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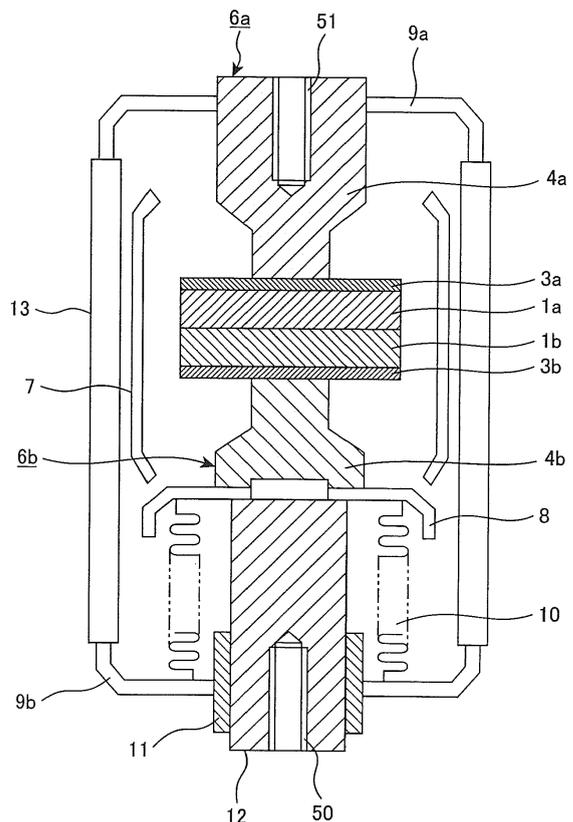
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(54) **Electric contact and vacuum interrupter using the same**

(57) The invention proposes electric contact made of a sintered alloy consisting essentially of chromium, copper and tellurium, wherein the sintered alloy is composed of copper matrix and a chromium phase, and wherein particles of a ternary intermetallic compound consisting of chromium, copper and tellurium are present in grains and at grain boundaries of the copper matrix, and at interfaces between the chromium phase and the copper matrix.

The disclosure also discloses an electrode for a vacuum interrupter, a vacuum interrupter, a vacuum circuit breaker and a vacuum switch.

FIG. 2



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Description

FIELD OF THE INVENTION:

5 **[0001]** The present invention relates to an electric contact for a vacuum interrupter, an electrode for a vacuum interrupter using the electric contact, a vacuum interrupter using the electrode, a vacuum circuit breaker using the vacuum interrupter, and a vacuum switch using the vacuum interrupter.

DESCRIPTION OF RELATED ART:

10 **[0002]** Power distribution equipments such as vacuum interrupters need small size and low prices. In order to attain the demands, small-sized operating systems are designed wherein a mechanical strength of electric contacts in a vacuum interrupter is lowered to make small a separation force for separating contacts welded by joule heat at the time of current interruption. The electric contacts have been mainly made of sintered alloys of Cr-Cu, and as a method of lowering the
15 mechanical strength of the contact alloys, low melting point metals such as Te are added to the alloys.

[0003] The low melting point metals are added as an anti-welding component or a component for suppressing roughening of the surface of the contact face after current interruption. An additive amount of the low melting point metals is several % by weight, in general.

20 **[0004]** Patent documents:

Patent document No. 1; JP laid-open 2005-135778

Patent document No. 2; JP laid-open 2006-140073

Patent document No. 3; JP laid-open 2003-223834

25 **[0005]** When the low melting point metals of several % by weight are added to the alloys, defects for current conduction may be formed in a Cu matrix or sintering of the alloys may become insufficient so that desired current conduction performance and interruption characteristics may not be attained in some cases.

[0006] In manufacturing the vacuum interrupter by vacuum-sealing with a solder, the low melting point metals may vaporize from the contacts so that the soundness of the soldered portions or a vacuum degree may be deteriorated.

30 **[0007]** In addition, if an additive amount of the low melting point metals is lower than an optimum amount, lowering of the mechanical strength of the electric contacts is insufficient so that a reduction in separation force is insufficient.

SUMMARY OF THE INVENTION:

35 **[0008]** It is an object of the present invention to provide an electric contact for a vacuum interrupter having electric contacts with a low separation force and excellent electric conductivity as well as interruption characteristics. It is another object of the present invention to provide the vacuum interrupter, a vacuum circuit breaker and a vacuum switch.

[0009] The present invention relates to an electric contact for a vacuum interrupter having electric contacts at least one of which is made of a Cu-Cr alloy wherein Cr particles are dispersed in a Cu matrix and particles of a ternary
40 intermetallic compound are dispersed in the Cu matrix. Particularly, the particles of the intermetallic compound are present in crystal grains of the Cu matrix and at grain boundaries of the Cu matrix or interfaces between Cr and Cu. The electric contact is made of alloy consisting essentially of Cr, Cu and a ternary intermetallic compound of chromium, copper and tellurium. The alloy should preferably be free from elemental tellurium. The present invention also relates to a vacuum interrupter, vacuum circuit breaker and vacuum switch.

