 with respect to the axis thereof. One end of the curved portions is bonded to the fixing portion 164a and the other to the fixing portion 164b. Current from the bus conductor 68 or 72 flows into the curved portions 164c and 164d, and the branched current flows through the fixing portion b to the movable electrode rod 168 or 170.

[0063] The direction of current at the end of the curved portion 164c is opposite to that of the curved portion 164d. As a result, electro-magnetic force created by current flowing through each of the curved portions works to separate the both ends of the curved portions 164c, 164d. Therefore, bonding force between the fixing portion 164a and the bus conductor 68 or 72 is strengthened, and the bonding force between the fixing portion 164b and the movable electrode rod 168 or 170 is also strengthened. Further, a contact force between the movable electrode 176 and the fixed electrode 178 increases, and the contact force between the movable electrode 194 and the fixed electrode also increases.

[0064] The inner faces of the cable heads 48, 50, 52 that face the load side electrode 120 are provided with conductive coatings thereby to make an even potential at the inner faces of the cable heads. Therefore, the insulating gap between the load side electrode 120 and

the insulating 122 can be minimized. That is, the inner faces of the insulating bushing 122 and the load side electrode 120 are kept at the same potential.

[0065] A gap equivalent to the thermal expansion of metallic components is enough. The thermal expansion is caused by heat which is generated in soldering at 800 °C for assembly. Consequently, the volume that is occupied by the cable heads 48, 50, 52 can be made small, and work efficiency is increased.

[0066] A part of the cable heads 48, 50, 52 in the embodiments is inserted into the vacuum container 10, and the ring 130 supports the step portion 126. Therefore, at the time of switching "on", if an impact force is imparted to the cable heads 48, 50, 52 when the movable electrode 176 or 194 is pressed towards the fixed electrode 178 or 196, the ring 130 supports the impact force and the lower plate 14 so that the damage to the cable heads 48, 50, 52 by the impact force is prevented.

[0067] The electro-magnetic operation device (the electro-magnetic operation device connected to the operating rods 34, 40), the switches (the disconnecter 58, the interrupter 62) and the cable heads 50, 52 (the load side electrode 120 and insulating bushing 122) are aligned in a straight line along the axis (vertical direction) of the vacuum container. As a result, the spaces between the components can be minimized to downsize the switchgear.

[0068] The vacuum switchgear described above can be utilized as a switch having functions of a rated voltage of 24kV, a rated current of 630/1250A, and a rated short period current of 25kA/3s (4s), for example.

[0069] A method of fabrication of the switchgears of the present invention will be described by reference to the drawings.

[0070] In fabricating the switchgear, the components for constituting the switchgear are grouped according to their functions, locations, etc. For example, the upper plate 12, the lower plate 14 and the side plate 16 constitute the vacuum container 10. The supporting rod 140, the supporting base 142, the insulating rod 144 and the supporting base 146 constitute the supporting members 74 to 78. The fixing portions 146a, 146b, the curved portions 164c, 164d, the movable electrode rod 168, the movable electrode 176, the fixed electrode 178, the fixed electrode rod 180, the electrode shield 182, the insulating shields 184, 186, the shield 188 and the connecting base 190 constitute the disconnecter 58.

[0071] Then, the grouped parts are classified according to locations, functions, materials such as a group of parts that are disposed on the upper plate 12, a group of parts that constitute the supporting members 74 to 78, and a group of parts that constitute the supporting rods 34, 36, 40. The parts are classified into groups such as a group of parts that are disposed on the lower plate 14, a group of parts that constitute the supporting members 80, 82, 84, 86, and a group of parts that constitute the cable heads 48, 50, 52.

[0072] The parts are grouped into insulating parts

such as insulating rods 114, 116, 154, the insulating shields 184, 186 and the insulating bushing 122 and other parts.

[0073] Then, a plate made of silver and copper having a thickness of 0.1 mm is sandwiched between the parts other than the insulating parts as a soldering material. These parts are heated at 960 °C for about 10 min. in a vacuum atmosphere, followed by natural cooling to solder the parts each other, and the parts are fixed to the upper plate 12 and the lower plate 14.

[0074] Thereafter, soldering process is applied to the insulating parts that are soldered to the parts fixed to the upper plates 12, 14. That is, the insulating rods 144, 154 are to be fixed as insulating parts to the upper plate as shown in Fig. 5 (a), 5 (b), and the insulating rod 116, the insulating shields 184, 186, and the insulating bushing 122 are to be fixed as insulating parts to the lower plate 14 as shown in Fig. 6 (a), 6 (b). Thus, in the next step, a soldering material is sandwiched between the insulating parts such as the flange 192 and the supporting base 118, and they are heated at about 835 °C for 10 min. in a vacuum atmosphere, followed by natural cooling to fix the insulating parts to the upper plate 12 and to the lower plate 14.

[0075] Since the copper made supporting member 118 has a thermal expansion coefficient different from that of the insulating bushing 122, a residual stress is imparted to the supporting base 118 and the insulating bushing 122 as temperature changes at the time of soldering, which may lead to deformation of the parts. Because of a plurality of the circular grooves 118a formed in the supporting base 118, the residual stress that is imparted to the supporting base 118 and the insulating bushing 122 can be absorbed in the circular grooves 118a that have lower rigidity than the insulating bushing 122. Thus, the supporting base 118 and the insulating bushing 122 are surely soldered.

[0076] Since the insulating bushing 122 is fixed to the inner part of the lower plate in the vacuum container, shocks from the electrodes given to the bushing through the load side electrodes is supported by the wall of the vacuum container. Therefore, damage of the insulating bushing is prevented to improve reliability.

[0077] Then, as shown in Fig. 7, the upper plate 12 to which the upper parts are fixed and the lower plate 14 to which the lower parts are fixed are placed in opposite relation in an inert gas atmosphere, and the side plate 16 is adjoined to the upper plate 12 and the lower plate 14. Then the peripheries of the upper plate 12, the lower plate 14 and the side plate 16 are welded by TIG welding method to seal the vacuum container.

[0078] Then, as shown in Fig. 8, the evacuating pipe 18 is connected to a vacuum pump 220 to evacuate the vacuum container. In this case, the vacuum container 10 is heated to 430 °C for 12 hours to evacuate. After the vacuum container is evacuated, a vacuum detection terminal 20 is connected to a vacuum sensor so as to find out whether the predetermined degree of vacuum

is maintained in the vacuum container by measurement of vacuum.

[0079] In the embodiment, since the parts are grouped into parts for the upper parts, which are fixed to the upper plate 12 and parts for the lower parts, which are fixed to the lower plate 14, fabrication can be carried out easily.

[0080] Further, since the parts are grouped into insulating parts and other parts, and since the soldering steps are carried out by two steps at different temperatures, soldering between the insulating parts and other parts can be carried out with certainty.

[0081] In this embodiment, when the operating rods 34, 36, 40 are operated, the flexible conductor 164 curves in accordance with the reciprocal movement of the connecting rod 158 so that the bus conductors 68, 72 stay in the fixed state. Thus, deformation of the bus conductors 68, 72 is avoided when the operating rods 34, 36, 40 are operated.

[0082] In this embodiment, the vacuum switchgear is described wherein the disconnectors 58, 60 have the insulating shields 184, 186, but it is possible to omit the insulating shields for the disconnectors.

