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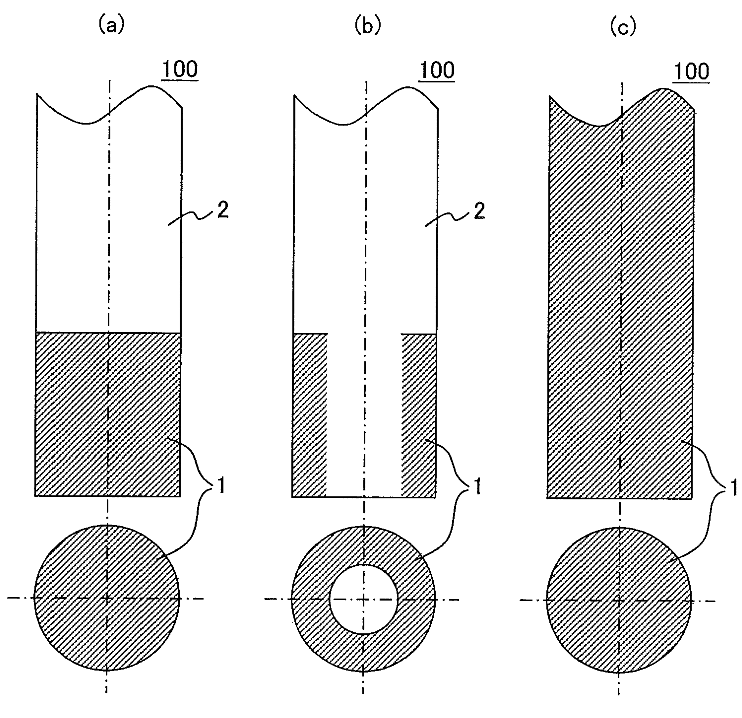
(54) **Electrical contact and switch device using same**

(57) An electrical contact made of a sintered body comprising particles of a refractory metal selected from the group consisting of C, Mo and W, particles of copper with an electrical conductivity of 95 % or more of an oxygen free pure copper, and particles of an easily oxidizable metal having a free energy for oxide formation lower than those of the refractory metal and the high conductive metal, and a melting point of the easily oxidizable metal being high than that of the high conductive metal, wherein the particles of copper bind the particles of the refractory metal and easily oxidizable metal.

FIG. 1



EP 2 362 400 A2

Description

Field of the invention:

[0001] The present invention relates to an electrical contact for closing and interrupting current in air or in vacuum by sliding and a switch device using the same.

Background art:

[0002] In circuit breakers and switches as protecting devices of power receiving-distributing systems, current interrupting devices are generally constituted in vacuum because of good insulation, arc dispersion and dissipation so that interruption of current is effectively carried out. Therefore, a vacuum container for maintaining vacuum atmosphere is necessary, which leads to complexity of structures and manufacturing methods.

[0003] However, the switch devices should be small-sized and at low cost, which need simplification of structures. Accordingly, switch devices, which do not need vacuum containers and are simple in structures and are capable of switching in air are desired. In order to down size the switch devices, down-sizing an operating mechanism for operating electrical contacts is particularly effective. In order to simplify the operating mechanism, it is necessary to make small a separation force for separating contacts welded by joule heat at the time of current interruption. Further, because the contact between the electrical contacts accompanies sliding (friction) more or less, the electrical contacts should have good friction resistance and a small ware by sliding. Accordingly, the electrical contacts of this type should conduct and interrupt current in air without any problems, have a small separation force and have a good anti-wearing.

[0004] Patent document No. 1 discloses electrical contacts for use in air with high density, good electrical characteristics and properties. The electrical contacts are made of a sintered body of Cu-W, Cu-Mo, etc impregnated with molten Cu to thereby densify them to improve electrical characteristics such as electrical conductivity. The contacts materials contain a sliding property improving component such as BN, etc to improve air sliding properties.

[0005] Patent document no. 2 discloses an electrical contact for use in vacuum valves, which comprises a sintered material of a high conductive metal powder such as copper alloy containing Mg, Al, Ti, Cr, Zr, Sn, Sn, Zn, Ni, Co, Fe, Mn and/or Sn and a refractory metal powder such as Cr, W, Nb, Ta, Mo, Be, Hf, Ir, Pt, Zr, Ti, Si, Rh and/or Ru. The electrical contacts are used for a vacuum valve. The high conductive metal powder is an alloy of copper containing various metal elements, which increase electric resistance of the copper alloy even if an amount of alloying elements is small. The alloying elements include such low melting point metals such as Al, Sn and Zn.

[0006] Patent document No. 3 discloses an electrical contact for a vacuum valve, which comprises a high electrical conductive metal such as copper alloy, active components such as metal oxides and a refractory metal such as titanium.

(Patent documents)

[0007]

No. 1 Japanese patent laid-open H09-111312
No. 2 Japanese patent laid-open 2003-147407
No. 3 Japanese patent laid-open 2004-211192

[0008] Electrical contact materials for switch devices are generally made of composite materials comprising a high electrical conductive metal and a refractory metal. The refractory metal imparts anti-arc property and voltage withstanding performance to the electrical contacts. The refractory metal has a melting point of 1800 °C or higher. The high electrical conductive metal gives a high electrical conductivity to the electrical contact, which is typically copper and has a specific resistance of 3 $\mu\Omega \cdot$ cm or less at room temperature.

