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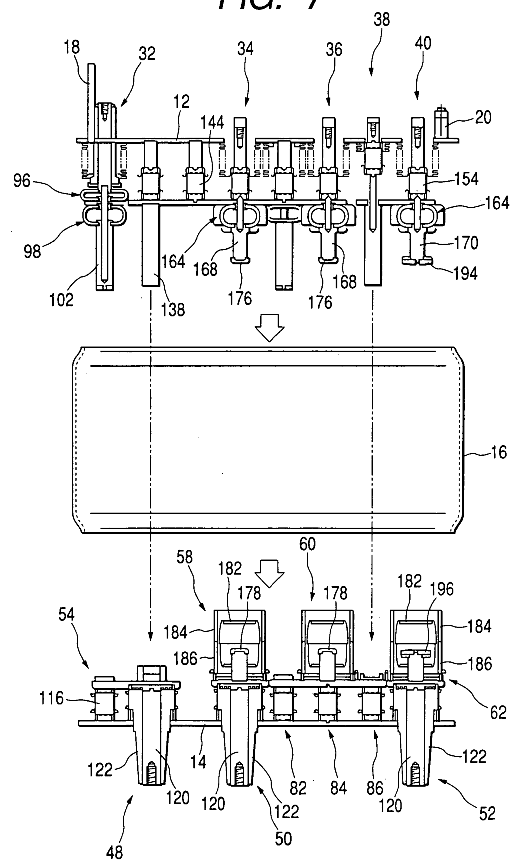
(54) Vacuum switchgear assembling method

(57) A method comprising the steps of dividing constituent elements of a vacuum switchgear assembly into parts, dividing each of the parts into an upper part group (movable electrode 176, ...) which is placed on said upper plate material 12 and a lower part group (stationary electrode 178, ...) which is placed on said lower plate material, dividing each part group into insulating parts and non-insulating parts, filling spaces among non-insulating parts with a brazing material, heating these part groups at 960 °C to fix them with the brazing material, applying a brazing material to spaces between the insulating parts and parts to be brazed (supporting base 118, ...), heating these part groups at 835 °C to fix the parts with the brazing material, TIG-welding the upper plate material 12 on which the upper part groups are fixed, the lower plate material 14 on which the lower part groups are fixed, and the side plate material 16 together at their joints in an inert gas, and thus sealing the vacuum container hermetically.

FIG. 7



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Description

BACKGROUND OF THE INVENTION

[0001] This invention relates to a method for manufacturing a vacuum switchgear assembly, particularly a vacuum switchgear assembly which is equipped with a plurality of switches in a vacuum container and suitable for the use as a power receiving and distributing facility in a power system.

[0002] A switchgear assembly is provided as an element of a power receiving and distributing facility in a power distribution system. Most of conventional switchgear assemblies have been of the air insulation type. Recently, to make them smaller, switchgear assemblies of the gas insulation type which uses SF_6 gas has been employed gradually. However, because the SF_6 gas is said to be harmful to the environment, switchgear assemblies of a vacuum insulation type which uses vacuum as an insulation medium have been proposed.

[0003] For example, Japanese Laid-Open Patent Publication No. 2000-268685 discloses a vacuum-insulation type switchgear assembly which contains, in a vacuum container, some pairs of main circuit switch means each of which comprises a stationary electrode and an opposite movable electrode. Further, the switchgear assembly is characterized in that the movable electrode is connected to a conductor in the bus side and the stationary electrode is connected to a conductor in the load side, that each main circuit switch means is covered with an arc shield, and that each conductor in the bus are connected by means of flexible conductors. According to shorter insulation gap between electrodes, the vacuum-insulation type switchgear assembly can be made smaller than the gas-insulation type switchgear assembly.

SUMMARY OF THE INVENTION

[0004] As each main circuit switching means in the above prior art is covered with an arc shield, the switchgear assembly can shut out, by the arc shield, a metal vapor that generates when the switch trips by a short-circuiting and the movable electrode moves apart from the stationary electrode. However, when part of the metal vapor flies and hits the wall of the vacuum container through a shield gap, a current flows from the electrode to the grounding point through the metal vapor and the vacuum container and thus a ground fault occurs.

[0005] Further, the conductor in the load side is connected to an electrode rod in the load side. Part of the electrode rod protrudes from the vacuum container and its projection is covered with a cylindrical insulating material which has one end secured to the wall of the vacuum container and the other end sealed with a sealing member with a vacuum gap provided between the cylindrical insulating material and the electrode rod in the load side. In other words, a vacuum gap is provided between the cylindrical insulating material and the electrode rod in the load side to relieve field concentration due to a difference in dielectric constant between the metal and the insulating material.

[0006] However, also when a vacuum gap is provided between the cylindrical insulating material and the electrode rod in the load side, the vacuum gap must be widened to relieve field concentration. This increases the whole diameter of the cable head including the electrode rod in the load side and the cylindrical insulating material, and also the occupying spaces, but decreases the workability. Worse still, a shock made when the switch is closed and the movable electrode touches the stationary electrode.

[0007] The shock propagates to the sealing member via the electrode rod in the load side and applies forces the sealing member and the cylindrical insulating material to pull them apart. This may reduce the strength of the joint surface between the cylindrical insulating material and the sealing member.

[0008] An object of this invention is to provide a method for manufacturing a highly reliable vacuum switchgear assembly.

[0009] To accomplish the object, this invention employs a method for providing a vacuum switchgear assembly having a plurality of switches in a vacuum container formed with an upper plate material, a lower plate material, and a side plate material with one end of each switch connected to an operation rod and the other end thereof connected to a load-side rod which is covered with an insulating bushing; the method comprising the steps of dividing constituent elements of said vacuum switchgear assembly into parts, dividing each of said parts into an upper part group which is placed on said upper plate material and a lower part group which is placed on said lower plate material, dividing each part group into insulating parts and non-insulating parts, filling spaces among non-insulating parts with a brazing material, heating these part groups at a selected temperature to fix them with the brazing material, applying a brazing material to spaces between the insulating parts and parts to be brazed, heating these part groups at a temperature lower than the above selected temperature to fix the parts with the brazing material, welding the upper plate material on which the upper part groups are fixed, the lower plate material on which the lower part groups are fixed, and the side plate material together at their joints in an inert gas, and thus sealing the vacuum container hermetically.

[0010] Further, this invention employs a method for providing a vacuum switchgear assembly comprising a vacuum container enclosed with upper, lower, and side plate materials, a plurality of switches containing movable electrodes which are held on movable electrode rods and opposite stationary electrodes held on stationary electrode rods in said vacuum container, one or more bus conductors which connect the movable or stationary electrode rods of said switches, a plurality of operation rods which are respectively connected to the movable electrode rods of said switches and partially connected to an operation means outside said vacuum container, a plurality of load-side rods which are respectively connected to the stationary electrode rods of said switches and partially protruded outside from said vacuum container, a plurality of insulating bushings provided inside and outside said vacuum container to cover each of said load-side rods, wherein each of said switches comprises a cylindrical electrode shield which encloses said movable and stationary electrodes to prevent scattering of metallic vapor arising from said movable and stationary electrodes and an insulating shield which covers said electrode shield; the method further comprising the steps of dividing constituent elements of said vacuum switchgear assembly into parts, dividing each of said parts into an upper part group which is to be placed on said upper plate material and a lower part group which is to be placed on said lower plate material, filling spaces among non-insulating parts in said part groups with a brazing material, heating thereof, cooling the molten brazing material to fix them with the brazing material, mounting said lower part group on said lower plate material, applying a brazing material to spaces between the insulating parts and the parts to be brazed, heating thereof at a temperature lower than the above selected temperature, cooling the molten brazing material to fix said insulating parts and said parts to be brazed with the brazing material, matching the upper plate material having said upper part groups oppositely with the lower plate material having said lower part groups, fitting said side plate material to said upper and lower plate materials, welding said upper and side plate materials together, welding said lower and side plate materials together, evacuating air from said vacuum container, and sealing said vacuum container hermetically.

[0011] The switchgear assembly whose manufacturing method is adopted can be made up with elements as described below.

(1) The vacuum switchgear assembly comprises a vacuum container enclosed with upper, lower, and side plate materials, a plurality of switches containing movable electrodes which are held on movable electrode rods and opposite stationary electrodes held on stationary electrode rods in said vacuum container, one or more bus conductors which connect the movable or stationary electrode rods of said switches, a plurality of operation rods which are respectively connected to the movable electrode rods of said switches and partially connected to respective operation means outside said vacuum container, a plurality of load-side rods which are respectively connected to the stationary electrode rods of said switches and partially protruded outside from said vacuum container, a plurality of insulating bushings provided inside and outside said vacuum container to cover each of said load-side rods, wherein each of said switches comprises a cylindrical electrode shield which encloses said movable and stationary electrodes to prevent scattering of metallic vapor arising from said movable and stationary electrodes and an insulating shield which covers said electrode shield, said bus conductor is secured on said vacuum container, and the movable electrode rode of each of said switches is connected to said bus conductor via a flexible medium.

(2) The vacuum switchgear assembly comprises a vacuum container enclosed with upper, lower, and side plate materials, a plurality of switches containing movable electrodes which are held on movable electrode rods and opposite stationary electrodes held on stationary electrode rods in said vacuum container, one or more bus conductors which connect the movable or stationary electrode rods of said switches, a plurality of operation rods which are respectively connected to the movable electrode rods of said switches and partially connected to an operation means outside said vacuum container, a plurality of load-side rods which are respectively connected to the stationary electrode rods of said switches and partially protruded outside from said vacuum container, a plurality of insulating bushings provided inside and outside said vacuum container to cover each of said load-side rods, wherein each of said insulating bushings is partially held on the inner wall of said vacuum container.

[0012] The above method for manufacturing a switchgear assembly can additionally contain elements below.

[0013] Forming an electro-conductive film on a surface of each of said insulating bushings which faces to the corresponding load-side rod.

[0014] The above-described method employs two brazing steps at different melting temperatures after classifying part groups into an insulating part group and a non-insulating part group. This assures solid braze-fixing of the insulating and non-insulating parts and increases the reliability of the switchgear assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 shows a front sectional view of the main part of a vacuum switchgear assembly which is an embodiment of the present invention;

FIG. 2 is a plane view of the vacuum switchgear assembly of FIG. 1;

FIG. 3 shows a side sectional view of the main part of the vacuum switchgear assembly of FIG. 1;

FIG. 4 is a circuit diagram of the vacuum switchgear assembly of FIG. 1;

FIG. 5a and FIG. 5b are explanatory drawings of a method for manufacturing the vacuum switchgear assembly. FIG. 5a shows a block diagram of the upper plate material having upper part groups on it. FIG. 5b shows a side view of the upper plate material 12 having upper part groups on it;

FIG. 6a and FIG. 6b are explanatory drawings of a method for manufacturing the vacuum switchgear assembly. FIG. 6a shows a plane view of the lower plate material having lower part groups on it. FIG. 6b shows a side view of the lower plate material having lower part groups on it;

FIG. 7 is an explanatory drawing of a method for manufacturing the vacuum switchgear assembly. This figure shows a method of welding the upper, lower, and side plate materials together in an inert gas.