[0083] Further, in this embodiment, the bus conductors 68, 72 are fixed, but it is possible to employ such a structure that as diagrammatically shown in Fig. 9, thin plates are laminated to form bus conductors 222, which has a curved portion at an intermediate thereof is used to connect the operating rods 34, 36, 40 to the bus conductor 222, thereby to bend the curved portion 224 of the bus conductor 222 in response to operation of the operating rods 34, 36, 40.

[0084] In this embodiment, the vacuum switchgear for three circuits is described wherein the earth switches 54, 56, the disconnectors 58, 60 and interrupter 62. However, the number of the earth switches 54, 56, the disconnectors 58, 60 and the interrupter 62 can be freely selected in accordance with circuit construction.

[0085] For example, when a vacuum switchgear is constituted by three disconnectors 58 and three earth switches 54, the construction shown in Fig. 10 can be employed.

[0086] When a vacuum switchgear is constituted by two disconnectors 58 and two earth switches 54, the construction shown in Fig. 11 can be employed.

[0087] When a vacuum switchgear is constituted by one interrupter 62 and one earth switch 54, the construction shown in Fig. 12 can be employed.

[0088] As circuit systems, a two circuit system, a three circuit system, a four circuit system, a five circuit system or a combination of the three circuit system and the four circuit system, and other various constitutions can be employed.

[0089] In considering a series connection of plural vacuum switchgears, it is possible to employ an open loop system wherein the interrupter is arranged in the center, and disconnectors are arranged at both side of the vacuum switchgear or a closed loop system wherein

all switches other than the earth switch are constituted by interrupters.

[0090] In this embodiment, since the various switches are insulated by vacuum, it is possible to expect maintenance-free of the main circuit. Since the electro-magnetic operation device is employed as an operation device, it is possible to expect the maintenance-free. Further, when each phase is separated from other phases in the vacuum container, a short circuit accident is avoided. When the degree of vacuum in the vacuum container is always monitored, short circuit accident is avoided.

[0091] Though in this embodiment, only one element for one phase disposed in the vacuum container 10 is shown, it is possible to arrange, as shown in Figs. 13 (a), 13 (b), disconnectors 58U, ..., 60U,... for three phases (U phase, V phase, W phase), interrupters 62U, 62V, 62W for three phases, etc can be disposed in the vacuum container 10.

[0092] In this case, electro-magnetic operation devices (electro-magnetic type operation devices) 230U, ..., 232U, 234U, 234V, 234W are fixed to the outer wall surface of the vacuum container 10. That is, electro-magnetic operation devices are fixed to the surface of the upper plate 12, in correspondence with operating rods 34U, ..., 36U, 40U, 40V, 40W, whereby each of the electro-magnetic operation devices 230U, ..., 232U, 234U, 234V, 234W is connected to each of the operating rods 34U, ..., 36U, 40U, 40V, 40W.

[0093] Each of the electro-magnetic operation devices 230U, ..., 232U, 234U, 234V, 234W is so constituted as to automatically operate each of the operating rods 34U, ..., 36U, 40U, 40V, 40W, in response to on-off signals issued from a controller (not shown).

[0094] Since each of the electro-magnetic operation devices 230U, ..., 232U, 234U, 234V, 234W, each of switches (disconnectors 58U, ..., 60U, ..., interrupters 62U, 62V, 62W) and each of the cable heads (load side electrodes 120U, 120V, 120W, ... and the insulating bushing covering each of the load side electrodes) are aligned in a straight line along the axis (a vertical direction), the spaces between the switches can be minimized thereby to contribute to downsizing.

[0095] As having been described, there is disposed the cylindrical electrode shield around the movable electrode and the fixed electrode, and there is also disposed an insulating shield around the electrode shield. Thus, it is possible to prevent metal vapor generated from the electrodes from adhering to the vacuum container, even if part of the metal vapor scatters through gaps between the electrode shields, and earthing phenomenon due to metal vapor is prevented. That leads to increase reliability.

Claims

1. A vacuum switchgear, which comprises a vacuum container to be earthed; a plurality of switches dis-

posed in the vacuum container, wherein each of the switches is so constituted that a movable electrode supported by a movable electrode rod and a fixed electrode supported by a fixed electrode rod are opposed to each other; one or more bus conductors connected to the movable electrode rod or the fixed electrode rod of each of the switches; a plurality of operating rods connected to the movable electrode rod of each of the switches and a part of an operating rods being projected outside the container and connected to each of operation devices of the container; a plurality of load side electrodes each being connected to each of the fixed electrodes; and a plurality of insulating bushings each extending through the inside and outside of the container and covering the load side electrodes, wherein each of the switches is constituted by comprising a cylindrical electrode shield which is disposed around the movable electrode and the fixed electrode for preventing scattering of metal vapor generated from the movable electrode and the fixed electrode, and cylindrical shields each covering each of the electrode shields.

2. The vacuum switchgear according to claim 1, wherein the bus conductor is fixed to the container and the movable electrode rod of each of the switches is connected through a flexible conductor to the bus conductor.
3. The vacuum switchgear as defined in Claim 2, wherein each of the flexible conductors is constituted by a pair of fixing portions each being fixed to the bus conductor and the movable electrode rod and a pair of curved portions connected by a curved line through one of the fixing portion to the other portion, and wherein a hole into which the operating rod is inserted is formed in one of the fixing portions that is fixed to the bus conductor.
4. The vacuum switchgear as defined in claim 3, wherein the pair of curved portions of the flexible conductors is formed by stacking different kinds of metals.
5. The vacuum switchgear as defined in any one of claims 1, 2, 3 and 4, which further comprises return connection conductors connected to one of the bus conductors more than 2, returning flexible conductors connected to the connection conductors and to another bus conductor, and return supporting rods for biasing the return connection conductors towards one of the bus conductors, the return supporting rods being connected to the return connection conductors and fixed to the vacuum container, wherein the returning flexible conductors each has a pair of fixing portions fixed to the one bus conductors and to the one return connection conductor and

a pair of curved portions constituted by a pair of curved lines connecting through the fixing portions, the curved portions being arranged at the both ends of the fixing portions with respect to the axis of the returning connection conductors, and wherein a hole for inserting the return supporting rod is formed in one of the fixing portion to be fixed to the another bus conductor. 5

6. The vacuum switchgear as defined in any one of claims 1, 2, 3 and 4, wherein a conductive coating is formed on the surface of the insulating bushings that face the load side electrodes. 10
7. The vacuum switchgear as defined in any one of claims 1, 2, 3, 4, and 5, wherein the insulating bushings are separated along the axial direction into a movable electrode side and a fixed electrode side with respect to the each of the electrodes. 15
8. The vacuum switchgear as defined in any one of claims 1, 2, 3, 4, 5, 6 and 7, wherein the operation devices, switches and insulating bushings are aligned in a straight line along the axial direction. 20
9. The vacuum switchgear as defined in any one of claims 1, 2, 3, 4, 5, 6, 7 and 8, wherein the operation device is of electro-magnetic type. 25
10. The vacuum switchgear according to claim 1 or 2, wherein the operation devices, switches and insulating bushings are aligned in a straight line along the axial direction. 30
11. The vacuum switchgear according to claim 1 or 2, wherein an electro-conductive coating is formed on the surface of each of the insulating bushings that faces the load side electrodes. 35
12. The vacuum switchgear according to claim 1 or 2, wherein the insulating bushing is fixed to the lower plate inside of the vacuum container. 40