[0009] The electrical contact materials containing these elements should be free from defects and sound dense body so as to secure the good electrical conductivity. In addition, the electrical contacts should be separated easily when the contacts are welded by joule heat at the time of current interruption. Thus the electrical contacts should preferably have a low mechanical strength.

[0010] In order to improve sliding properties and anti-wearing property of the electrical contacts for use in air, the electrical contacts disclosed by patent document No. 1, which contains boron nitride powder has poor sintering property because of BN powder. It is difficult to increase density of the contact materials by conventional low cost sintering methods. Accordingly, copper impregnation method wherein molten copper is impregnated into a sintered refractory metal body increase a production cost.

Summary of the invention:

[0011] It is an object of the present invention to provide an electrical contact using a refractory metal as an anti-arc component for use in air, which has good sintering property to make a dense contact material, a small separation force for separating welded contacts by lowering mechanical strength of the welded part of the contacts and has a good sliding properties in air. It is another object to provide a switch device using the electrical contact mentioned above.

[0012] The present invention provides:

(1) An electrical contact made of a sintered body comprising particles of a refractory metal selected from the group consisting of C, Mo and W, particles of copper with an electrical conductivity of 95 % or more of an oxygen free pure copper, and particles of an easily oxidizable metal having a free energy for oxide formation lower than those of the refractory metal and the high conductive metal, and a melting point of the easily oxidizable metal being high than that of the high conductive metal, wherein the particles of the high conductive metal bind the particles of the refractory metal and easily oxidizable metal.

(2) The electrical contact according to (1) above, wherein oxides formed from the easily oxidizable metal has a hexagonal.

(3) The electrical contact according to (1) or (2) above, wherein the easily oxidizable metal is a member selected from the group consisting of Co, Be, Fe, Si, Ti, Zr, B, V, Nb and combinations thereof.

(4) The electrical contact according to any one of (1) to (3) above, wherein an amount of the refractory metal is 1 to 60 % by volume, and an amount of the easily oxidizable metal is 0.3 to 6 % by volume.

(5) An electric current switch device for closing and opening electrical contacts in air that uses the electrical contacts according to any one of (1) to (4) above, wherein a pair of the contacts is bonded to both ends of a conducting rod.

(6) The electric current switch device according to (5) above, which is connected to a switch device that closes and opens current in vacuum.

(7) A method of manufacturing the electrical contact according to any one of (1) to (4) above, which comprises:

mixing particles of the refractory metal, easily oxidizable metal and the copper;
molding a resulting mixture to obtain a molding with a theoretical relative density of 65 % or more; and
sintering the molding at a temperature lower than the melting point of the copper.

(8) The method according to (7) above, which further comprises heating the resulting sintered body at 200 °C or higher in air or oxidative atmosphere.

[0013] The electrical contact according to the present invention contains a refractory metal selected from one of carbon, molybdenum and tungsten and copper as a high electrical conductive metal and a easily oxidizable metal having a standard free energy for formation of metal oxides being smaller than those of copper and the refractory metal and having a melting point higher than copper.

[0014] The electrical contact according to the present invention has an oxide layer of a hexagonal crystal structure on at least its surface opposed to the other contact.

[0015] The easily oxidizable metal is one or more selected from the group consisting of Co, Be, Fe, Si, Ti, Zr, B, V and Nb.

[0016] According to the present invention, it is possible to provide an electrical contact having good interrupting properties and low separation force for separating welded contacts for use in air, and to provide a switch device using the electrical contact.

Brief description of drawings:

[0017]

Fig. 1 shows cross sectional views of contact rods of an embodiment of the present invention.
Fig. 2 shows diagrammatic cross sectional vies of a switch device of another embodiment of the present invention.
Fig. 3 shows diagrammatic views relating operations of the switch devices of the present invention.

Detailed description of the preferred embodiments:

[0018] The present inventors have conceived that in order to attain good anti-wearing properties (slidability) of electrical contacts in air, sliding between sliding faces of the opposed electrical contacts should be carried out by wearing with oxidation. That is, wearing should take place by means of oxides. That is, the larger the amount of oxides formed at the surfaces of the electrical contacts by temperature elevation by friction heat, the smaller the wearing amount (erosion loss) of the electrical contacts. This is because only the very surface composed of oxide film is removed by friction, which is regarded as oxidative wear. On the other hand, if an amount of oxides on the surfaces of the contacts is small, the contact between the electrical contacts is direct contact of metallic materials, which causes the electrical contacts to be adhered, separated or fallen down. These wearing states are adhesive wear or abrasive wear, in which a wear amount is large. Accordingly, the surfaces of the electrical contacts should preferably be easy to form oxides by friction heat.