FIG. 8 shows a front sectional view of the main part of a completed vacuum switchgear assembly of the present invention;

FIG. 9 shows an explanatory schematic view of the other embodiment of the invention;

FIG. 10 shows a front sectional view of the main part of a vacuum switchgear assembly having three disconnecting switches and three grounding switches in accordance with the invention;

FIG. 11 shows a front sectional view of the main part of a vacuum switchgear assembly having two disconnecting switches and two grounding switches in accordance with the invention;

FIG. 12 shows a front sectional view of the main part of a vacuum switchgear assembly having one disconnecting switch and one grounding switch in accordance with the invention; and

FIG. 13a shows a front sectional view of the main part of a vacuum switchgear assembly housing switches of three phases. FIG. 13b shows a side sectional view of the main part of a vacuum switchgear assembly housing switches of three phases.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] One embodiment of this invention will be described below with the accompanying drawings.

[0017] FIG. 1 shows a front sectional view of a vacuum switchgear assembly which is an embodiment of this invention. FIG. 2 is a top plane view of the vacuum switchgear assembly of FIG. 1. FIG. 3 is a side view of the vacuum switchgear assembly of FIG. 1. FIG. 4 is a circuit diagram of the vacuum switchgear assembly of FIG. 1. Referring to FIG. 1 through FIG. 4, the vacuum switchgear assembly comprises a stainless-steel vacuum container as one element of a power receiving and distributing facility in a power distributing system. The vacuum container 10 is equipped with an upper plate material 12, a lower plate material 14, and a side plate material 16 which are welded together in a body at their joint edges (rims).

[0018] The whole side material is corrugated so that the vacuum container may endure the vacuum pressure even when the plate materials are made thinner. The whole side material is grounded together with the power receiving and distributing facility. Usually a vacuum switchgear assembly contains elements by three phases. However, this embodiment contains elements by a single phase as a container for phase separation for convenience of explanation.

[0019] The upper plate material has an exhaust pipe 18, a vacuum gauge terminal 20, and through-holes 22, 24, 26, 28, and 30. A grounding operation rod 32 is inserted into the through-hole 22 reciprocally (to move up and down). Switch operation rods 34 and 36 are respectively inserted into the through-holes 24 and 26 reciprocally (to move up and down). A returning support rod 38 is inserted into the through-hole 28 reciprocally (to move up and down).

[0020] A switch operation rod 40 is respectively inserted into the through-hole 30 reciprocally (to move up and down). At the same time, the lower plate material has through-holes 42, 44, and 46. A #1 cable head 48 is inserted into the through-hole 42. A #2 cable head 50 is inserted into the through-hole 44. A #3 cable head 52 is inserted into the through-hole 46.

[0021] The vacuum container 10 evacuated through the exhaust pipe 18 houses, as switches, grounding switches 54 and 56, disconnecting switches 58 and 60, and a breaker 62. The vacuum container 10 also houses copper-made bus conductors for grounding (or grounding bus bars) 64 and 66, copper bus conductors for energized circuits 68, 70, 72, and supporting members 74, 76, 78, 80, 82, 84, and 86.

[0022] The supporting members 74, 76, and 78 respectively have one end fixed to the upper plate material 12 and the other end fixed to the bus conductor 68 to support the bus conductor 68. The supporting member 80 has one end fixed to the lower plate material 14 and the other end fixed to the bus conductor 66 to support the bus conductor 66. The supporting members 82, 84, and 86 respectively have one end fixed to the lower plate material 14 and the other end fixed to the bus conductor 70 to support the bus conductor 70.

[0023] The grounding operation rode 32 to be operated to open and close the grounding switch 54 comprises a column-shaped grounding terminal 88, a cylindrical air ceramic movable rod 90, a bellows 92, an approximately disk-shaped base 94, flexible conductors 96 and 98, stainless-steel coupling rod 100, a copper coupling rod 102, and a copper movable electrode 104.

[0024] The grounding terminal 88 is threaded (106) and a grounding operation unit (not shown in the drawing) is fastened to this threaded part 106 to ground the grounding terminal 88. The bellows 92 is fixed to the upper plate material 12 and a movable rod 90 is connected to the open end of the bellow. The base 94 is fixed to the other end (axial end) of the movable rod 90.

[0025] More specifically, the vicinity of the grounding terminal is hermetically sealed with the base 94, the movable rod 90, and the bellows 92. Further, the movable rod 90 is connected together with the base 94 to the flexible conductor 96 and the base 94 is connected to the grounding bus conductor 64.

[0026] The flexible conductor 98 is connected to both the grounding bus conductor 64 and the coupling rod 102. The coupling rod 100 is inserted into the shaft center of the coupling rod 102. The coupling rod is slidably inserted into through-holes 108a to 108d which pass through the flexible conductor 98, the bus conductor 64, and the flexible conductor 96. Its axial end is coupled with the grounding terminal 88.

[0027] More specifically, this mechanism is so designed that, when the grounding terminal 88 moves reciprocally (up and down), the movable electrode 104 may touch the stationary electrode 110 which is coupled with the bus conductor 100 and may go away from the stationary electrode 110. In this case, the flexible conductors 96 and 98 are designed to curve according to the reciprocal movement of the grounding terminal 88.

[0028] The operation rod (partially shown in the drawing) to operate the grounding switch 56 is approximately similar to the operation rod 32 in configuration and works to make the movable electrode touch the stationary electrode which is connected to the bus conductor 70.

[0029] The supporting members 80, 82, 84, and 86 respectively comprise copper supporting bases 112, and 114 and a column-shaped ceramic insulation rod 116. Both ends of the insulation rod 116 are supported by the supporting bases 112 and 114. The supporting base 112 of the supporting member 80 is connected to the bus conductor 66. The supporting bases 112 of the supporting members 82, 84, and 86 are respectively connected to the bus conductor 70. Similarly, the supporting bases 114 of the supporting members 80, 82, 84, and 86 are respectively connected to the lower plate material 14.

[0030] The #1 cable head 48 is connected to one end of the bus conductor 66 via the approximately disk-shaped base 118. Some grooves 118a are concentrically provided on the cable head 48 of the supporting base 118. The #1 cable head comprises a column-shaped copper rod 120 (in the load side) and an approximately cylindrical ceramic insulating bushing 122. The axial end of the load-side rod 120 is threaded (124).

[0031] A cable constituting a power distributing system is to be connected to this threaded part 124 and the insulation of the cable is connected to the outer periphery of the insulating bushing 122. The axial end of the load-side rod 120 and the axial end of the insulating bushing 122 are respectively connected to the supporting base 118. The insulating bushing has a stepped part 126 and a smaller stepped part 128 (smaller in diameter).

[0032] Part of the load-side rod 120 and part of the insulating bushing 122 (which are respectively connected to the supporting base 122) are housed in the vacuum container and the other parts of them are protruded out from the vacuum container 10. A supporting ring 130 is provided on the outer periphery of the stepped part 128 with the ring 130 in contact with the stepped part 126 and the lower plate material. The supporting ring 130 supports the bottom of the stepped part 126. Further, a cylindrical stainless steel shield 132 is provided on the outer peripheries of the supporting ring and the stepped part 126.

[0033] A copper coupling rod 134 and a supporting ring 136 are connected to the other end of the bus conductor 66. A coupling rod 138 is connected to the coupling rod 136. The other end of the coupling rod 138 is connected to the bus conductor 68.

[0034] Each of the supporting members 74, 76, and 78 which are connected to the bus conductor 68 comprises a column-shaped supporting rod 140, a copper supporting base 142, a ceramic insulating rod 144, and a copper supporting base 146. The supporting bases 142 and 146 are respectively connected to both axial ends of the insulating rod 144. The supporting rod 140 is connected to the supporting base 142 and the axial end of the supporting rod 140 is connected to the upper plate material 12. The supporting base 146 is connected to the bus conductor 68. In other words, the supporting members 74, 76, and 78 connect the bus conductor to the upper plate material 12 with the insulating rod 144 therebetween to support it.

[0035] Each of the operation rods 34, 36, and 40 for respectively operating the disconnecting switches 58 and 60 and the breaker 62 comprises a column-shaped movable rod 148, a bellows 150, a supporting base 152, a ceramic insulating rod 154, a copper supporting base 156, and an approximately column-shaped stainless-steel coupling rod 158. The axial end of the movable rod 148 is threaded (160).

[0036] An operation means is to be connected to this threaded part 160. An approximately disk-shaped copper supporting base 152 is connected to the other axial end of the movable rod 148 and the bellows 150 is connected to the outer periphery of the supporting base 152. One axial end of the bellows 150 is fixed to the upper plate material 12.

[0037] The movable rod 148 and the supporting base 152 are supported on the bellows 150 reciprocally (to move up and down). The ceramic insulating rod 154 is connected to the supporting base 152 and the copper supporting base 152 is connected to one axial end of the insulating rod 154. The coupling rod 158 is inserted into a rod insertion hole 160 formed on the bus conductor 68 or into a rod insertion hole 162 formed on the bus conductor 72, and a rod insertion hole 166 formed on the flexible conductor 164 of the disconnecting switches 58 and 60 and the breaker 62 reciprocally (to move up and down). One axial end of the coupling rod is connected to the stationary electrode rods 168 and 170 of the disconnecting switches 58 and 60 and the breaker 62.

[0038] The disconnecting switches 58 and 60 respectively comprise a flexible conductor 164, a cylindrical stainless-steel shield 172 to prevent arc diffusion, an approximately dish-shaped stainless-steel annular shield 174, a copper movable electrode rod 168, a copper movable electrode 176, a copper stationary electrode rod 180, an approximately cylindrical stainless-steel electrode shield 182, an approximately cylindrical ceramic insulating shield 184 which covers the whole electrode shield 182, and an approximately column-shaped stainless-steel shield 188.

[0039] The shield 188 of the disconnecting switch 58 is connected to the stationary electrode rod 180 and to the disk-shaped coupling base 190. The shield 188 of the disconnecting switch 60 is connected together with the stationary electrode rod 180 to the bus conductor 70.

[0040] The shield 172 has the upper end connected to the bus conductor 68 and the bottom fitted to the inner periphery of the insulating shield 184. The flexible conductor 164 has one end connected to the bus conductor 68 and the other end connected to the movable electrode rod 168. The shield 174 is provided between the electrode shield 182 and the flexible conductor 164 to prevent scattering of metallic vapor arising from said movable electrode 176 and the stationary electrode 178.

[0041] The movable electrode 176 is connected to one axial end of the movable electrode rod 168 and supported thereby. The stationary electrode 178 is connected to one axial end of the stationary electrode rod 180 and supported thereby. The movable electrode 176 and the stationary electrode 178 are enclosed in the electrode shield 182 to prevent scattering of metallic vapor arising from said movable and stationary electrodes.