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FIG. 1

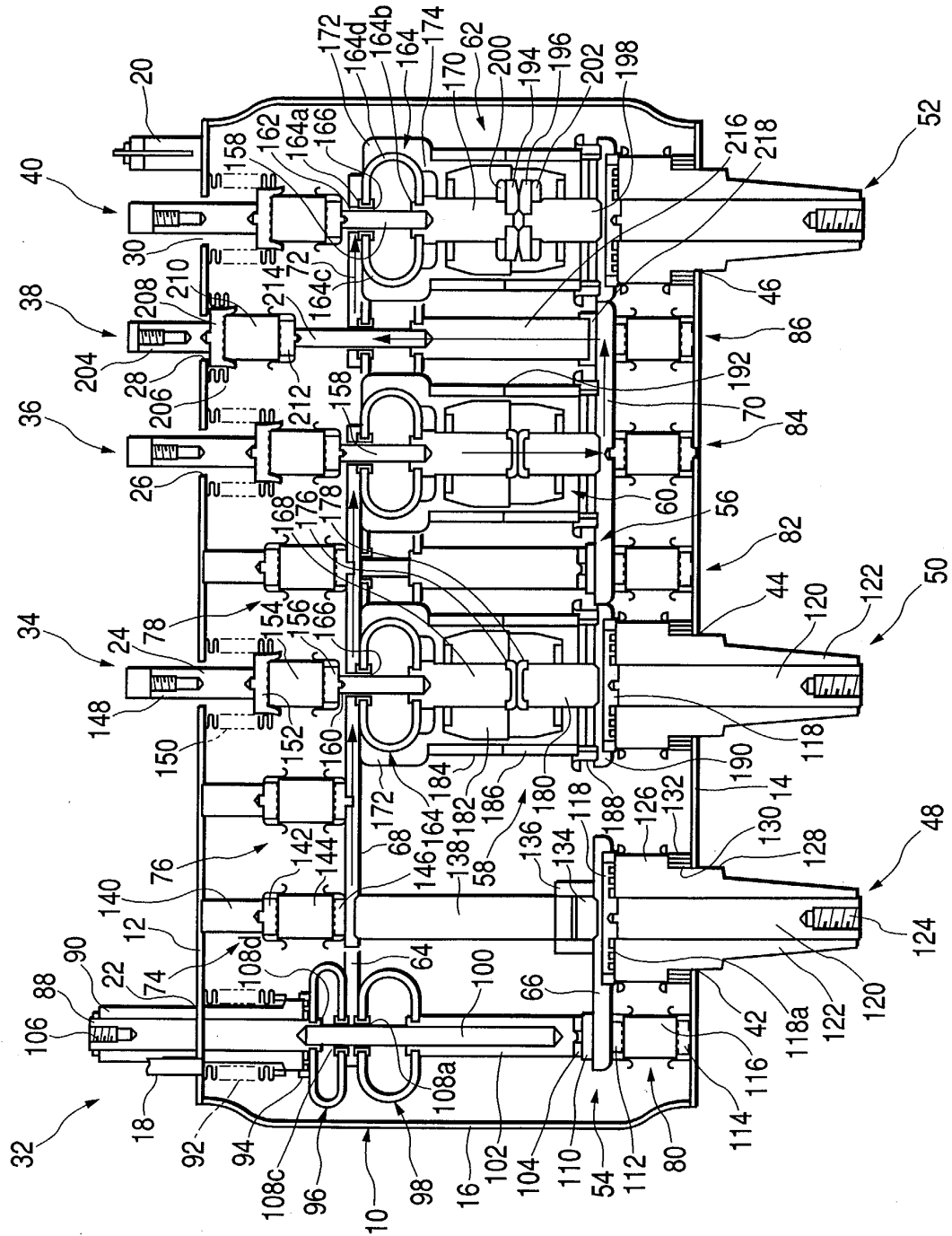


FIG. 2

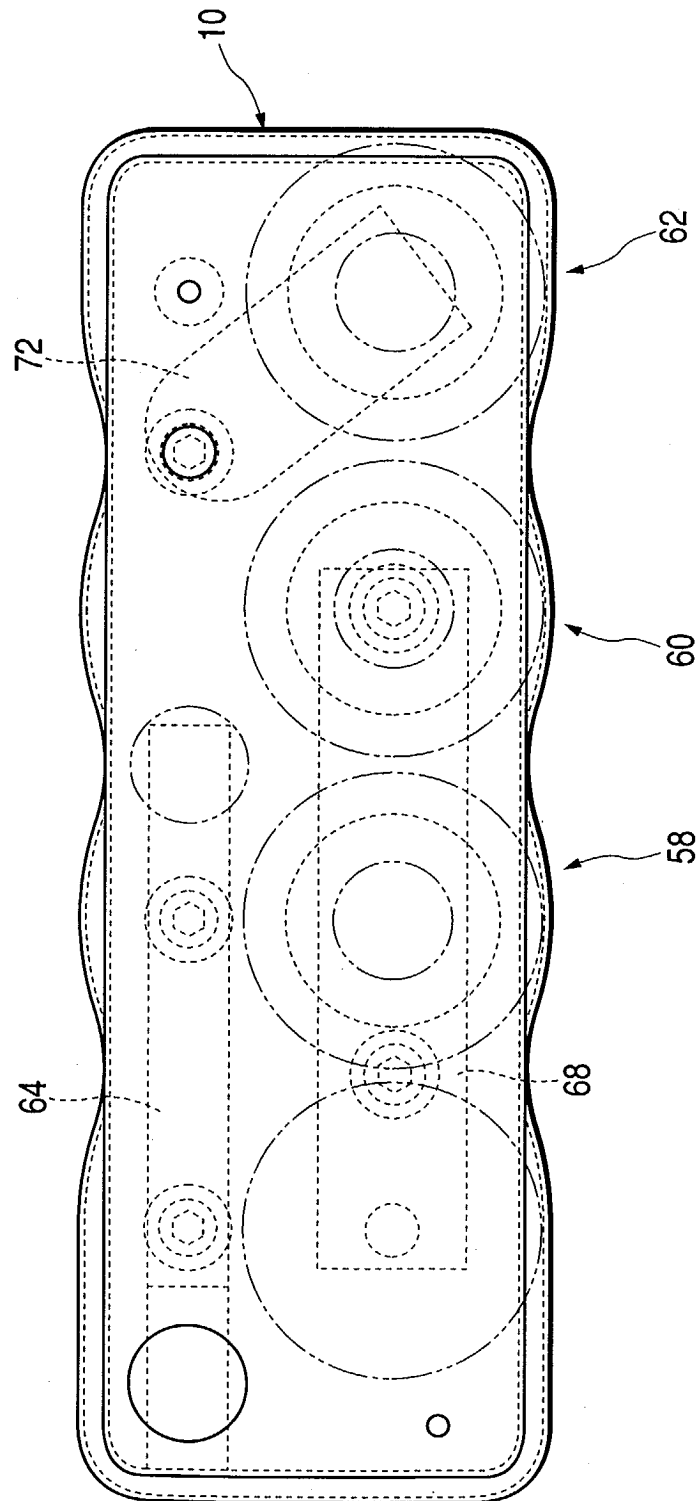


FIG. 3

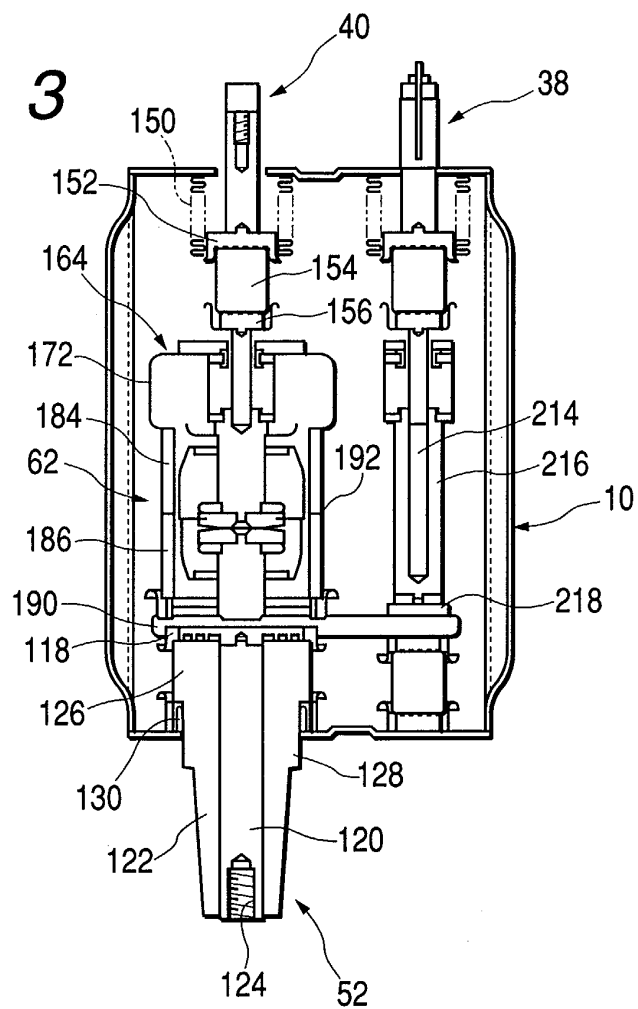