[0019] In order to balance the densification of the electrical contact material and lowering of the mechanical strength of the contacts, separation or dissociation of the refractory metal particles and the high electrical conductive metal particles is important. Proper combinations of the refractory metal and the high electrical conductive metal cause the separation or dissociation to lower the mechanical strength of the contact material so that a separation force of the welded contacts can be lowered.

[0020] The easily oxidizable metal should have a melting point higher than copper so that in manufacturing the sintered contact material from the refractory metal powder, copper powder and the easily oxidizable metal powder it is possible to avoid formation of copper alloys wherein the easily oxidizable metals alloy with copper. That is it is possible to avoid increase of electrical resistance of copper.

[0021] Based on the above knowledge, the present inventors invented the electrical contact made of a sintered body comprising one refractory metal selected from the group consisting of carbon, molybdenum and tungsten, copper as the high electrical conductive metal and the easily oxidizable metal having the standard free energy for formation of oxides lower than those of the refractory metal and copper so that oxides of the easily oxidizable metals are formed on the surface of the contacts in air by friction heat in air. As a result, the abrasion phenomenon becomes oxidative wear to suppress the wear of the contact. Since C, Mo and W do not react with or dissolve in copper, separation or dissociation of the refractory metals and copper easily takes place to lower the separation force.

[0022] The sintered contact material of the present invention is featured by the refractory metal powder particles, copper powder particles and the easily oxidizable metal powder particles being present in the sintered contact material without forming alloys with one another, wherein copper having the lowest melting point may work as a binding material for the powders.

[0023] The easily oxidizable metals form oxides of a hexagonal crystal structure. The hexagonal crystals improve sliding property by self-lubricating effect by interlayer shearing of the hexagonal planes of the crystals to relief friction ware in the contact faces.

[0024] The easily oxidizable metals that satisfy the above requirements include Co, Be, Fe, Si, Ti, Zr, B, V and Nb. These metals are used singly or in combinations of two or more. These metals form easily oxides on the surface of the contacts by friction heat or the hexagonal crystals formed in the surface of the contact lowers abrasion wear or improve sliding properties.

[0025] In the electrical contacts of the present invention, an amount of the refractory metal should preferably be 1 to 60 % by volume per the volume of the contact. If the amount of the refractory metal is less than 1 % by volume, reduction in mechanical strength by separation or dissociation of the refractory metal and copper is insufficient, and reduction in separation force is insufficient. If the amount of the refractory metal is more than 60 % by volume, densification of the sintered body becomes insufficient and electrical resistance increases to bring about insufficient anti-adhesion and improper current conduction. Preferable amounts of C, Mo and W are, by volume, C: 1.0 to 4.0 %, Mo: 8.0 to 32.0 %, and W: 15.3 to 60.0 %.

[0026] In the electrical contact of the present invention, an amount of the easily oxidizable metal should preferably be 0.3 to 6 % by volume. If the amount is less than 0.3 %, formation of oxides is insufficient, which leads to insufficient improvement of the sliding properties. If the amount is larger than 6 %, an excessively thick oxide layer is formed in the surface of the contact to hinder electrical conduction.

[0027] A method of manufacturing the electrical contact of the present invention comprises mixing the refractory metal powder, copper powder and easily oxidizable metal powder, compression molding the mixed powder to produce a molding with a density of at least 65 %, and sintering the molding at a temperature lower than the melting point of copper (1083 °C). According to this method, the refractory metal powder particles, easily oxidizable metal powder particles and the copper powder particles are distributed homogeneously in the sintered body and there are separation gaps or voids among the refractory metal powder particles and copper powder particles so that the separation force of the welded contacts can be remarkably reduced. The voids may be formed by shrinkage difference in thermal expansion coefficients of the refractory metal and copper, which are formed during cooling after the sintering.

[0028] Since the copper powder has a larger thermal expansion coefficient than the refractory metals, copper particles shrink more than the refractory metal particles, and the tensile force may generate in the copper particles. If the sintered body is cut for observing the sectional area the tensile force is released to form the voids in the sintered body. When a tensile force is applied to the sintered body, the tensile force is in the copper particles is released by destruction to form the voids. As having described above, formation of the tensile force in the copper particles near the interfaces of the particles is important. Therefore, a cooling rate of the sintered body should preferably be 6 to 35 °C/ min.

[0029] Since the easily oxidizable metal powder particles are present homogeneously in the contact material, it is possible to form an oxide layer in the surface thereof during the sliding in air. This oxide layer exhibits the sliding characteristics effectively. In the above method, it is possible to manufacture molding having a near-net shape when a mold having a shape of a final contact, which eliminates machining work after sintering to thereby cut the cost.

[0030] The method of manufacturing the electrical contacts of the present invention may comprise heating the sintered body at 200 °C to 400 °C in air or an oxidative atmosphere so as to an oxide layer is formed in the surface of the sintered body to improve anti-wear property at the initial sliding state of the contact. If the heating temperature is lower than 200 °C, formation of oxide layer is insufficient, and if the temperature is higher than 400 °C, a thickness of the oxide layer becomes too large, which leads to cracks or peel-off of the oxide layer.