[0042] The electrode shield 182 has a flange 192 on the outer periphery in its axial center which separates the insulating shield into two (upper insulating shield 184 and lower insulating shield 186). In other words, the insulating shields 184 and 186 are provided relative to the movable electrode 176 and the stationary electrode 178 along their axes. These insulating shields 184 and 186 together with the shields 172 and 188 are provided to cover the outer peripheries of the electrodes 176 and 178 to prevent any part of metallic vapor arising from said movable and stationary electrodes from flying to the vacuum container through holes of the electrode shield 182.

[0043] Further, the insulating shields 184 and 186 are so configured as to prevent a current flow through the insulating shields 184 and 186 even when the movable electrode 176 goes apart from the stationary electrode 178 to make an open circuit and there generates a potential difference between the electrodes. This assures making an open circuit.

[0044] Meanwhile, the breaker 62 is equipped with a movable electrode 194 and a stationary electrode 196 provided opposite to the movable electrode 194. The movable electrode 194 is connected to one axial end of the movable electrode rod 170 and supported thereby. The stationary electrode 196 is connected to one axial end of the stationary electrode rod 198 and supported thereby.

[0045] A stainless-steel shield 200 next to the movable electrode is connected to the movable electrode rod 170. A stainless-steel shield 202 next to the stationary electrode 196 is connected to the stationary electrode rod 198. The movable electrode 194 and the stationary electrode 196 respectively have a spiral groove on the surface to confine arcs within the groove.

[0046] The other configuration of the disconnecting switch 62 is the same as that of the disconnecting switch 58. More specifically, the shield 172 is connected to the bus conductor 72 and the shield 188 is connected together with the stationary electrode rod 198 to the coupling base 190. The #2 cable head 50 and the #3 cable head 52 are respectively the same as that of the #1 cable head 48 in configuration.

[0047] Further, in the disconnecting switch, insulating shields 184 and 186 are provided enclosing the electrode shield 182 to prevent a current flow through the insulating shields 184 and 186 even when the movable electrode 194 goes apart from the stationary electrode 196 to make a trip and there generates a potential difference between the electrodes. This assures tripping.

[0048] Meanwhile, the supporting rod 38 for returning is provided to connect the disconnecting switch 60 and the breaker 62 in series. This supporting rod 38 comprises a movable rod 204, a bellows 206, a copper supporting base 208, a ceramic insulating rod 210, a copper supporting base 212, and a stainless-steel coupling rod 214. The supporting base 208 is connected to one axial end of the movable rod 204.

[0049] The bellows 206 is connected to the outer periphery of the supporting base 208. One axial end of the bellows 206 is fixed to the upper plate material 12. One axial end of the insulating rod 210 is connected to the supporting base 208 and the supporting base 212 is connected to the other axial end of the insulating rod 210. The coupling rod 214 is connected to the supporting base 212.

[0050] The coupling rod 214 is inserted into a rod insertion hole 162 formed on the bus conductor 72 and a rod insertion hole 166 formed on the flexible conductor 164 reciprocally (to move up and down). Its front end is connected to the copper-made coupling rod 216. One axial end of the coupling rod 216 is connected to the supporting base 218 which is connected to the bus conductor 70.

[0051] More specifically, the bus conductors 70 and 72 are connected with each other by means of the supporting base 218, the coupling rod 216, and the flexible conductor 164. In this case, the supporting base 218 and the coupling rod 216 work as connection conductor for returning. The flexible conductor 164 works as a flexible conductor for returning and the supporting rod 38 works as a supporting rod for returning to energize the supporting rod 216 and the supporting base 218 towards the bus conductor 70.

[0052] Each flexible conductor 164 (96, or 98) comprises a pair of stationary parts 164a and 164b, and a pair of curved parts 164c and 164d. The stationary part 164a has a through-hole 166 into which a rod is inserted and is connected to the bus conductor 68 or 72. The stationary part 164b is connected to the movable electrode rod 168 or 170. Each of the curved parts 164c and 164d is made of two strips of different metals such as copper and stainless steel.

[0053] The curved parts 164c and 164d are symmetrically arranged relative to the axis center of the movable electrode rod 168 or 170. One end of the curved part is connected to the stationary part 164a and the other end of the curved part is connected to the stationary part 164b. In this mechanism, a current from the bus conductor 68 or 72 branches into the curved parts 164c and 164d through the stationary part 164a.

[0054] The branched currents from the curved parts 164c and 164d respectively flow to the movable electrode rod 168 or 170 through the stationary part 164b. In this case, currents flow in reverse directions each other at both ends of each curved part (164c or 164d). Therefore, the electromagnetic forces generated by currents flowing through the curved parts 164c and 164d work to separate both ends of the curved parts 164c and 164d.

[0055] As the result, these electromagnetic forces strengthen the connection between the stationary part 164a and the bus conductor 68 or 72, and the connection between the stationary part 164b and the movable electrode rod 168 or 170. These electromagnetic forces can also increase the contact force between the movable electrode 176 and the stationary electrode 178 and the contact force between the movable electrode 194 and the stationary electrode 196.

[0056] Further in this embodiment, an electro-conductive layer is formed on the inner wall of the insulating bushing 122 of respective cable heads 48, 50, and 52, that is, on the wall opposite to the load-side rod 120 and the electric potential on the inner wall of the insulating bushing 122 is as high as that of the load-side rod 120. Therefore, this can minimize an insulating gap between the load-side rod 120 and the insulating bushing 122.

[0057] More specifically, as the inner wall of the insulating bushing 122 and the load-side rod 120 have the same electrical potential, the gap can be equal to a difference between the thermal expansion of a ceramic material of which the insulating bushing 122 is made and a metal of which the insulating bushing 122 is made, substantially, to a thermal expansion difference caused by brazing (at 800 C). This can reduce the occupying spaces of the cable heads 48, 50, and 52 and at the same time can increase the workability of the vacuum switch assembly.

[0058] Further, as each of the cable heads 48, 50, and 52 of this embodiment has its part inserted into the vacuum container 10 and its stepped part 126 supported by the ring 130, the ring 130 and the lower plate material 14 instead of the cable heads 48, 50, and 52 receive shocks made when the movable electrode 176 or 194 is pressed against the stationary electrode 178 or 196 to make a circuit. With this, the cable heads 48, 50, and 52 are protected against the shocks and can serve longer.

[0059] Furthermore, the switchgear assembly of this embodiment arranges the electromagnetic operation means (connected to the operation rods 34 and 40), switches (the disconnecting switch 58 and the breaker 62) and cable heads 50 and 52 (the load-side rod 120 and the insulating bushing 122) in a line along the axis (vertically). This configuration can minimize spaces between switches and thus make the whole switchgear assembly smaller.

[0060] The vacuum switchgear assembly of the above configuration can be used as a switch having a function of, for example, a rated voltage of 24 kV, a rated current of 630A/1250A, and a rated short-time current of 25 kA/3s (4s).

[0061] Below will be described a method of manufacturing a vacuum switchgear assembly of the present invention with the accompanying drawings. The method of manufacturing a vacuum switchgear assembly first begins with a step of dividing constituent elements of the vacuum switchgear assembly into parts. For example, the step divides constituent elements of the vacuum container 10 into the upper plate material 12, the lower plate material 14, and the side plate material 16; constituent elements of the supporting members 74 through 78 into the supporting rod 140, the supporting base 142, the insulating rod 144, and the supporting base 146; and constituent elements of the disconnecting switch 58 into the stationary parts 164a and 164b, the curved parts 164c and 164d, the shields 172 and 174, the movable electrode rod 168, the movable electrode 176, the stationary electrode 178, the stationary electrode rod 180, the electrode shield 182, the insulating shields 184 and 186, the shield 188, and the coupling base 190.

[0062] The next step divides the above-divided parts into a group of upper parts which are mounted on the upper plate material 12 such as parts constituting the supporting member 74 to 78, and parts constituting the operation rods 34, 36, and 40; a group of lower parts which are mounted on the lower plate material 14 such as parts constituting the supporting member 80, 82, 84, and 86 and parts constituting the cable heads 48, 50, and 52; a group of insulating parts such as the insulating rods 114, 116, and 154 and the insulating shields 184 and 186, and the insulating bushing 122; and a group of non-insulating parts.

[0063] The next steps are inserting a brazing material such as silver-copper plate materials (0.1 mm thick) in spaces among non-insulating parts, heating these part groups at 960 C for about 10 minutes in a vacuum atmosphere, and naturally cooling thereof to braze the upper parts together to the upper plate material 12 and the lower parts together to the lower plate material 14.

[0064] The succeeding step is to braze insulating parts to the upper part group which is fixed to the upper plate material 12 and to the lower part group which is fixed to the lower plate material 14. More specifically, as the insulating rods 144 and 154 are to be fixed as insulating parts to the upper plate material 12 as shown in FIG. 5(a) and FIG. 5(b) and as the insulating rod 146, the insulating shields 184 and 186, and the insulating bushing 122 are to be fixed as insulating parts to the lower plate material 14 as shown in FIG. 6(a) and FIG. 6(b), the succeeding steps comprises placing brazing materials in a space between the insulating and non-insulating part groups which are to be brazed such as a place between the flange 192 and the supporting base 118, heating these part groups at 835 C for about 10 minutes in a vacuum atmosphere, and naturally cooling thereof to braze the insulating part group and the other upper part groups to the upper plate material 12 and the insulating part group and the other lower part groups to the lower plate material 14.

[0065] In this case, as the copper supporting base 118 and the insulating bushing 122 have different thermal expansion coefficients, there exists a residual stress due to heating between the copper supporting base 118 and the insulating bushing 122 when these parts are brazed and this stress will deform any of these parts. However, in this embodiment, a plurality of circular grooves 118a formed on the supporting base 118 and having lower rigidity than the insulating bushing 122 can absorb this residual stress if any. This can assure brazing of the supporting base 118 and the insulating bushing 122.

[0066] Referring to FIG. 7, the following steps comprise arranging the upper plate material 12 on which the upper part groups are fixed and the lower plate material 14 on which the lower part groups are fixed in a face-to-face manner in an inert gas, disposing the side plate material 16 between the upper plate material 12 and the lower plate material 14 with their edges matched, and welding the edges of the upper plate material 12, the lower plate material 14, and the side plate material 16 by TIG-welding to hermetically seal the vacuum container 10.

[0067] Referring to FIG. 8, the following steps comprise connecting a vacuum pump 220 to the exhaust pipe 18, evacuating the vacuum container 10 by the vacuum pump 220 at 430 C for about 12 hours, connecting a vacuum gauge to the vacuum gauge terminal 20, measuring the degree of vacuum in the vacuum container, and making sure the inside of the vacuum container 10 is kept at a specified degree of vacuum.

[0068] As the method of this embodiment divides part groups to be fixed to the vacuum container into the upper part groups and the lower part groups and fixes the upper part groups to the upper plate material 12 and the lower part groups to the lower plate material 14, the assembly work of the vacuum container becomes easier.