FIG. 4

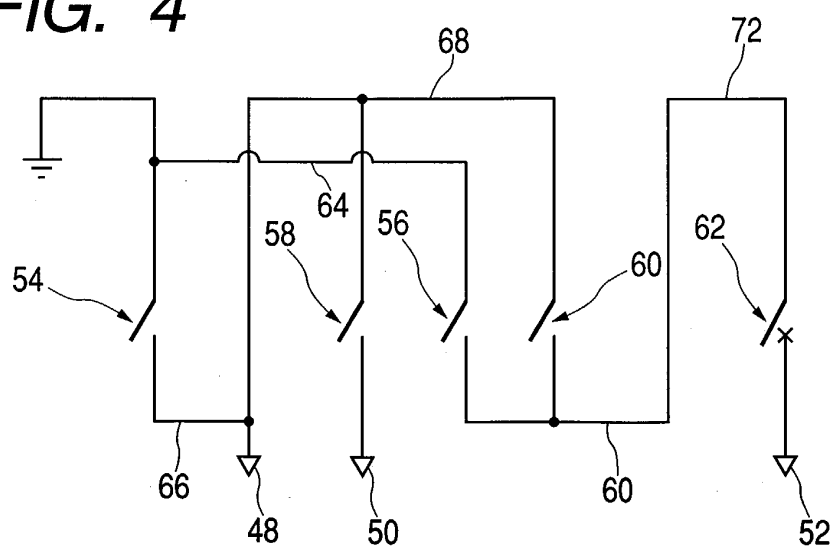


FIG. 5(a)

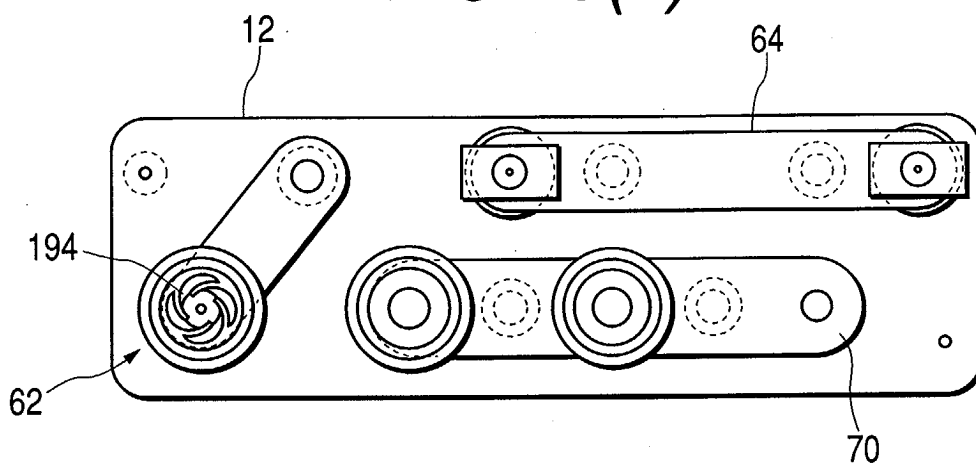


FIG. 5(b)

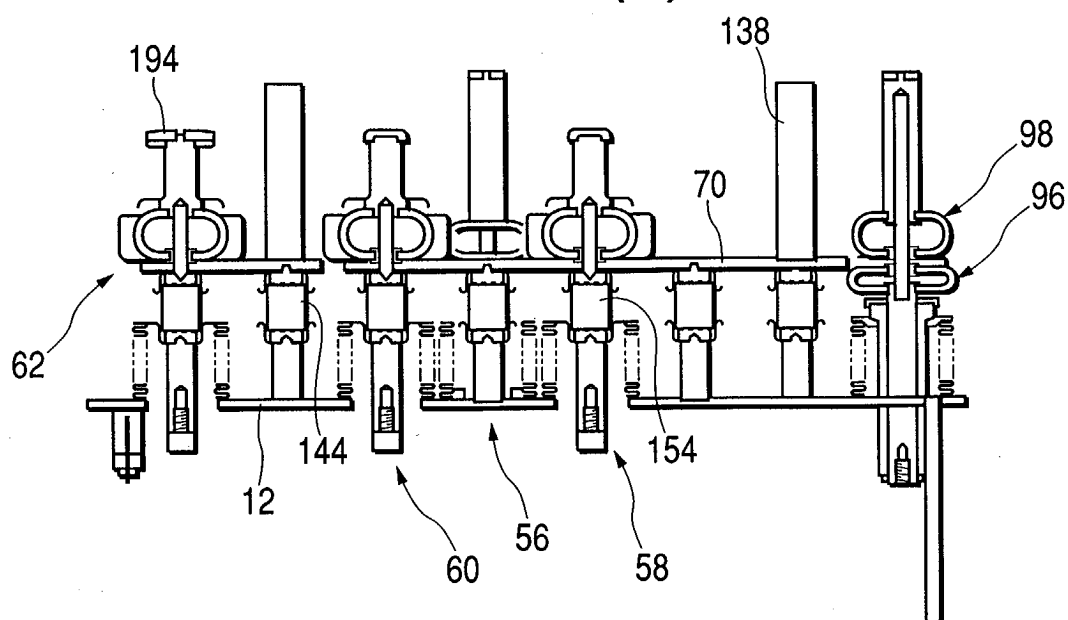


FIG. 6(a)