[0031] The switch device of the present invention uses a pair of the electrical contacts disposed at both ends of a conduction rod, which moves along an axis thereof in air to close or interrupt current. The conduction rod with electrical contacts at both ends is moved by an operating mechanism whereby one of the electric contacts makes a contact with a closing electrode at the time of closing current. When the conduction rod moves towards current interruption, the electric contact separates from the closing electrode and makes a contact with a disconnection electrode and the other electric contact makes a contact with an earthing electrode.

[0032] The closing and interruption of current accompanies sliding with other conductive members of the switch device, which makes the device small in size, simple in structure and low in cost.

[0033] The switch device of the present invention is provided with an operation mechanism for moving the conduction rod having the electrical contacts. The operating mechanism can be disposed in vacuum so that the closing of current and interruption of large current such as accident current can be carried out in vacuum and small current in switching of circuits are carried out in air. That is, according to current capacity, the operating mechanism can be used to provide switch devices with high reliability at low cost.

[0034] In the following, the embodiments of the present invention will be explained in detail by reference to drawings.

(Embodiment 1)

[0035] Electrical contacts having compositions shown in Table 1 were prepared and electrical characteristics and wear amounts in air were measured.

Table 1

	No.	Composition (vol. %)						Conductivity (relative value)	Wear amount (mm^3/m)	Separation force (relative value)*	Comments
		High conductive metal	Refractory metal		Easily oxidizable metal						
		Cu	Mo	W	Nb	Zr	Fe				
INVENTION	1	balance	8	-	1.5	-	-	0.90	1.74	0.64	
	2		18	-	1.5	-	-	0.74	2.76	0.31	
	3		18	-	-	1.5	-	0.74	2.81.	0.30	
	4		18	-	-	-	1.5	0.73	2.96	0.31	
	5		32	-	1.5	-	-	0.64	4.03	0.44	
	6		-	15	1.5	-	-	0.83	0.20	0.64	
	7		-	41	0.3	-	-	0.67	0.16	0.51	
	8		-	41	1.5	-	-	0.64	0.07	0.47	
	9		-	41	6.0	-	-	0.61	0.03	0.49	
	10		-	60	1.5	-	-	0.60	0.01	0.39	
COMPARA.	11		-	-	-	-	-	1.0	Adhesion Impossible to measure	1.0	Standard value for relative values
	12		18	-	-	-	-	0.76	6.05	0.36	
	13		-	41	-	-	-	0.63	0.22	0.53	
	14		-	41	0.1	-	-	0.68	0.21	0.53	
	15		-	41	7.0	-	-	0.53	0.01	0.54	

[0036] Methods of manufacturing the electrical contacts are as follows.

[0037] Raw materials were copper power having a particle size of 60 μ m or less as the high conductive metal, Mo powder and W powder having a particle size of 63 μ m, and Nb powder, Zr powder and Fe powder having a particle size of 5 μ m or less as the easily oxidizable metal. These raw material powders were mixed in compositions shown in Table 1 using a V type mixer.

[0038] The mixed powders were filled in a metal mold having a disc form, and the filled powders were compression-molded under a pressure of 294 MPa to obtain moldings with a theoretical relative density of about 72 %. After the resulting moldings were heated in vacuum of 10^{-2} Pa at 1060 °C for 2 hours, they were cooled at a cooling rate of about 13 °C/min. to produce electrical contact materials. As comparative electrical contact materials, a contact material using copper powder only and contact materials not containing easily oxidizable metal were prepared. The sintering can be carried out not only in vacuum, but also non-oxidizing atmosphere or inert gas atmosphere cane be utilized.

[0039] As electrical characteristics of the resulting electrical contact materials, conductivity thereof (current conduction) were measured using an eddy current type conductivity measuring device. The results are show in Table 1.

[0040] The conductivity is shown as relative values with respect to the contact material (No. 11) composed of copper only. The contact materials No. 1 to No. 10 exhibit conductivity of 0.6 or more, which keeps good conductivity applicable for air contacts. The comparative contact materials No. 12 to 14 exhibit fairly good conductivity, but when an amount of the easily oxidizable metal exceeds 6 volume %, the conductivity becomes less than 0.6.

[0041] Abrasion rates in air were measured by a Matsubara type abrasion test method. A counter member for abrasion was made of oxygen-free copper. Abrasion test pieces were fixed pieces (10 X 10 X 36 mm) made of the contact materials, and the abrasion counter member were movable pieces of a ring shape (an outer diameter; 25.6 mm, an inner diameter; 20 mm and a length of the ring; 15 mm) made of oxygen-free copper.

[0042] After the fixed contact materials were heated at 200 °C for 30 minutes in air, the fixed test pieces and the movable test pieces were contacted under a load of 98 N and the movable test pieces were rotated at a speed of 200 mm/sec. An abrasion rate was measured by dividing the abrasion volumes of the fixed test pieces with sliding distances. The results are shown in Table 1.

[0043] The contact material (No. 11) made of copper only generated adhesion immediately after the sliding test, and accordingly, the abrasion rate could not be measured. In cases where the easily oxidizable metals are not contained, the contact material (No. 12) containing Mo exhibited an abrasion amount larger than the contact material (No. 13) containing W.