[0069] Further, as the insulating parts and the non-insulating parts are separately brazed in two steps at different temperatures, they can be brazed steadily.

[0070] Furthermore, this embodiment is so designed that, when the operation rods 34, 36, and 40 are operated, the flexible conductor 164 singly curves by the reciprocal movement of the coupling rod and the bus conductors 68 and 72 remain fixed. This can prevent the bus conductors 68 and 72 from being deformed by movement of the operation rods 34, 36, and 40.

[0071] Although the disconnecting switches 58 and 60 of this embodiment are respectively equipped with the insulating shields 184 and 186, these insulating shields can be omitted.

[0072] Further, although this embodiment employs stationary bus conductors 68 and 72, it is also possible to employ a laminated bus conductor 222 having parts 224 curved according to the movement of the operation rods 34, 36, and 40 which are connected to the bus conductor 222.

[0073] Furthermore, the vacuum switchgear assembly of this embodiment works as a three-circuit vacuum switchgear assembly having grounding switches 54 and 56, disconnecting switches 58 and 60, and a breaker 62. However, the combination and number of grounding switches, disconnecting switches, and breakers can be selected freely according to the circuit configuration of the vacuum switchgear assembly.

[0074] For example, the vacuum switchgear assembly can take a configuration of three disconnecting switches 58 and three grounding switches 54 as shown in FIG. 10.

[0075] Further, the vacuum switchgear assembly can take a configuration of two disconnecting switches 58 and two grounding switches 54 as shown in FIG. 11.

[0076] Furthermore, the vacuum switchgear assembly can take a configuration of one disconnecting switch 62 and one grounding switch 54 as shown in FIG. 12.

[0077] Similarly, the vacuum switchgear assembly can employ any circuit mode such as 2-circuit, 3-circuit, 4-circuit, 5-circuit or a combination of 3-circuit and 4-circuit modes.

[0078] Assuming that a plurality of vacuum switchgear assemblies may be connected in series in an open-loop system, the vacuum switchgear assembly can arrange disconnecting switches with a breaker between them. Further assuming that a plurality of vacuum switchgear assemblies may be used in a closed-loop system, the vacuum switchgear assembly can comprise all breakers except for the grounding switch.

[0079] As each switch in the vacuum container 10 of this embodiment is vacuum-insulated, the main circuit can be free from maintenance. Similarly, when electromagnetic operation means are employed, the operation means can also be free from maintenance. Further, short-circuiting in the vacuum container can be suppressed by isolating the circuits by phase. Furthermore, the reliability of the vacuum switchgear assembly can be increased by always monitoring the degree of vacuum in the vacuum switchgear assembly.

[0080] Although the vacuum container 10 of this embodiment contains elements by a single phase as a container for each separate phase, the container 10 can house disconnecting switches (58U, ..., and 60U, ...) by three phases and breakers (62U, 62V, and 62W) by three phases as indicated by FIG. 13(a) and FIG. 13(b). In this case, electromagnetic operation means (solenoid operation units) (230U, ..., 232U, 234U, 234V, and 234W) are fixed onto the outer periphery of the vacuum container, that is, on the surface of the upper plate material 10 in correspondence with the rods (34U, ..., 36U, ..., 40U, 40V, and 40W) for operating the switches. These electromagnetic operation means are respectively coupled with the corresponding operation rods. Each of the electromagnetic operation means) (230U, ..., 232U, 234U, 234V, and 234W) is configured to open and close the corresponding operation rod (34U, ... 36U, ..., 40U, 40V, and 40W) in response to Switch ON/OFF signals sent from a controller (not shown in the drawing). With this, the switches can be automatically turned on and off.

[0081] Further, the switchgear assembly of this embodiment arranges the electromagnetic operation means (230U, ..., 232U, 234U, 234V, and 234W) of each phase, the switches (disconnecting switches 58U, ..., and 60U, ..., and breakers 62U, 62V, and 62W) of each phase, and cable heads (load-side rods 120U, 120V, 120W, ..., and insulating bushings which respectively cover the load-side rods) in a line along the axis (vertically). This configuration can minimize spaces between switches and thus make the whole switchgear assembly smaller.

[0082] Reference signs show the following parts:

10···Vacuum container, 12···Upper plate material, 14 ···Lower plate material, 16···Side plate material, 48, 50, 52···Cable head, 54, 56···Grounding switch, 58, 60··· Disconnecting switch, 62···Breaker, 64, 66 ···Grounding bus conductor, 68, 70, 72···Bus conductor for energized circuit, 34, 36, 40···Operation rod, 38···Supporting rod, 96, 98, 164···Flexible conductor, 168, 170···Movable electrode rod, 176, 194···Movable electrode, 178, 196 Stationary electrode, 180, 198···Stationary electrode rod, 120···Load-side rod, 122···Insulating bushing, 182 Electrode shield, 184, 186···Insulating shield.

[0083] As already described, the method of this invention employs two brazing steps at different melting temperatures after classifying part groups into an insulating part group and a non-insulating part group. This assures solid braze-fixing of insulating and non-insulating parts and increases the reliability of the switchgear assembly.

Claims

1. Vacuum switchgear assembling method having a plurality of switches in a vacuum container formed with an upper plate material, a lower plate material, and a side plate material with one end of each switch connected to an operation rod and the other end thereof connected to a load-side rod which is covered with an insulating bushing, the method comprising the steps of:

   dividing constituent elements of said vacuum switchgear assembly into parts, dividing each of said parts into an upper part group which is placed on said upper plate material and a lower part group which is placed on said lower plate material, dividing each part group into insulating parts and non-insulating parts, filling spaces among non-insulating parts with a brazing material, heating these part groups at a selected temperature to fix them with the brazing material, applying a brazing material to spaces between the insulating parts and parts to be brazed, heating these part groups at a temperature lower than the above selected temperature to fix the parts with the brazing material, welding the upper plate material on which the upper part groups are fixed, the lower plate material on which the lower part groups are fixed, and the side plate material together at their joints in an inert gas, and thus sealing the vacuum container hermetically.

2. A method for assembling a vacuum switchgear assembly according to Claim 1, wherein each of said insulating bushings has an electro-conductive film on a surface facing to the corresponding load-side rod.

3. A method for assembling Vacuum switchgear comprising a vacuum container enclosed with upper, lower, and side plate materials, a plurality of switches containing movable electrodes which are held on movable electrode rods and opposite stationary electrodes held on stationary electrode rods in said vacuum container, one or more bus conductors which connect the movable or stationary electrode rods of said switches, a plurality of operation rods which are respectively connected to the movable electrode rods of said switches and partially connected to an operation means outside said vacuum container, a plurality of load-side rods which are respectively connected to the stationary electrode rods of said switches and partially protruded outside from said vacuum container, a plurality of insulating bushings provided inside and outside said vacuum container to cover each of said load-side rods, wherein each of said switches comprises a cylindrical electrode shield which encloses said movable and stationary electrodes to prevent scattering of metallic vapor arising from said movable and stationary electrodes and an insulating shield which covers said electrode shield; the method further comprising the steps of:

dividing constituent elements of said vacuum switchgear assembly into parts, dividing each of said parts into an upper part group which is to be placed on said upper plate material and a lower part group which is to be placed on said lower plate material, filling spaces among non-insulating parts in said part groups with a brazing material, heating thereof, cooling the molten brazing material to fix them with the brazing material, mounting said lower part group on said lower plate material, applying a brazing material to spaces between the insulating parts and the parts to be brazed, heating thereof at a temperature lower than the above selected temperature, cooling the molten brazing material to fix said insulating parts and said parts to be brazed with the brazing material, matching the upper plate material having said upper part groups oppositely with the lower plate material having said lower part groups, fitting said side plate material to said upper and lower plate materials, welding said upper and side plate materials together, welding said lower and side plate materials together, evacuating air from said vacuum container, and sealing said vacuum container hermetically.

4. A method for assembling a vacuum switchgear assembly according to Claim 3, wherein each of said insulating bushings has an electro-conductive film on a surface facing to the corresponding load-side rod.

5. A method for assembling a Vacuum switchgear comprising a vacuum container enclosed with upper, lower, and side plate materials, a plurality of switches containing movable electrodes which are held on movable electrode rods and opposite stationary electrodes held on stationary electrode rods in said vacuum container, one or more bus conductors which connect the movable or stationary electrode rods of said switches, a plurality of operation rods which are respectively connected to the movable electrode rods of said switches and partially connected to respective operation means outside said vacuum container, a plurality of load-side rods which are respectively connected to the stationary electrode rods of said switches and partially protruded outside from said vacuum container, a plurality of insulating bushings provided inside and outside said vacuum container to cover each of said load-side rods, wherein each of said switches comprises a cylindrical electrode shield which encloses said movable and stationary electrodes to prevent scattering of metallic vapor arising from said movable and stationary electrodes and an insulating shield which covers said electrode shield, said bus conductor is secured on said vacuum container, and the movable electrode rode of each of said switches is connected to said bus conductor via a flexible medium; the method further comprising the steps of:

dividing constituent elements of said vacuum switchgear assembly into parts, dividing each of said parts into an upper part group which is to be placed on said upper plate material and a lower part group which is to be placed on said lower plate material, filling spaces among non-insulating parts in said part groups with a brazing material, heating thereof, cooling the molten brazing material to fix them with the brazing material, mounting said lower part group on said lower plate material, applying a brazing material to spaces between the insulating parts and the parts to be brazed, heating thereof at a temperature lower than the above selected temperature, cooling the molten brazing material to fix said insulating parts and said parts to be brazed with the brazing material, matching the upper plate material having said upper part groups oppositely with the lower plate material having said lower part groups, fitting said side plate material to said upper and lower plate materials, welding said upper and side plate materials together, welding said lower and side plate materials together, evacuating air from said vacuum container, and sealing said vacuum container hermetically.

6. A method for assembling a vacuum switchgear assembly according to Claim 5, wherein each of said insulating bushings has an electro-conductive film on a surface facing to the corresponding load-side rod.

7. A method for assembling a vacuum switchgear comprising a vacuum container enclosed with upper, lower, and side plate materials, a plurality of switches containing movable electrodes which are held on movable electrode rods and opposite stationary electrodes held on stationary electrode rods in said vacuum container, one or more bus conductors which connect the movable or stationary electrode rods of said switches, a plurality of operation rods which are respectively connected to the movable electrode rods of said switches and partially connected to an operation means outside said vacuum container, a plurality of load-side rods which are respectively connected to the stationary electrode rods of said switches and partially protruded outside from said vacuum container, a plurality of insulating bushings provided inside and outside said vacuum container to cover each of said load-side rods, wherein each of said insulating bushings is partially held on the inner wall of said vacuum container; the method further comprising the steps of:

dividing constituent elements of said vacuum switchgear assembly into parts, dividing each of said parts into an upper part group which is to be placed on said upper plate material and a lower part group which is to be placed on said lower plate material, filling spaces among non-insulating parts in said part groups with a brazing material, heating thereof, cooling the molten brazing material to fix them with the brazing material, mounting said lower part group on said lower plate material, applying a brazing material to spaces between the insulating parts and the parts to be brazed, heating thereof at a temperature lower than the above selected temperature, cooling the molten brazing material to fix said insulating parts and said parts to be brazed with the brazing material, matching the upper plate material having said upper part groups oppositely with the lower plate material having said lower part groups, fitting said side plate material to said upper and lower plate materials, welding said upper and side plate materials together, welding said lower and side plate materials together, evacuating air from said vacuum container, and sealing said vacuum container hermetically.