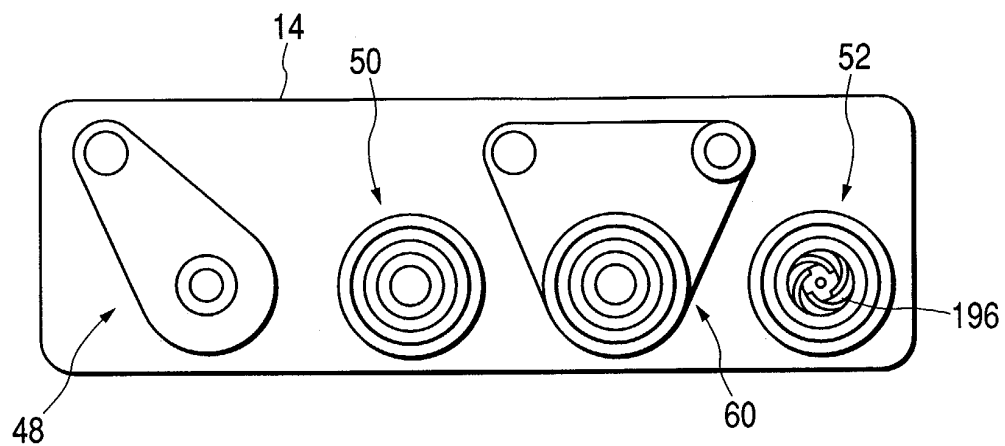


FIG. 6(b)