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BRIEF DESCRIPTION OF DRAWINGS:

[0010]

50 Fig. 1A shows a plan view of an electric contact to which the present invention is applied.
Fig. 1B shows a cross sectional view of an electrode having the electric contact shown in Fig. 1A.
Fig. 2 is a cross sectional view of a vacuum interrupter to which the present invention is applied.
Fig. 3 shows a diagrammatic view of a vacuum interrupter to which the present invention is applied.
Fig. 4 shows a cross sectional view of a load break switch for a pad mounted transformer.

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[0011] Reference numerals:

1; electric contact, 1a; fixed side electric contact, 1b; movable side electric contact, 2; slit groove, 3, 3a, 3b; reinforcing

plate, 4, 4a, 4b; electrode rod, 5; solder material, 6a; fixed side electrode, 6b; movable side electrode, 7; shield, 8; movable side shield, 9a; fixed side end plate, 9b; movable side end plate, 10; bellows, 11; guide, 12; movable side holder, 13; insulating cylinder, 14; vacuum interrupter, 15; epoxy resin cylinder, 16; insulating operation rod, 17; upper terminal, 18; collector, 19; lower terminal, 20; contact spring, 21; supporting lever, 22; prop, 23; plunger, 24; knocking rod, 25; roller, 26; main lever, 27; tripping coil, 28; tripping lever, 29; reset spring, 30; closing coil, 31; evacuation cylinder, 32; outer vacuum container, 33; upper plate, 43; lower plate, 35; side plate, 36; upper through hole, 37; upper base, 38; outer bellows, 39; lower through hole, 40; insulating bushing, 41; lower base, 42; flexible conductor, 43; through hole for the flexible conductor, 44; center aperture, 50, 51; screws.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS:

[0012] Vacuum circuit breakers comprise a vacuum interrupter, a fixed side electrode having an electric contact, a movable side electrode having an electric contact, conductor terminals each being connected to the fixed side electrode or the movable side electrode, and an opening-closing means for driving the movable side electrode. Vacuum switches are composed of a plurality of vacuum interrupters, which are connected in series by conductors, and an opening-closing means for driving the movable side electrodes. The vacuum interrupter is equipped with a pair of the fixed side electrode and the movable side electrode. The present invention is applied to at least one of electric contacts of the fixed side electrode and the movable side electrode.

[0013] Electrodes of the vacuum interrupters comprise a disc shape electric contact having a center aperture formed at the center thereof. A plurality of slit grooves not in contact with the center aperture and the slit grooves are formed towards an outer periphery of the disc electric contact, and an electrode rod connected to the surface opposite to the arc generation surface of the disc electric contact. If a material having good electrical conductivity and interruption performance is used for the disc shape electric contact, downsizing of apparatuses such as vacuum interrupters, vacuum switches etc is realized.

[0014] The present inventors have discovered that a mechanism of lowering mechanical strength of Cr-Cu sintered electric contacts containing low melting point metals is caused by formation of a brittle layer at the interface between Cr particles and Cu matrix in the sintered material. That is, the low melting point metals melt during the sintering step to move into the Cu powder and the Cr powder to thereby form a ternary intermetallic compound consisting of Cr, Cu and the low melting point metal. As a result of measuring a mechanical property (fracture toughness K_{IC}) of the intermetallic compound, it was revealed that the fracture toughness K_{IC} was about 1/2 that of Cr particles.

[0015] The fracture toughness K_{IC} is a value representing resistance to fracture; the smaller the value, the easier the fracture progresses in the welded portion. The easy fracture means brittleness. Accordingly, it is thought that the brittle intermetallic compound formed at the interface between the Cr particles and Cu matrix lowers strength at the interface between the Cr powder and the Cu matrix so that the progress of the fracture was assisted to reduce the strength of the sintering material. From the above observation, distribution of the intermetallic compound in the structure is effective for lowering the strength of the sintered electric contact.

[0016] Based on the above information, the inventors prepared electric contacts having a metallurgical structure comprising Cr, Cu and intermetallic compounds. The intermetallic compounds are present not only at the interfaces between Cr and Cu, but also in the grains of Cu matrix and grain boundaries. By virtue of the presence of the brittle intermetallic compound at the interface between Cr particles and the Cu matrix and in the ductile Cu matrix, elongated deformation of the Cu matrix is suppressed to accelerate fracture so as to make a separation force small for separating welded contacts. In addition, it is possible to relieve economical load because low melting point metals, which are generally poisonous, are not used.

[0017] Further, since the intermetallic compound is used as a material for the electric contact, evaporation of the low melting point metals during the sintering step or heating by arc at the time of current interruption is suppressed so that it is possible to prevent reduction in voltage withstanding performance due to lowering of strength reduction and/or deterioration of vacuum degree.

[0018] The intermetallic compounds are one or more of ternary compounds selected from Cr_2CuTe_4 and $Cr_4Cu_2Te_7$. When the intermetallic compound are constituted by the elements, it is possible to form starting points of brittle fracture in the electric contacts without imparting adverse influence on the current interruption performance while the intermetallic compounds are contained in the electric contacts.