[0044] The contact materials (No. 1 to 5) containing Mo and the contact materials (No. 6 to 10) containing W exhibited small abrasion amounts. That is, it was confirmed that addition of the easily oxidizable metals improved the anti-abrasion. When the easily oxidizable metals are contained in the contact materials, friction heat produces brittle, a high melting point surface oxide layer is easily formed so that oxidative wear takes place by removing only oxide layer without adhesion.

[0045] The easily oxidizable metals are one or more of Nb, Zr, Fe (No. 2 to 4) and other metals such as Co, Be, Si, Ti, B and V. An amount of the easily oxidizable metal should preferably be 0.3 to 6 volume % per the whole contact materials (No. 7 to No. 9). If the amount is smaller than 0.3 % by volume, effect of the easily oxidizable metals is not sufficient. If the amount is larger than 6 volume % (No. 15), conductivity becomes small even though the anti-abrasion property is good.

[0046] It was confirmed that the electrical contacts of the present invention has excellent electrical properties and anti-abrasion characteristics for use in air contacts.

[0047] Using the electrical contact material prepared in example 1, a contact rod shown in Fig. 1 was prepared.

[0048] In Figs. 1 (a) to (c), 1 denotes an electrical contact and 2 a conducting rod. A contact rod 100 is constituted by the electrical contact 1 alone or by a combination of the electrical contact 1 and the conducting rod 2. A method of preparing the contact rod 100 is as follows.

[0049] In case of Fig. 1(a), a solder material was placed between the electrical contact 1 prepared in example 1 and machined into a desired shape and the conducting rod 2 made of oxygen free copper machined into a desired shape in advance, and the assembly was heated in vacuum under a vacuum pressure of 8.2 X 10^{-4} Pa or less at 970 °C for 10 minutes to thereby metallurgically unite them.

[0050] Fig. 1 (b) shows a structure comprising the electrical contact 1 only on a portion, which contacts with a counter conducting part. In this case, Although it is possible to unite the electrical contact 1 machined into a ring shape as shown in Fig. 1 (a) and the conducting rod 2 by soldering, the electrical contact 1 and the conducting rod 2 can be integrated when a powder material for the electrical contact is molded into a ring form and the conducting rod 2 is inserted into the molding, followed by sintering, wherein the shrinkage of the powder molding is utilized at the sintering and cooling.

[0051] In case of Fig. 1 (c), the whole contact rod 100 was constituted by the electrical contact. In view of a cost and electrical conductivity, Figs. 1(a) and 1(b) wherein the contacting portion is constituted by the electrical contact material are preferable. In any case, the electrical contact 1 is machined into a final shape and then is sintered, whereby the conducting rod 100 can be produced at low cost and free from post-mechanical work.

[0052] An electrical contact having a diameter of 20 mm and a thickness of 20 mm was obtained from the electrical contact material prepared in example 1, and a separation force after current conduction in a butting state with a conducting rod in air was measured. The electrical contact 1 was soldered to the tip of the contact rod 100 shown in Fig. 1(a), and the assembly was heated in air at 200 °C for 30 minutes. A pair of contact rods 100 was subjected to a separation test for measuring a separation force by means of a simplified device, which makes contact and separation of the butted contact under a conduction voltage and current of 50 (kV · kA). The results are shown in Table 1.

[0053] The separation forces are shown as relative values with respect to those of the electrical contact (No. 11) made of copper only. In case where no easily oxidizable metal is contained, the separation forces are smaller in case of Mo (No. 12) as the refractory metal than in case of W (No. 13). When an amount of Mo and W is the same as in Nos. 2 to 4 and 7 to 9, abrasion amounts are smaller than the cases of Nos. 12 and 13. This is because the easily oxidizable metal forms a surface oxide layer to suppress welding and adhesion.

[0054] The above effects were observed when the easily oxidizable metal is contained in an amount of 0.3 to 6 volume % (Nos. 7 to 9) . When the amount is smaller than 0.3 volume %, no effect of lowering the separation force was observed, and when the amount is larger than 6 volume %, reduction in electrical conductivity and an increase in contact resistance caused by excessive oxide layer were observed. These phenomena lead to a slight increase of the separation force (No. 15).

[0055] As the easily oxidizable metals, any of Nb, Zr and Fe are useful (Nos. 2 to 4), and other metals such as Co, Be, Si, Ti, B, V or combinations thereof exhibit the same effect. These easily oxidizable metals should have a melting point higher than chat of copper so as to avoid alloying of the metals with copper.

[0056] In cases of W and Mo (Nos. 1, 5, 6, 10), when the amounts of Mo and W are small, the separation forces becomes larger because welding tends to occur. But, there is no problem from the practical point of view.

[0057] As having discussed, it was confirmed that the electrical contacts according to the present invention exhibited excellent anti-adhesion property.

[0058] Using the contact rod 100 prepared in example 2, a current switch device shown in Fig. 2 was assembled.