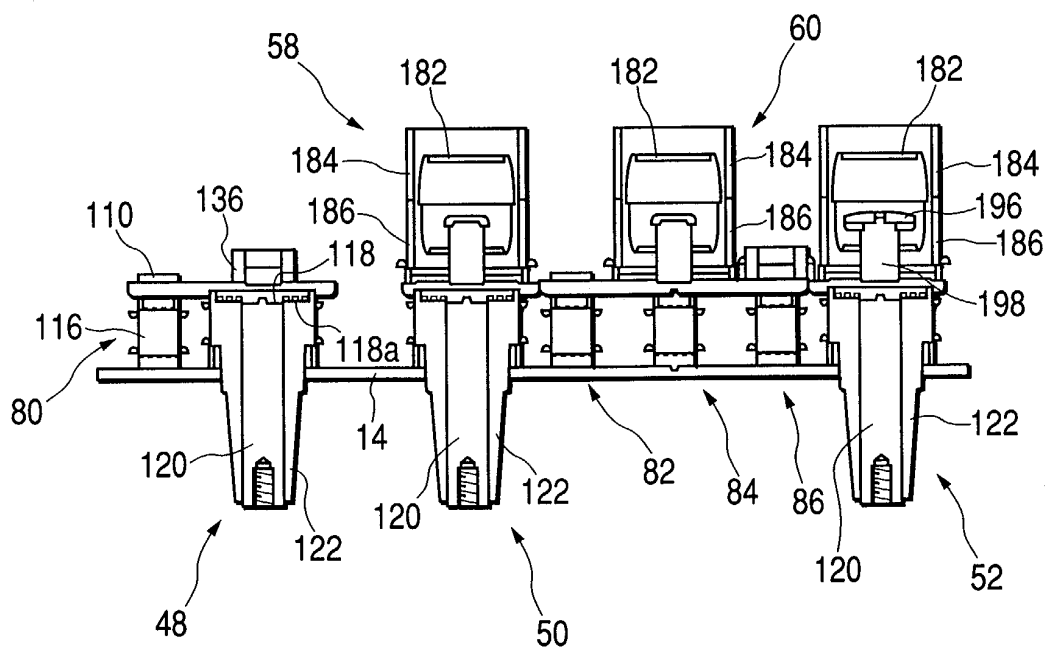


FIG. 7

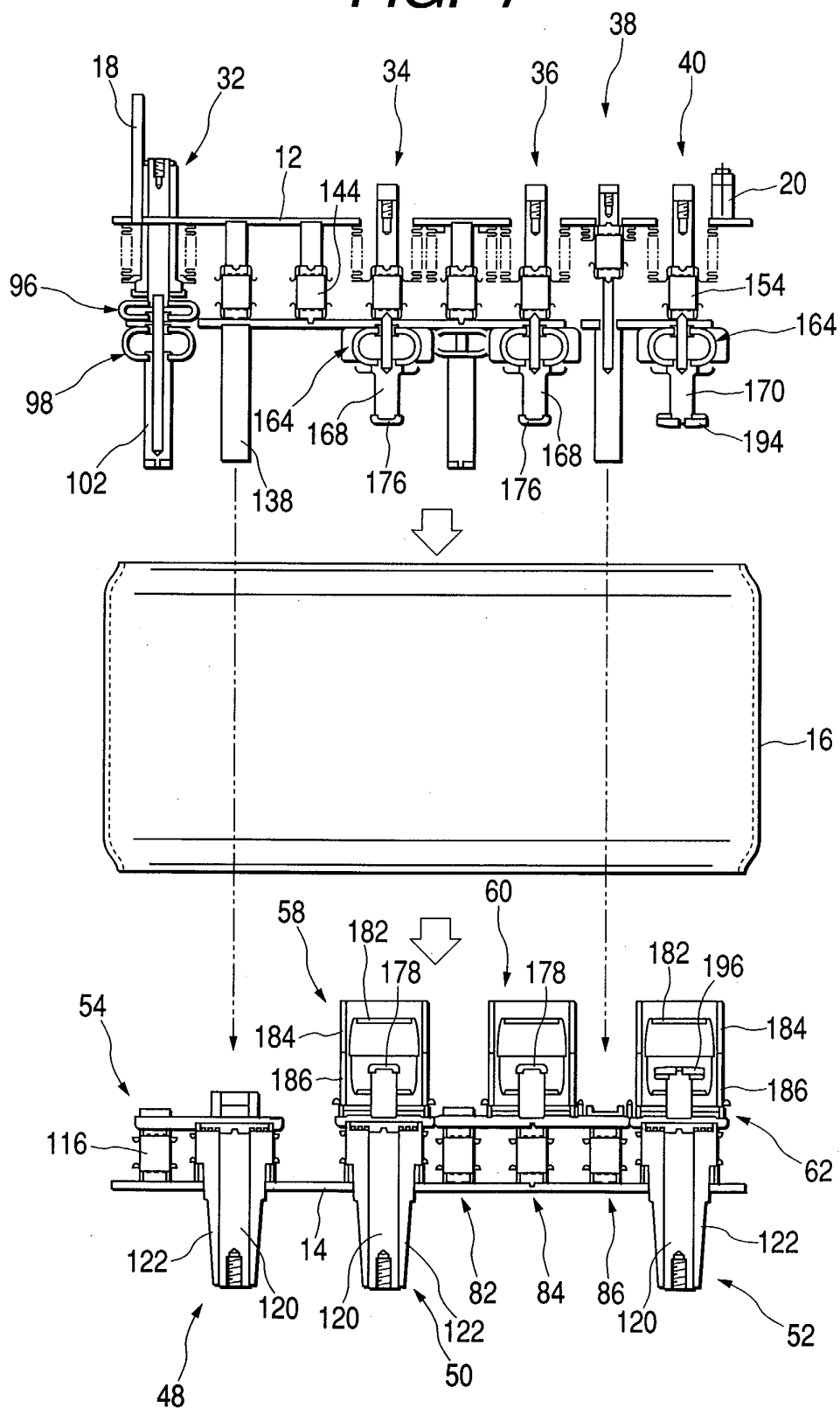


FIG. 8

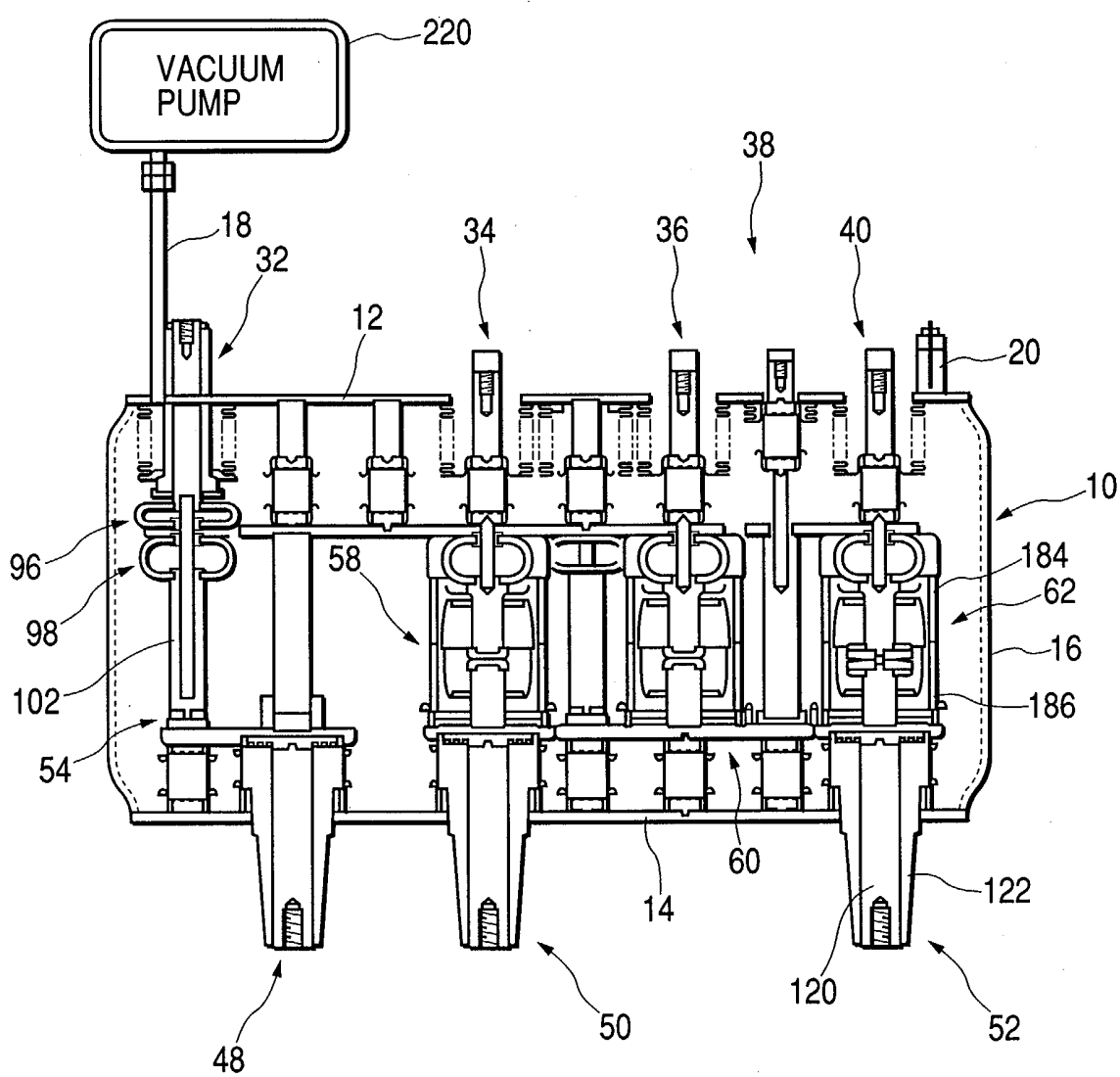


FIG. 9

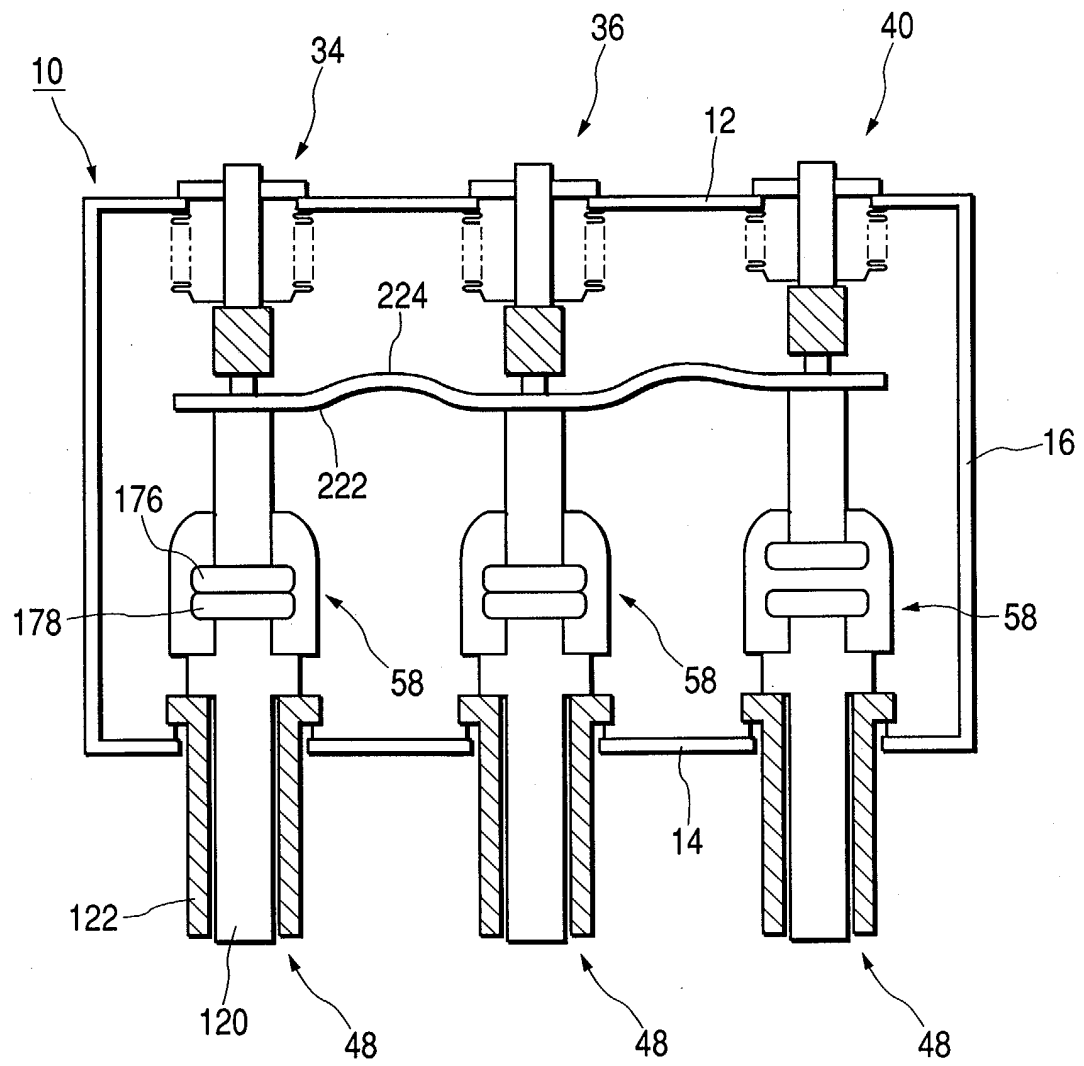


FIG. 10

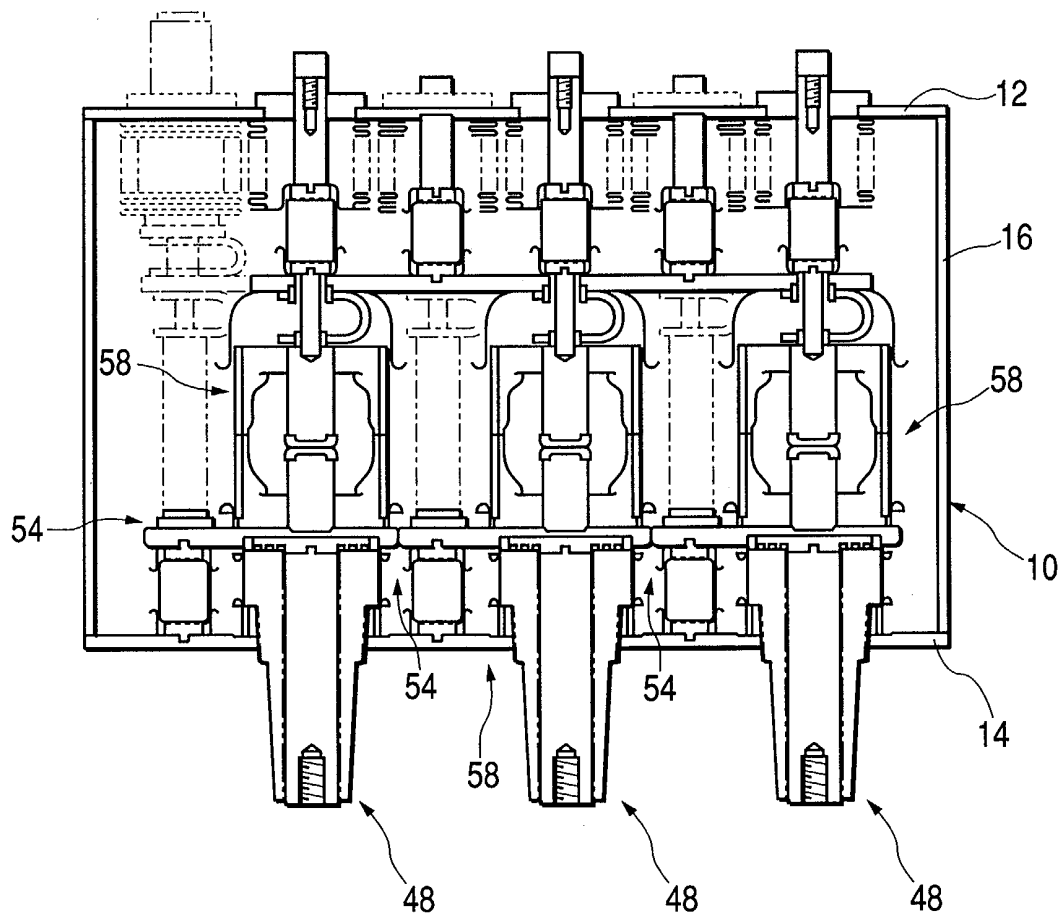


FIG. 11

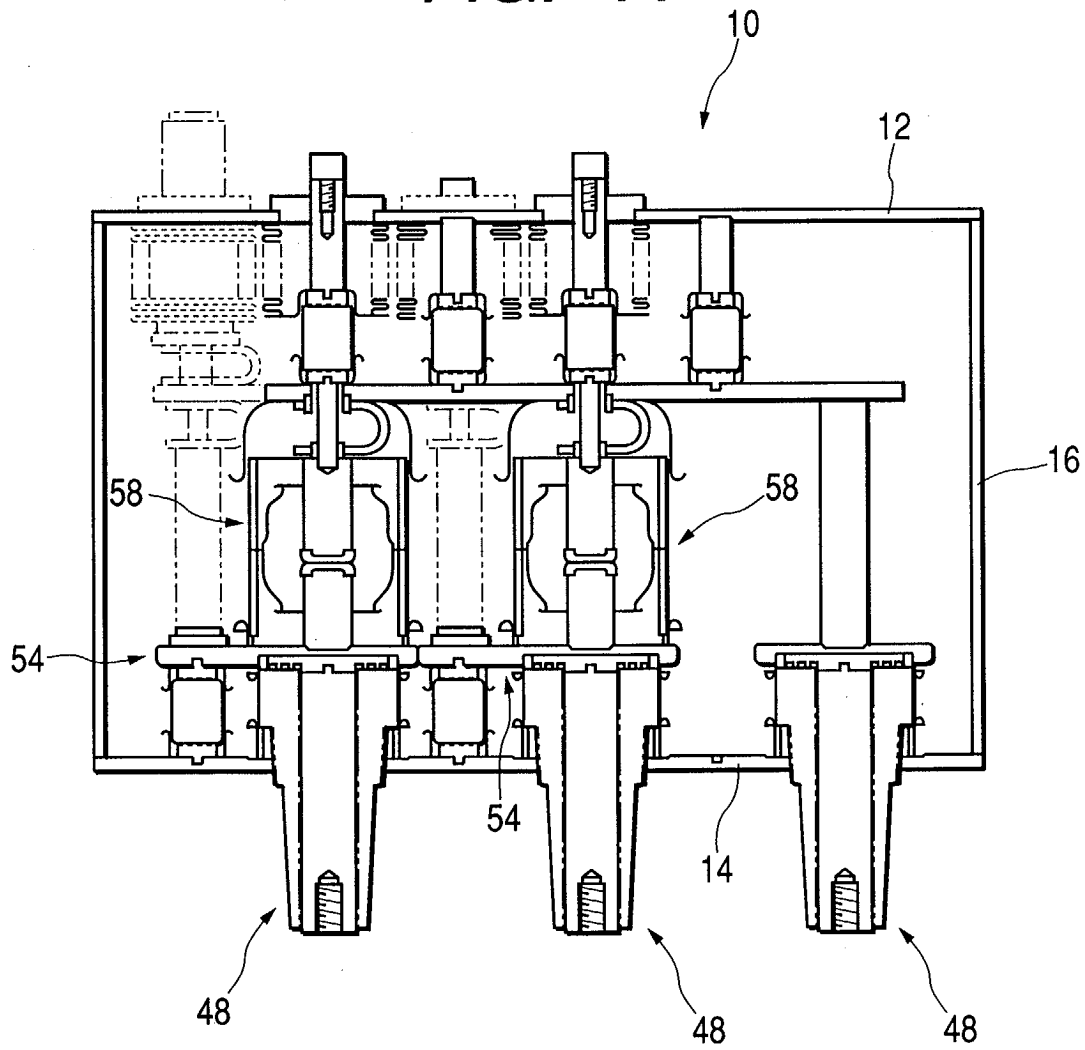