8. A method for assembling a vacuum switchgear assembly according to Claim 7, wherein each of said insulating bushings has an electro-conductive film on a surface facing to the corresponding load-side rod.

FIG. 1

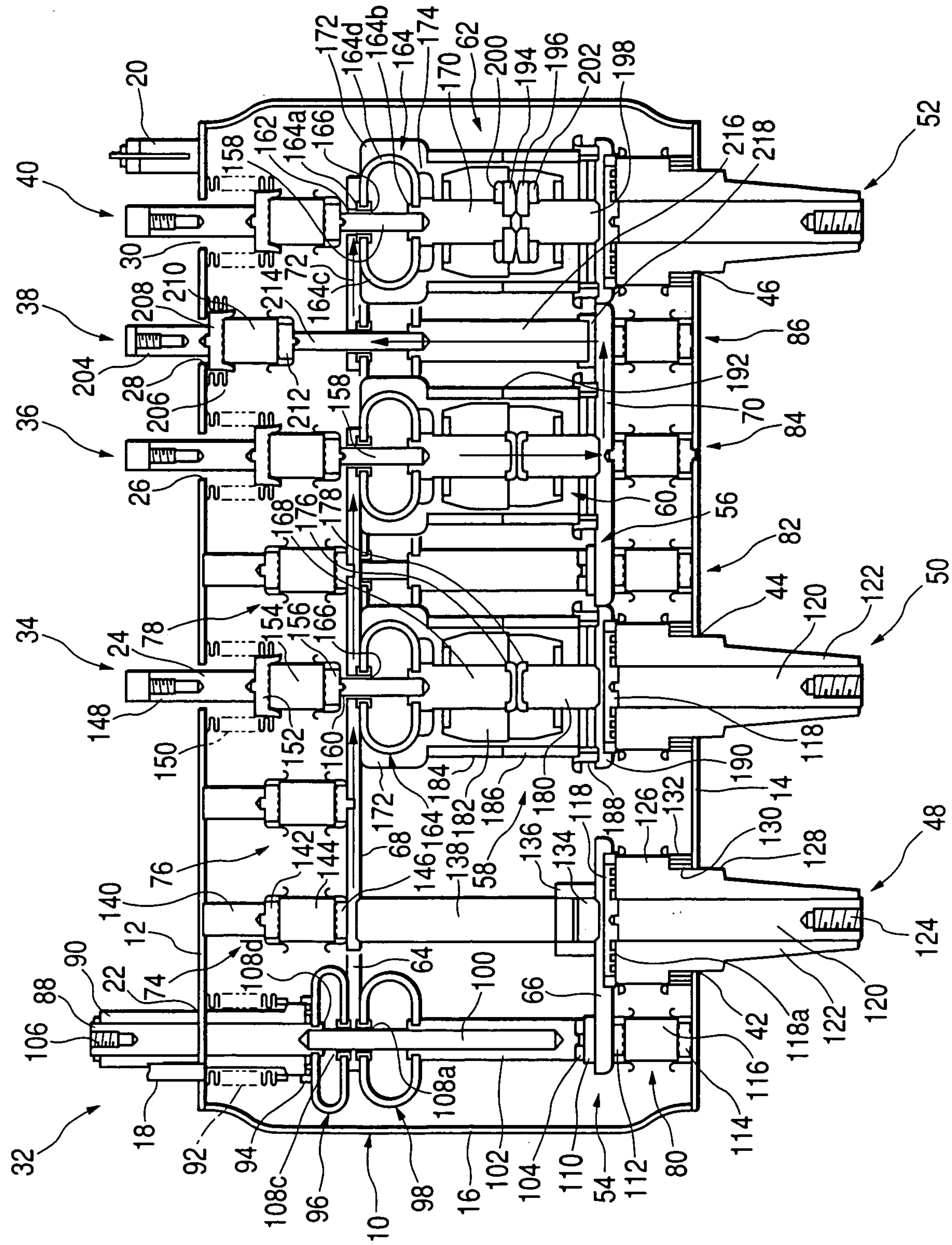

FIG. 2

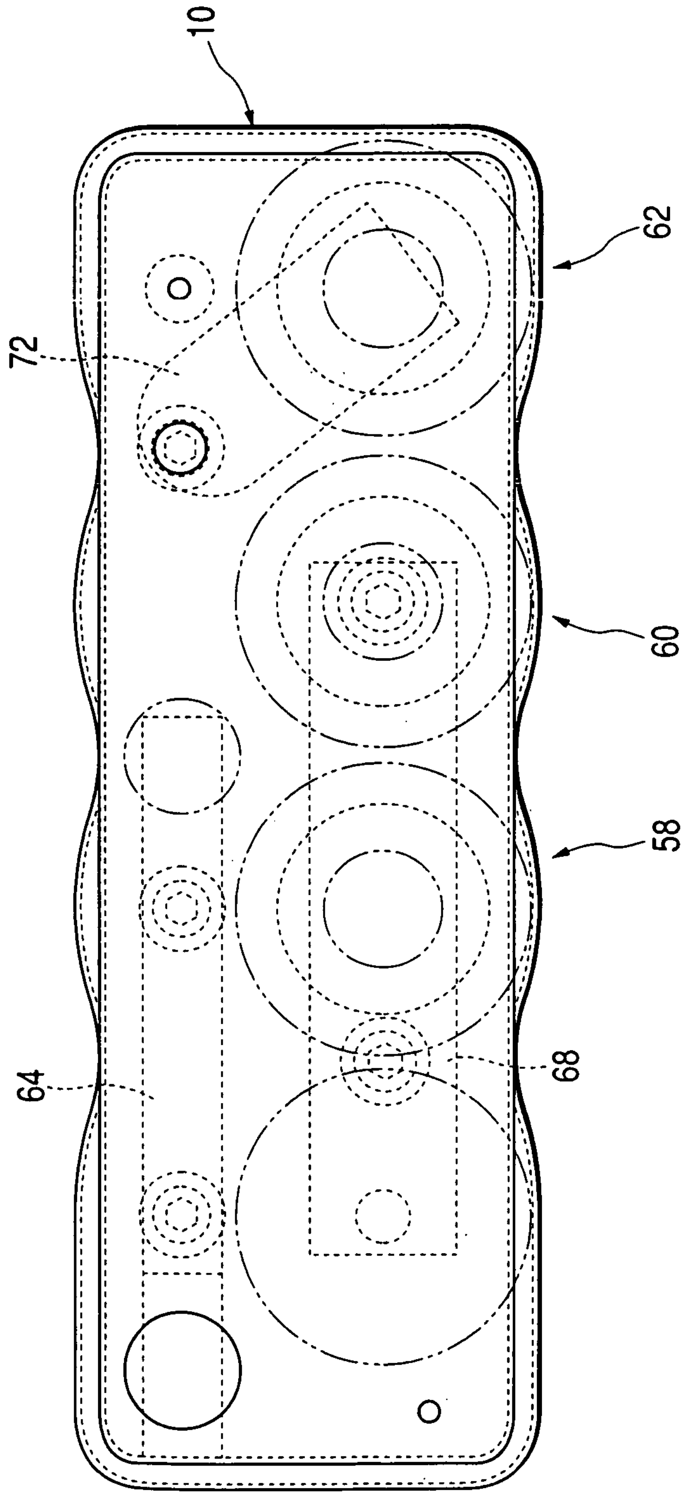

FIG. 3

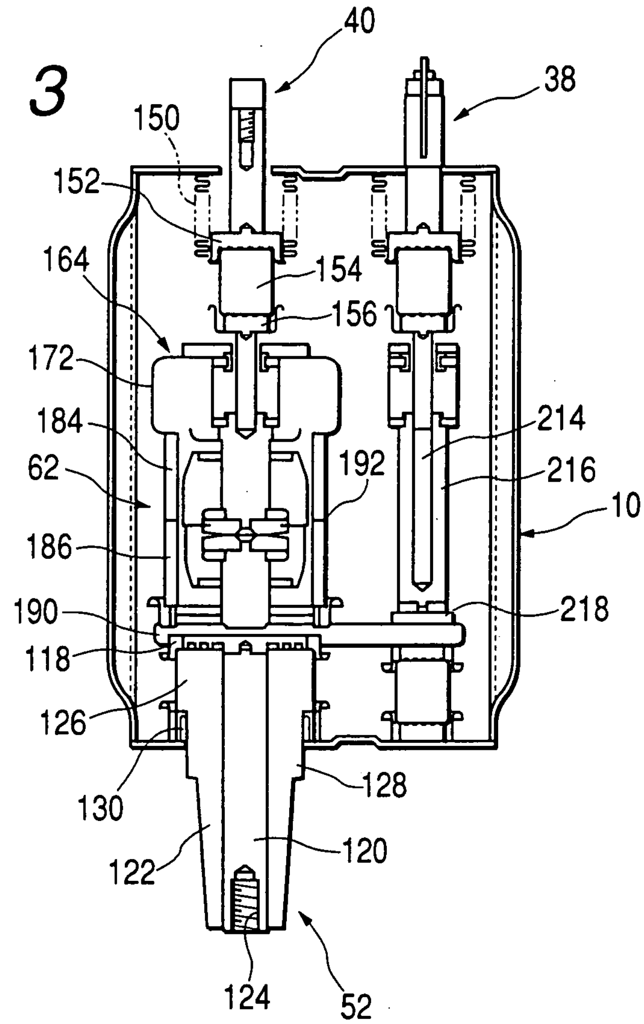
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FIG. 4