[0059] In Fig. 2, 1 denotes an electrical contact and 2 denotes a conducting rod, wherein the contact rod 100 has contacts 1 connected by soldering to both ends of the conducting rod 2. The soldering was carried out at 200 °C for 30 minutes in air. 3 denotes a closing electrode, 4 a disconnection electrode, and 5 an earth electrode, each being made of oxygen free copper. The electrodes 3, 4, 5 have inner diameters, which make a good contact condition with the electrical contact 1. The earth electrode 5 is connected to an earth.

[0060] The closing electrode 3, disconnection electrode 4 and earth electrode 5 are assembled in a manner that they are electrically insulated by an ceramic insulating cylinder 6. denotes a main circuit conductor, one end of which is connected to the closing electrode 3 and the disconnection electrode 4, and the other end is connected to an electric power switch device50, as shown in Figs. 3(a) to (d).

[0061] 9 denotes an operating rod, which is connected to one end of the contact rod 100 by means of an insulating connector 8, and the other end thereof is operated by an operator to operate the contact rod 100. An air space 10 confined by the closing electrode 3, disconnection electrode 4 and the insulating cylinder 6 is a semi-sealed space into which dust does not enter. The air insulated current switch 200 is constituted by the above mentioned components. Contacting spring elements may be provided to inner diameter sides of the closing electrode 3, disconnection electrode 4 and earth electrode 5 so as to secure a good contact condition with the electrical contact.

[0062] In the state of Fig. 2 (a), the closing electrode 3 and disconnection electrode 4 are electrically connected by the contact rod 100, wherein current flows the switch device 50 through the main circuit conductor 7. Therefore, opening and closing operations of the switch device 50 make a closing state or an open state of the air insulated current switch 200.

[0063] In the state of Fig. 2(b), wherein the disconnection electrode 4 and the earth electrode 5 are connected with the contact rod 100, opening and closing operations of the switch device 50 make a disconnection state or earth state of the air insulated current switch device 200. The above mentioned current switching is carried out with sliding among the closing electrode 3, disconnection electrode 4 and earth electrode 5 in air. When the electrical contact with excellent anti-abrasion property of the present invention is used, the switching operation can be conducted without adhesion.

[0064] In Figs. 3 (a) to (d), there are shown operations of the switch systems according to embodiments of the present invention. In this system, as the switch device 50, a vacuum valve can be used. Figs. 3(a) and (b) show a closed state of the switch system wherein the closing electrode 3 and the disconnection electrode 4 are connected by means of the contact rod 100. Fig. 3(a) shows that current flows through the main circuit. Fig. 3(b) shows the main switch device 50 is off by emergency caused by abnormal current, etc.

[0065] In Figs. 3 (c) and (d), the disconnection electrode 4 and the earth electrode 5 are connected by means of the contact rod 100. Fig. 3 (c) shows a disconnection state for maintenance where the switch system is completely separated for maintenance thereof. Fig. 3 (d) shows an earth state where the switch device 50 is closed by mistakes, but the disconnection state of the main circuit is kept.

Reference numerals

[0066]

1; electrical contact, 2; conducting rod, 3; closing electrode, 4; disconnection electrode, 5; earth electrode, 6; insulating cylinder, 7; main circuit conductor, 8; insulating connector, 9; operating rod, 50; main switch device, 100; contact rod, 200; air insulated current switch

[0067] The above embodiments of the invention as well as the appended claims and figures show multiple characterizing features of the invention in specific combinations. The skilled person will easily be able to consider further combinations or sub-combinations of these features in order to adapt the invention as defined in the in the claims to his specific needs.

Claims

1. An electrical contact made of a sintered body comprising particles of a refractory metal selected from the group consisting of C, Mo and W, particles of copper with an electrical conductivity of 95 % or more of an oxygen free pure copper, and particles of an easily oxidizable metal having a free energy for oxide formation lower than those of the refractory metal and the high conductive metal, and a melting point of the easily oxidizable metal being high than that of the high conductive metal, wherein copper particles bind the particles of the refractory metal and easily oxidizable metal.

2. The electrical contact according to claim 1, wherein oxides formed from the easily oxidizable metal has a hexagonal.

3. The electrical contact according to claim 1 or 2, wherein the easily oxidizable metal is a member selected from the group consisting of Co, Be, Fe, Si, Ti, Zr, B, V, Nb and combinations thereof.

4. The electrical contact according to any one of claims 1 to 3, wherein an amount of the refractory metal is 1 to 60 % by volume, and an amount of the easily oxidizable metal is 0.3 to 6 % by volume.

5. An electric current switch device for closing and opening electrical contacts in air that uses the electrical contacts according to any one of claims 1 to 4, wherein a pair of the contacts is bonded to both ends of a conducting rod.

6. The electric current switch device according to claim 5, which is connected to a switch device that closes and opens current in vacuum.

7. A method of manufacturing the electrical contact according to any one of claims 1 to 4, which comprises:

mixing particles of the refractory metal, easily oxidizable metal and copper;
molding a resulting mixture to obtain a molding with a theoretical relative density of 65 % or more; and
sintering the molding at a temperature lower than the melting point of copper.

8. The method according to claim 7, which further comprises heating the resulting sintered body at 200 °C or higher in air or oxidative atmosphere.