FIG. 12

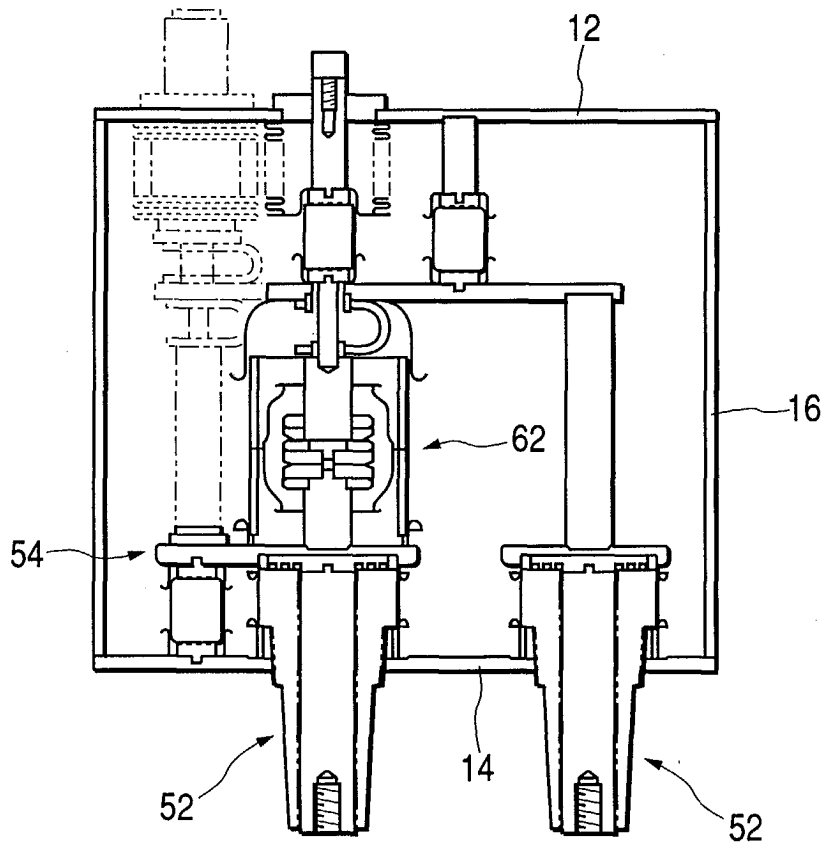


FIG. 13(a)

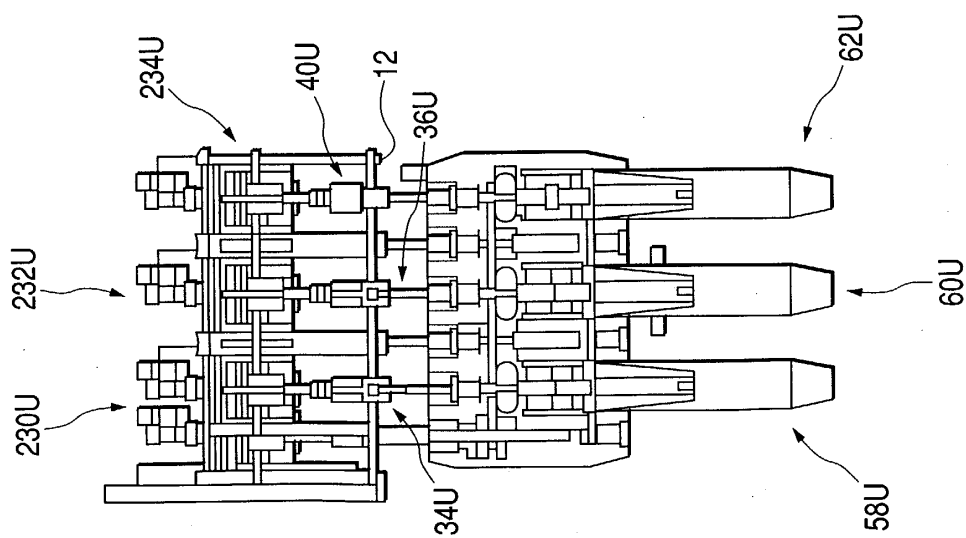
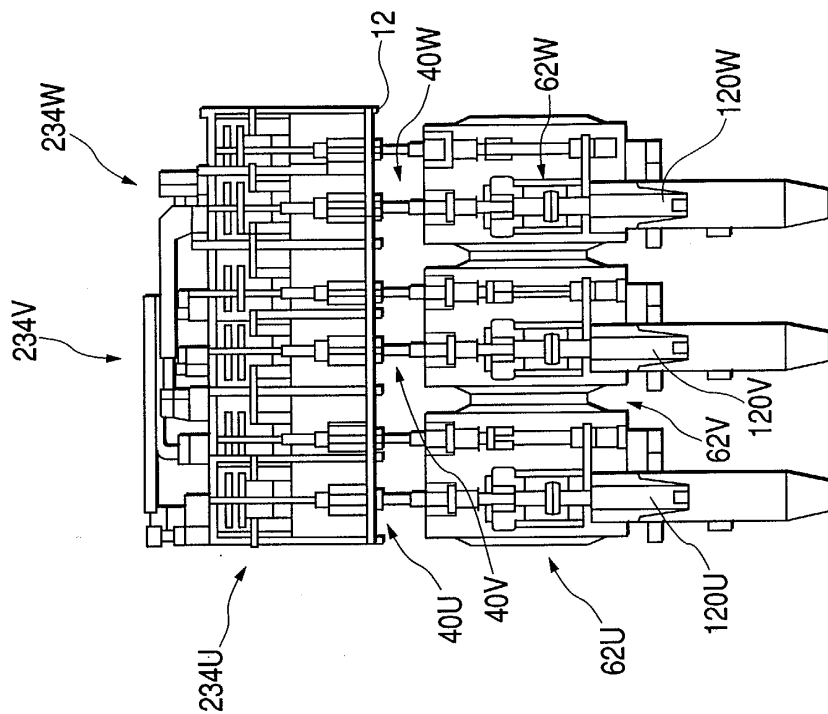


FIG. 13(b)





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The present search report has been drawn up for all claims				
Place of search MUNICH		Date of completion of the search 26 August 2003	Examiner Nieto, J.M.	
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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 26 August 2003	Examiner Nieto, J.M.
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