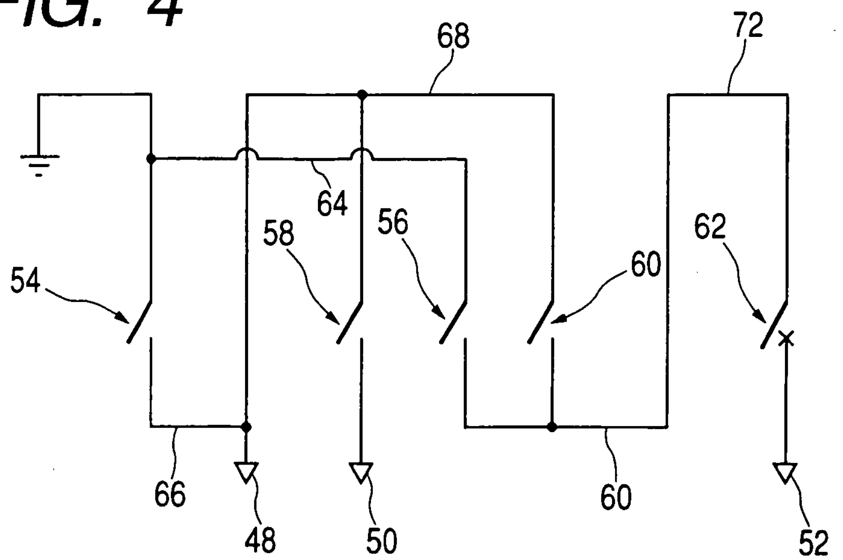
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FIG. 5(a)

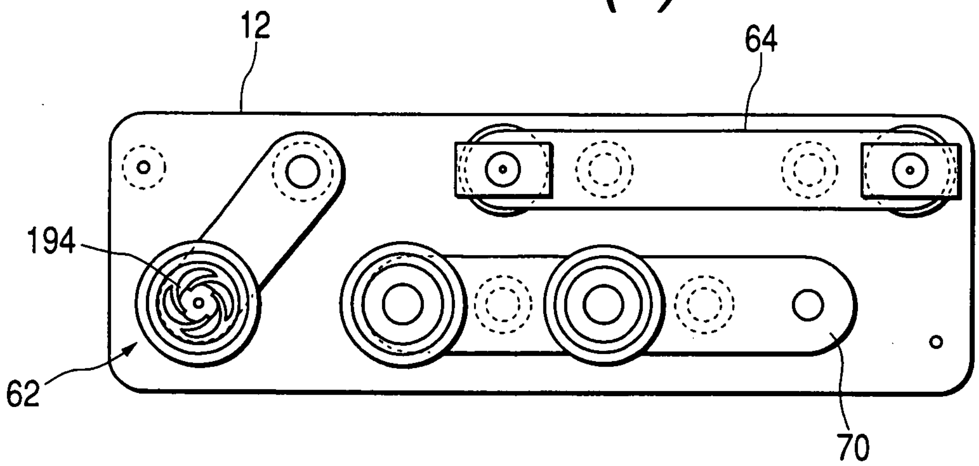

FIG. 5(b)

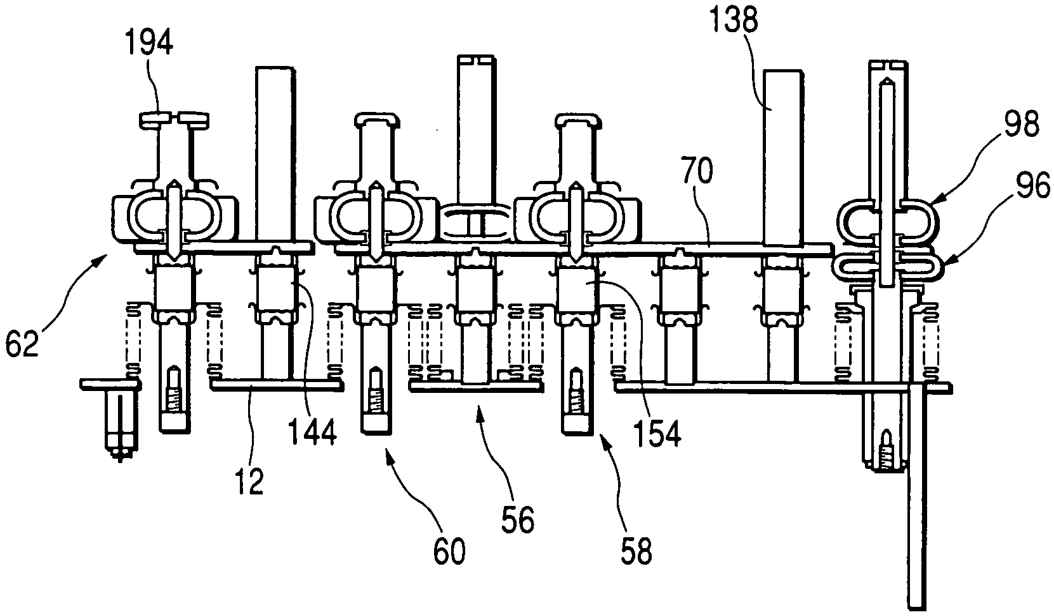

FIG. 6(a)

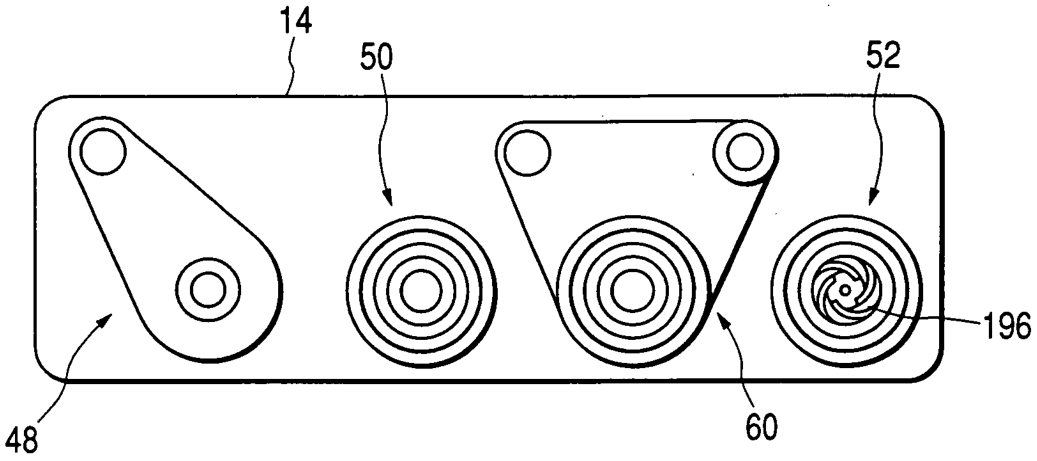
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FIG. 6(b)

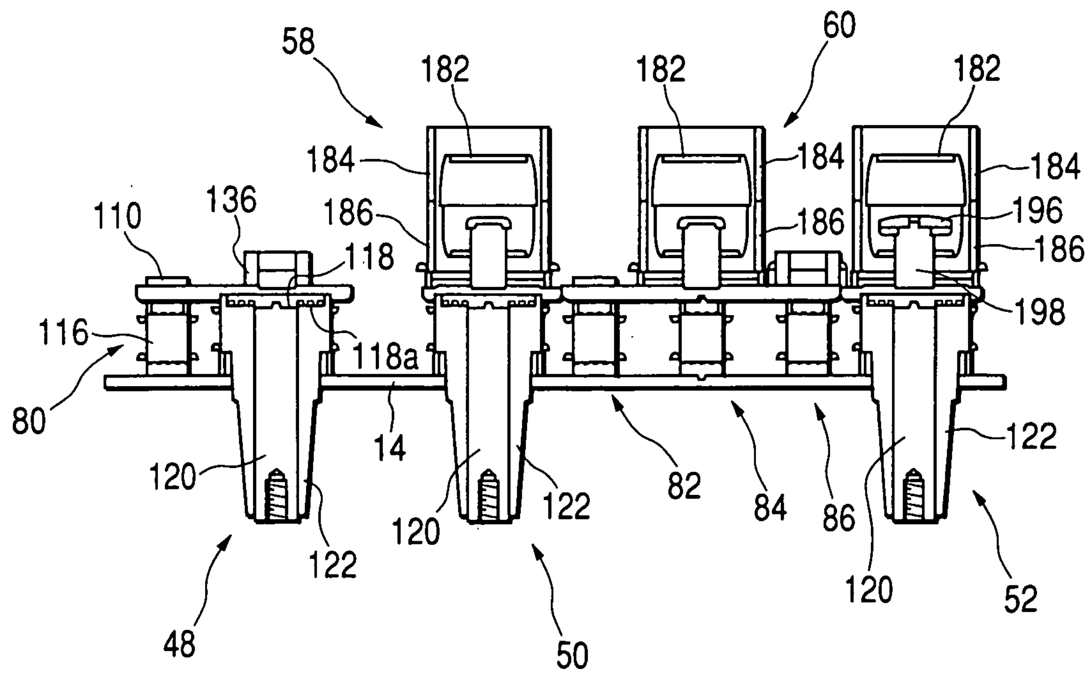
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FIG. 7