FIG. 1

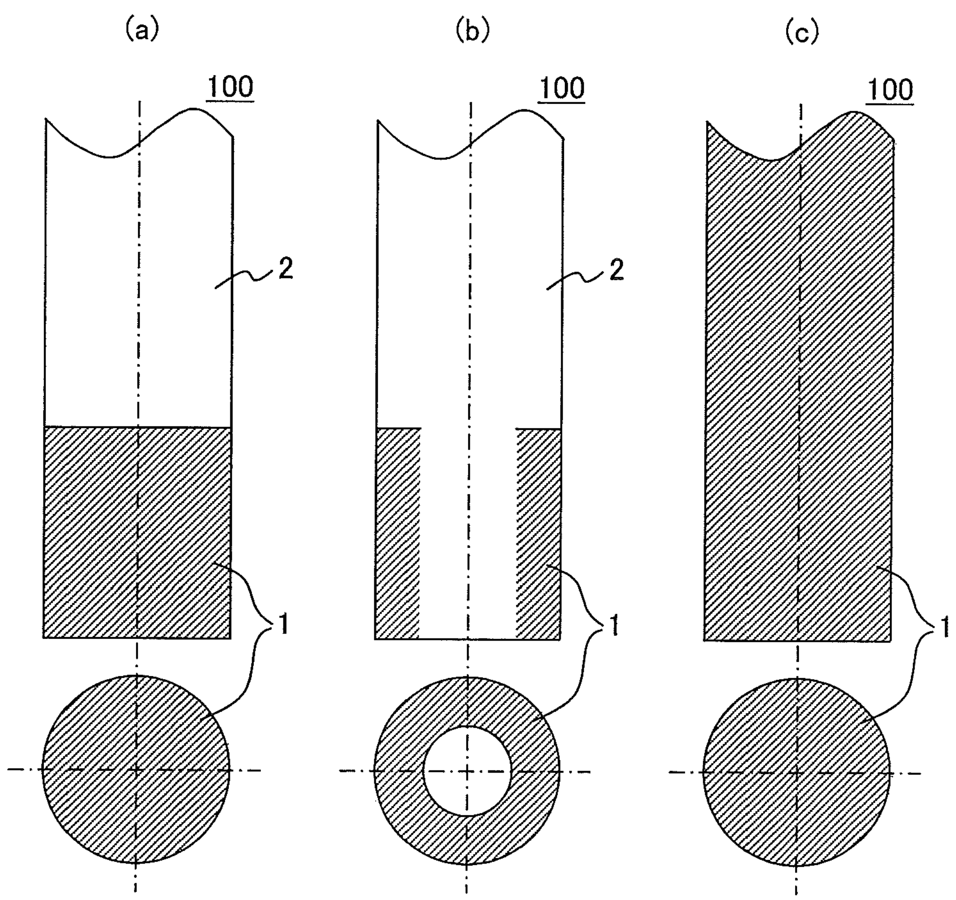


FIG. 2

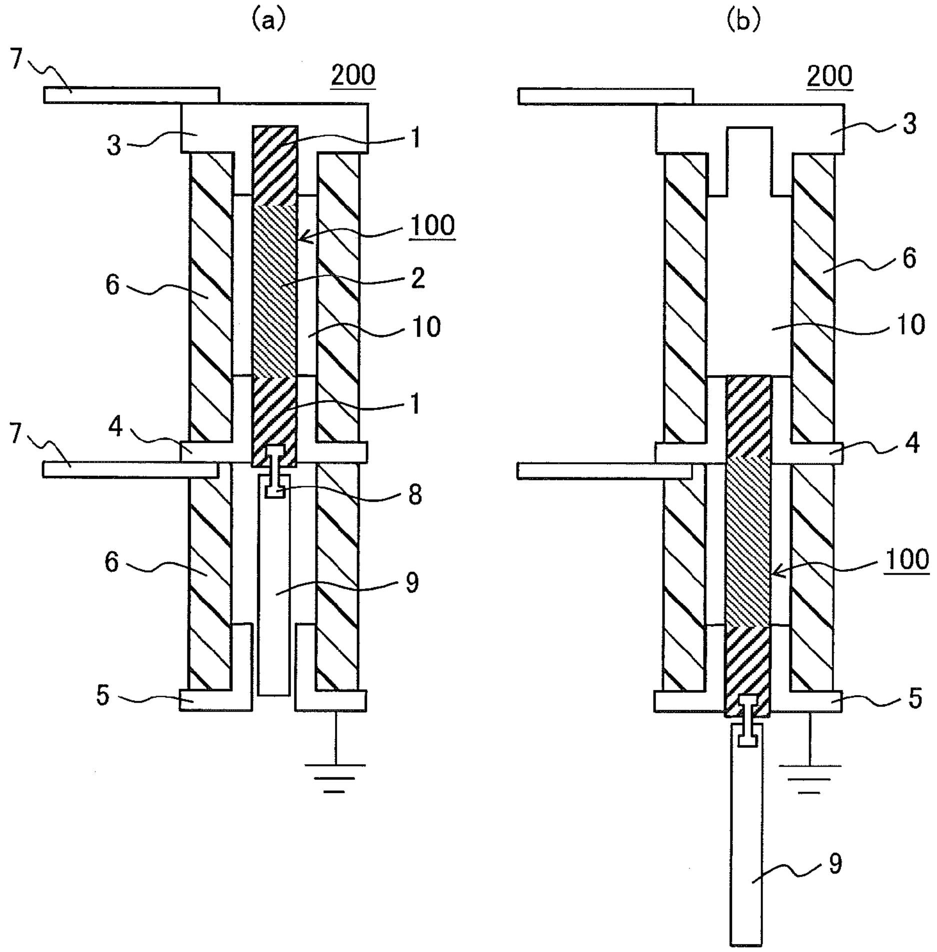
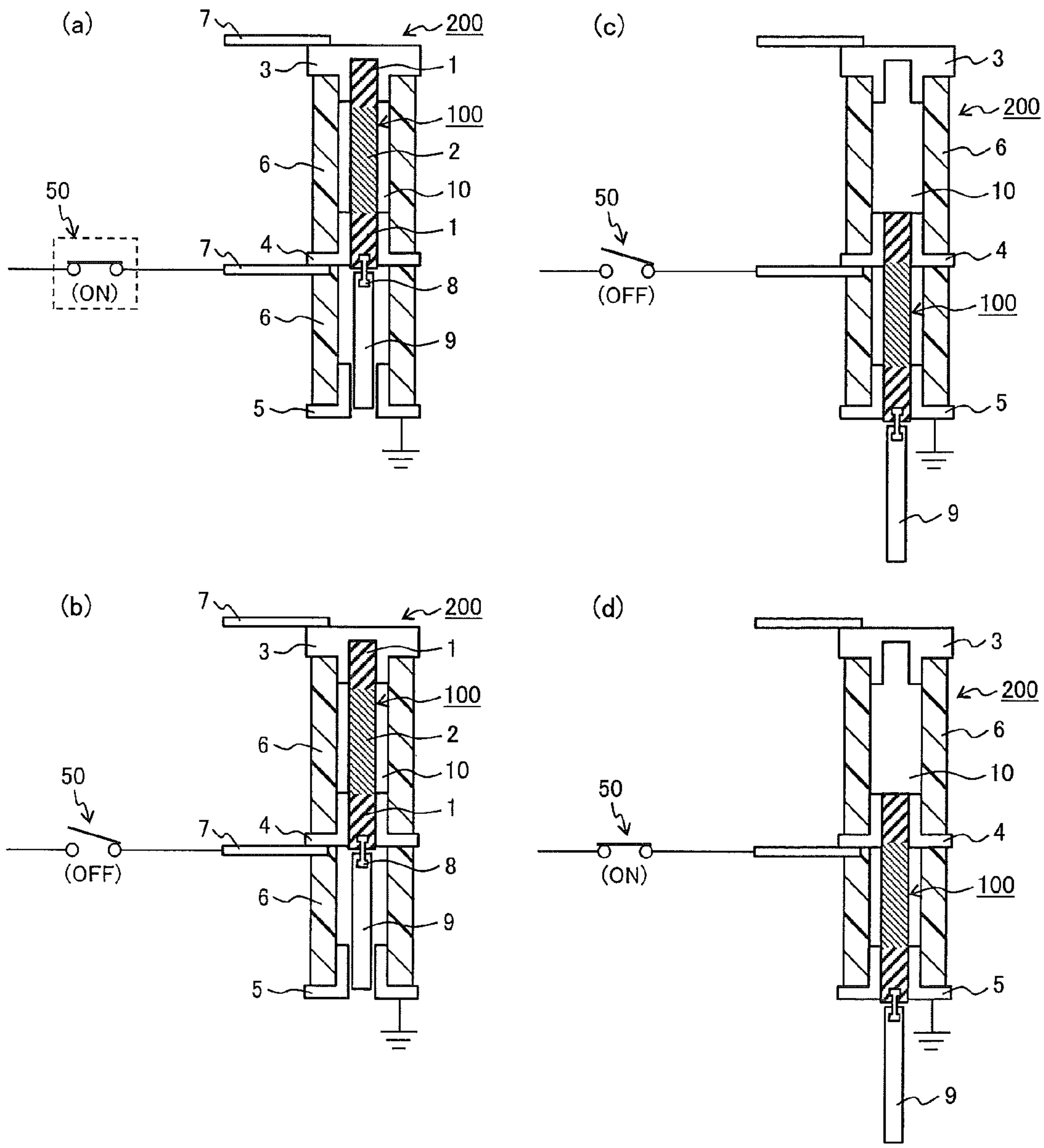


FIG. 3


(a)
7
200
3
1
100
2
6
10
50
1
7
4
(ON)
8
6
9
5
(c)
3
200
6
50
10
4
(OFF)
100
5
9
(b)
7
200
3
1
100
2
6
10
50
1
7
4
(OFF)
8
6
9
5
(d)
3
200
6
50
10
4
(ON)
100
5
9

REFERENCES CITED IN THE DESCRIPTION

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