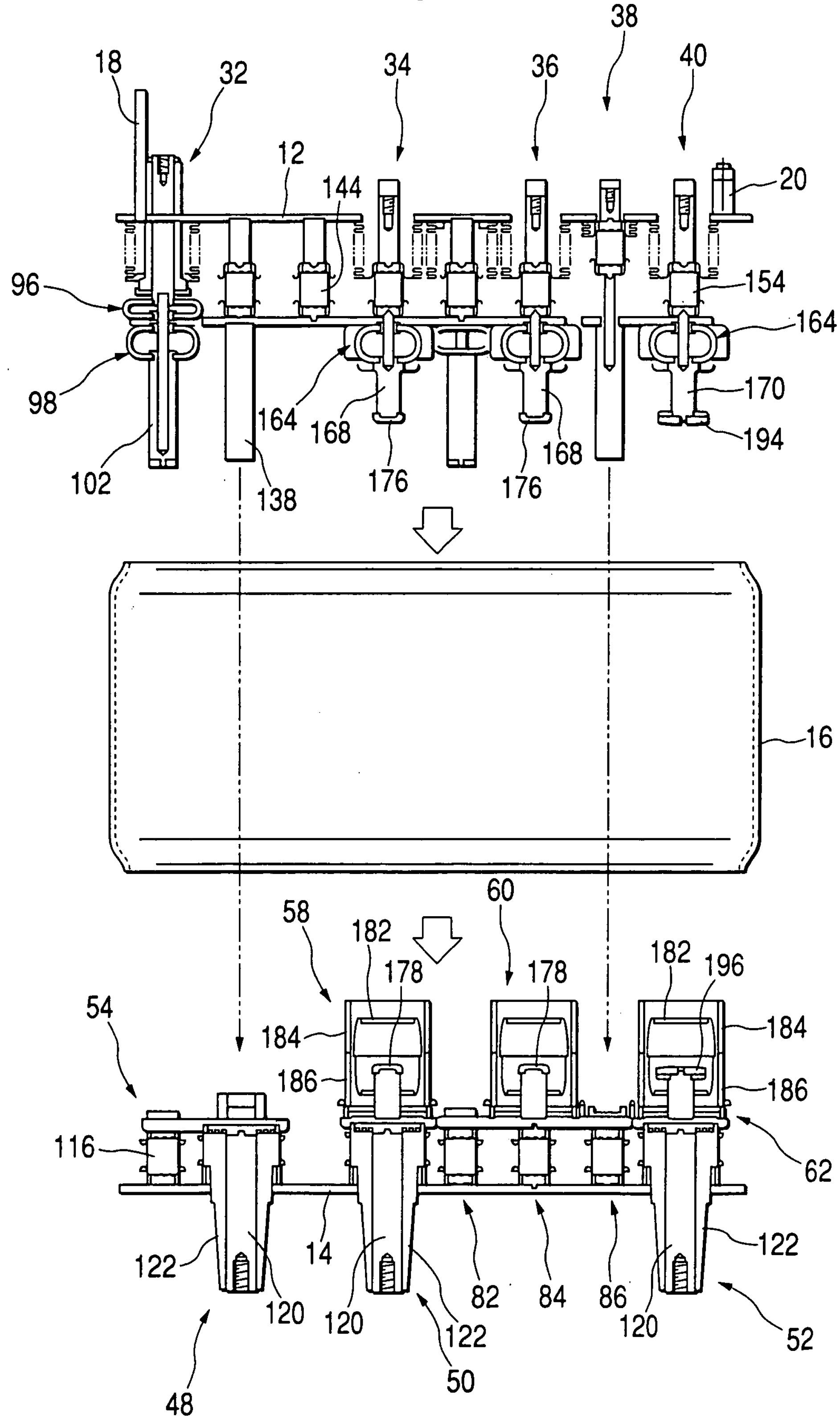

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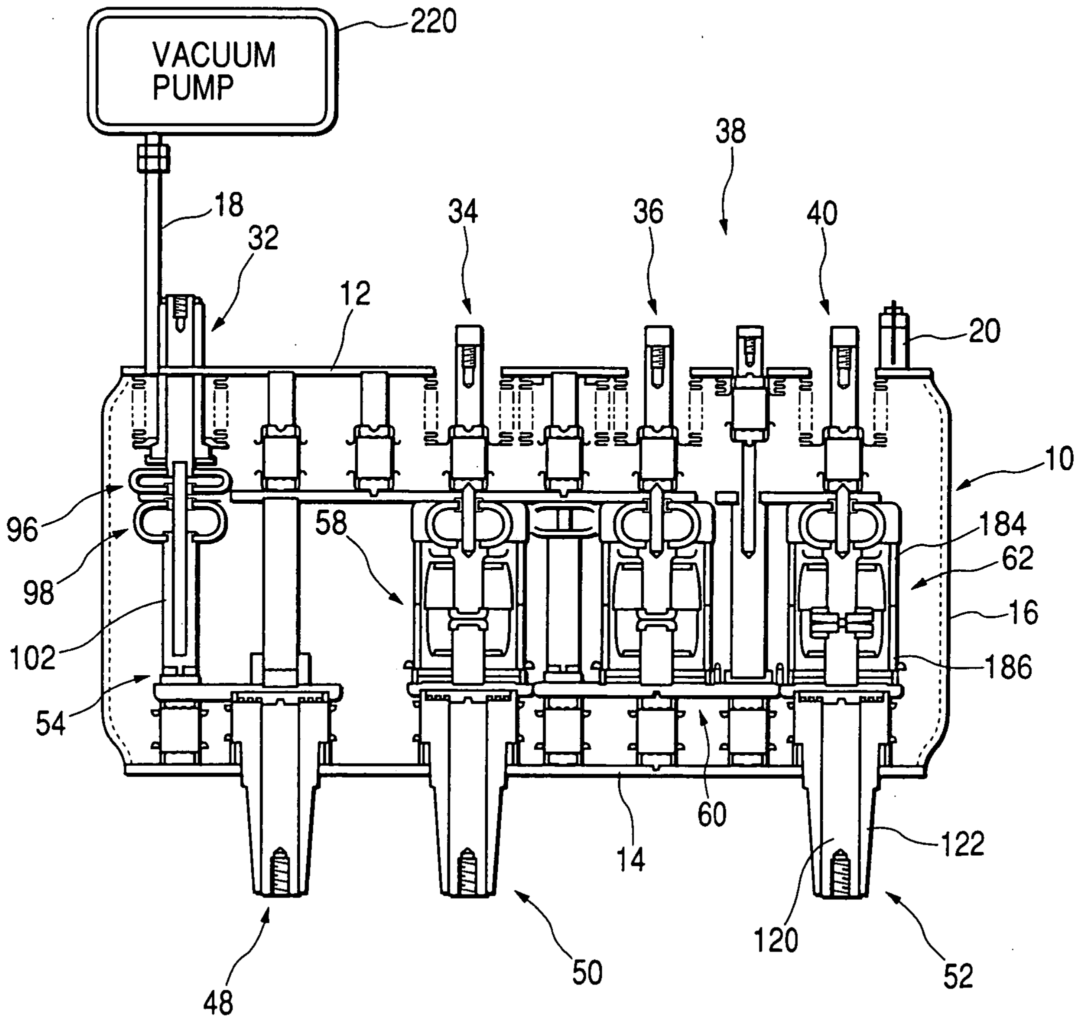
FIG. 8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52

FIG. 9

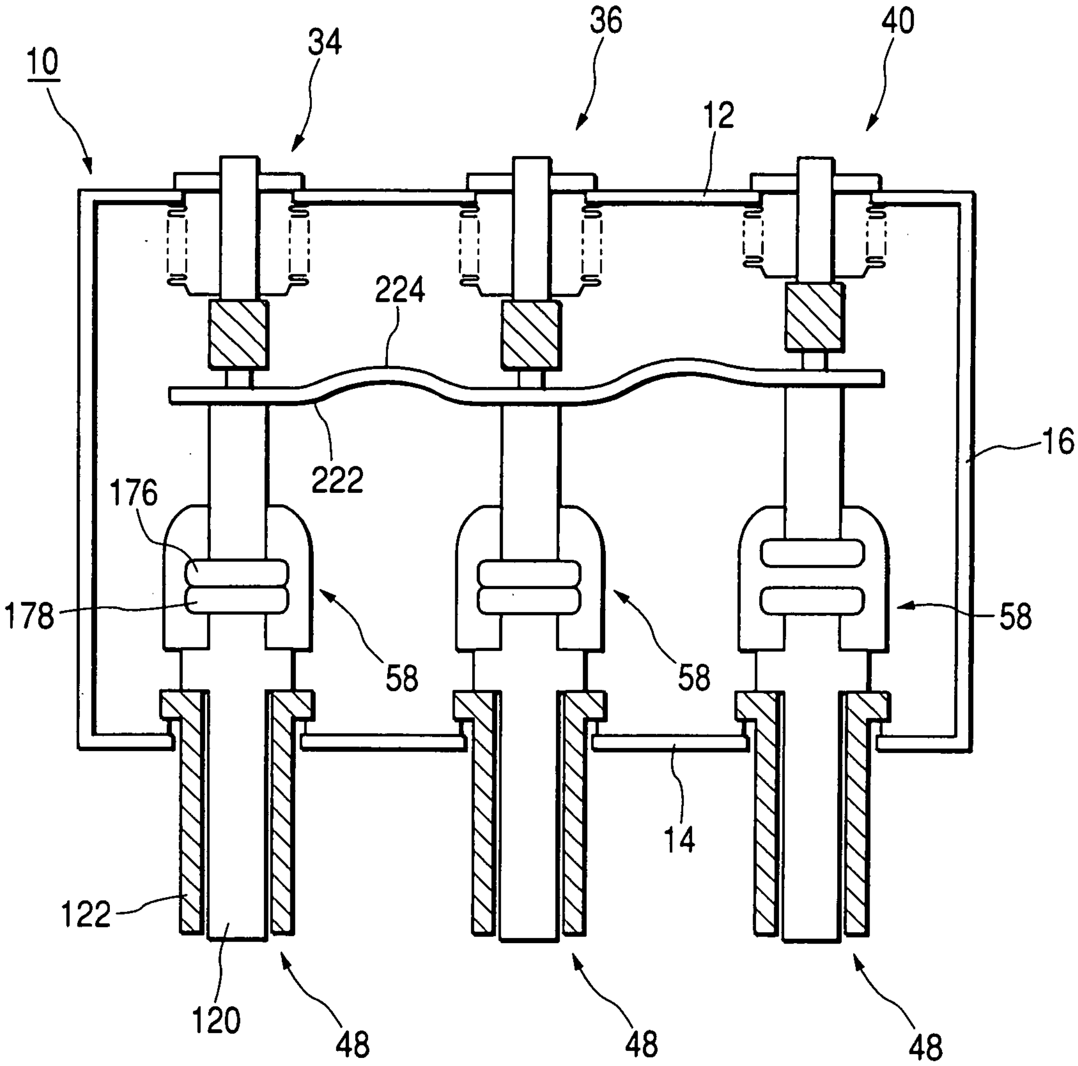


FIG. 10

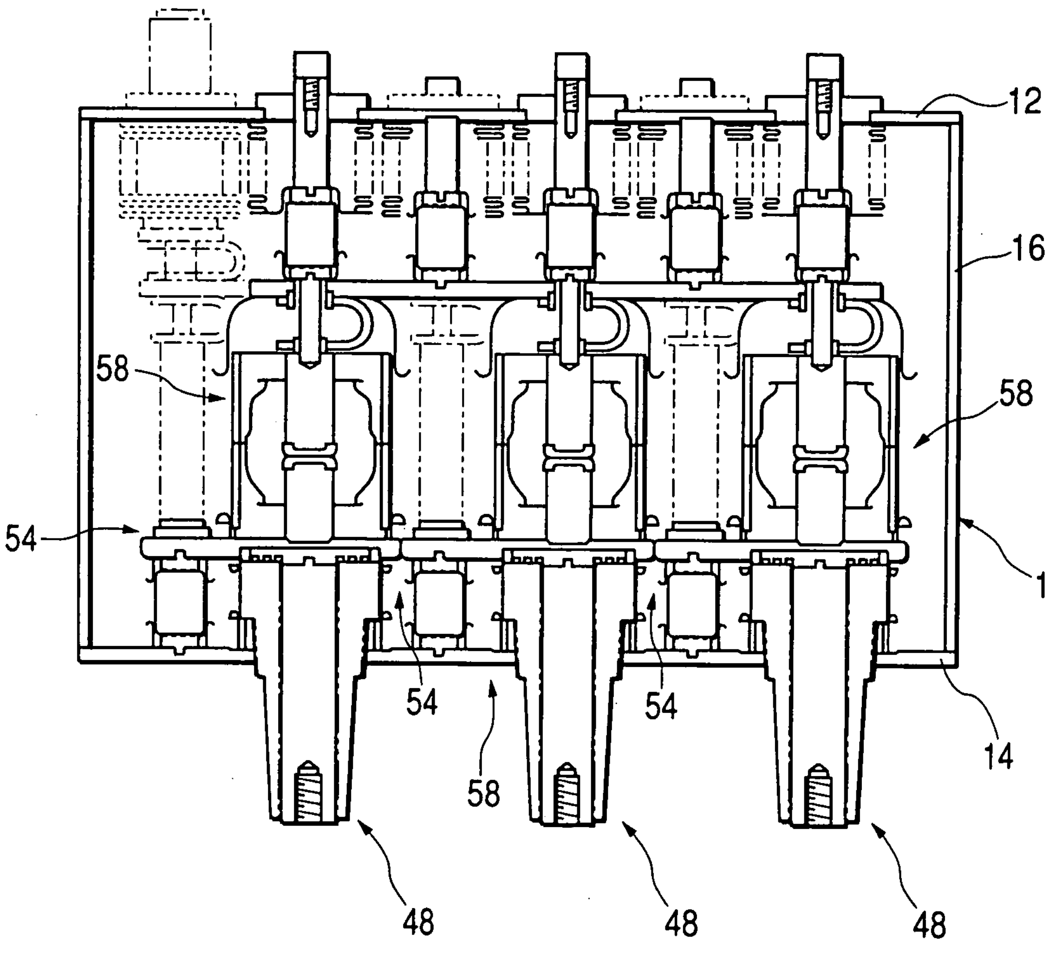


FIG. 11

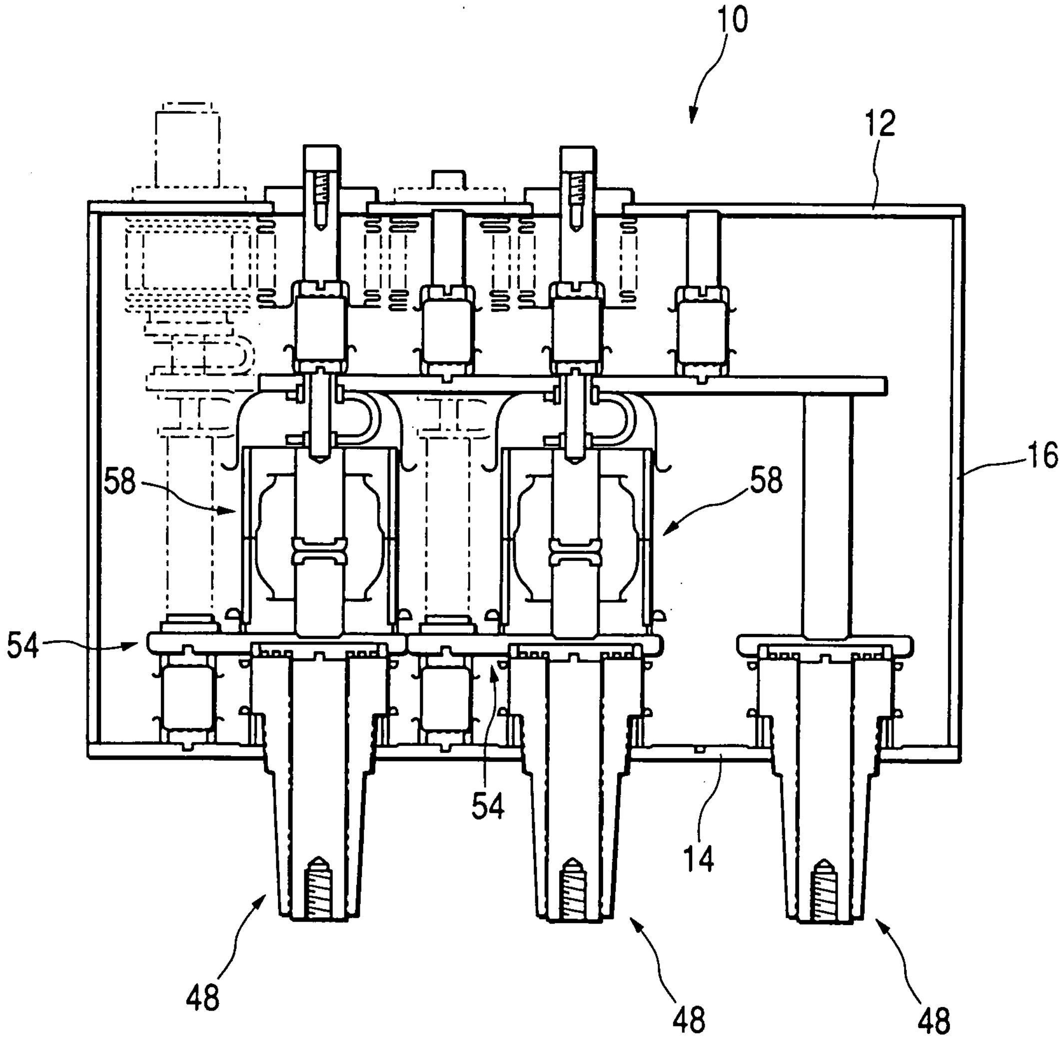
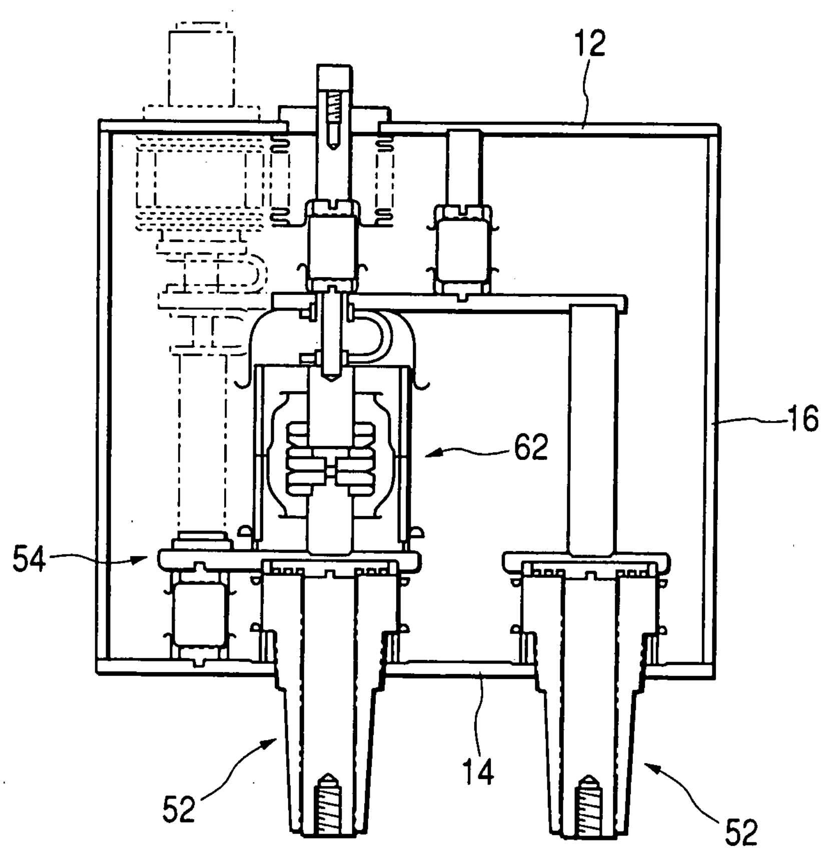


FIG. 12



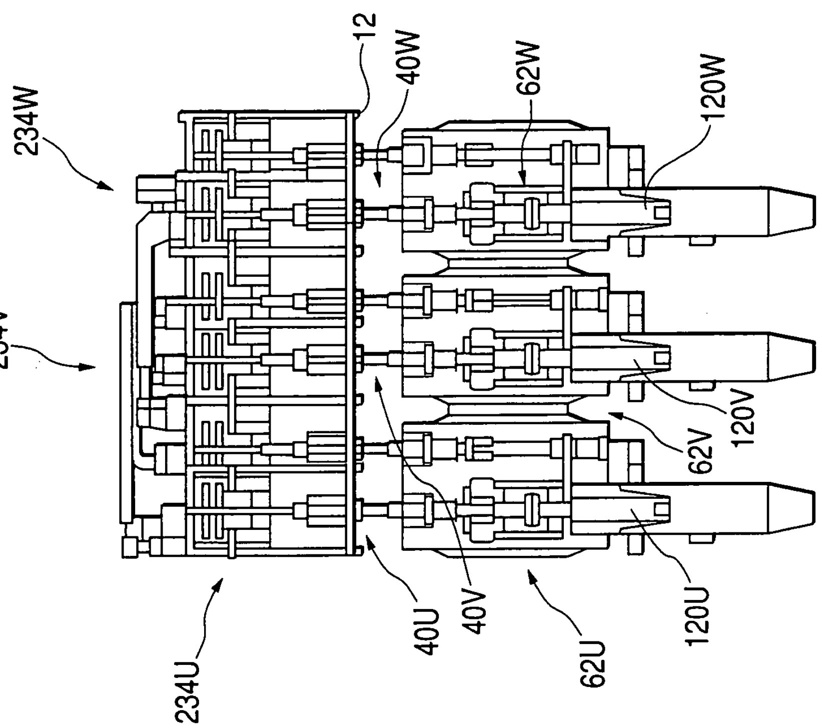


FIG. 13(b)

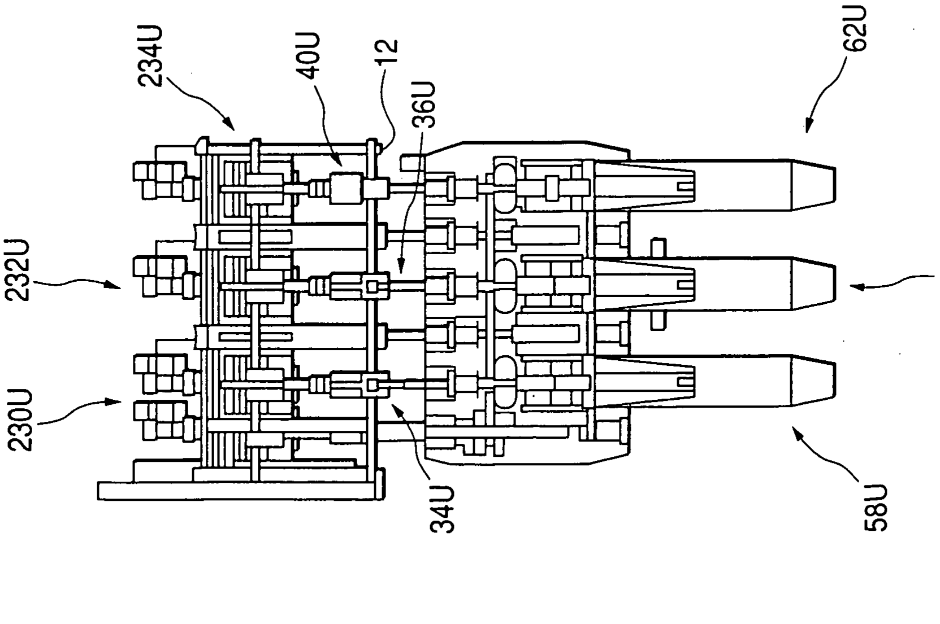


FIG. 13(a)

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Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	12 September 2003	Nieto, J.M.

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& : member of the same patent family, corresponding document

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The present search report has been drawn up for all claims

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