[0019] A preferable amount of Cr is 18 to 45 % by volume and a preferable amount of the intermetallic compound is 0.02 to 2 % by volume, and the balance is Cu. If the amount of Cr is less than 18 %, the voltage withstanding performance becomes insufficient. If the amount of Cr exceeds 45%, electrical conductivity becomes low and it is difficult to manufacture dense electric contacts because of reduction in sintering characteristics so that satisfactory interruption performance is not expected. If an amount of the intermetallic compound is larger than 2 % by volume, an amount of poisonous Te is too large, and there is no advantage of using the intermetallic compound in place of elemental Te.

[0020] A method of manufacturing the electric contacts comprises mixing Cr powder, Cu powder and powder of a

ternary intermetallic compound, compression-molding the mixed powders, and sintering the molding at a temperature lower than the melting point of Cu. This method realizes relatively easy production of the electric contacts at a low cost. The compression-molding of the mixed powders makes it possible to produce electric contacts of a final shape without mechanical working after the sintering.

[0021] The powder of the intermetallic compound is prepared by mixing powders of Cr, Cu and Te in a stoichiometric ratio of a ternary intermetallic compound to be synthesized, compression-molding the mixed powders, heating the molding at a temperature of the melting point of the intermetallic compound to synthesize the intermetallic compound, and crushing the resulting intermetallic compound. In another method, powders of Cu_2Te and Cr_2Te_3 are mixed in a stoichiometric ratio of the ternary intermetallic compound to be synthesized, compression-molding the mixed powders, heating the molding at a temperature of the melting point of the intermetallic compound, and crushing the resulting intermetallic compound. The desired ternary intermetallic compound is relatively easily prepared by these methods. Particle sizes of the powder of the intermetallic compound can be controlled by selecting degrees of crushing.

[0022] Sintering for preparing the electric contacts and thermal synthesis of the intermetallic compound are carried out in vacuum, inert gas atmosphere or reducing gas atmosphere to thereby prevent oxidation of the materials to keep high vacuum of a vacuum interrupter, as well as to provide desired electric contacts having a desired composition.

[0023] Particle sizes of powder materials for preparation of the electric contacts are preferably not larger than $104\ \mu\text{m}$ for Cr powder, and not larger than $61\ \mu\text{m}$ for Cu powder and the intermetallic compound. If the particles sizes are larger than the above values, homogeneity of the sintered products may not be expected to thereby melt out Cu from the contact face at the time of current interruption, which tends to occur welding or leads to instability of strength reduction effect by the intermetallic compound.

[0024] In electrodes using the electric contacts, each comprises the electric contact of a disc shape and a reinforcing disc supporting the electric contact in an opposite face with respect to arc generating face of the electric contact. The disc shape electric contact has a center aperture at the center thereof, and a plurality of slit grooves that penetrate the disc shape electric contact, the slit grooves being not in contact with the center aperture and directing towards the outer periphery of the disc shape electric contact from the center aperture. An electrode rod is connected through the center aperture of the electric contact to the electric contact and the reinforcing disc. The electrode using the electric contact exhibits excellent interruption performance and a small separation force of welding.

[0025] The vacuum interrupter is provided with a pair consisting of a fixed electrode and a movable electrode in a vacuum container, at least one of which uses the electric contact having been described heretofore. A vacuum circuit breaker comprises a conductor terminal connected to the fixed electrode and the movable electrode in the vacuum interrupter and an open-close means for the movable electrode. A vacuum switch comprises a plurality of the vacuum interrupters connected in series by a conductor, and an open-close means for operating the movable electrodes. The vacuum switch exhibits excellent interruption performance and current conduction performance with a small separation force for separating welded electric contacts so that the operating mechanism can be downsized to provide the vacuum switch at a low cost.

[0026] In the following, the embodiments of the present invention will be explained in detail by reference to drawings. The scope of the present invention is not limited to the embodiments.

(Embodiment)

[0027] In this embodiment, sintered bodies having the compositions shown in Table 1 for the electric contacts were prepared.

[0028] A method of preparation of the electric contact 1 is explained. At first, powder of the ternary intermetallic compound was prepared. In this embodiment, powders of Cu_2Te and Cr_2Te_3 each having a particle size of $10\ \mu\text{m}$ or less were mixed in a mortar at a rate of 48.2 % by weight of Cu_2Te and 51.8% by weight of Cr_2Te_3 , and the mixed powders were charged into a metal mold. Then the mixed powders were compression-molded under a pressure of 294 MPa, followed by heating at $800\ ^\circ\text{C}$ for 1 hour in vacuum to synthesize Cr_2CuTe_4 . The resulting intermetallic compound was crushed and ground in a mortar to obtain powder of Cr_2CuTe_4 having a particle size of $50\ \mu\text{m}$ or less.

[0029] Thereafter, Cr powder having a particle size of $80\ \mu\text{m}$ or less, Cu powder having a particle size of $50\ \mu\text{m}$ or less and the intermetallic compound powder mentioned above were mixed in mixing rates shown in Table 1 with a V-shaped mixer, and the resulting mixed powders were filled in a metal mold. The charged powders were compression-molded under a pressure of 294 MPa. Theoretical relative densities of the resulting moldings were about 74 %. The moldings were heated in vacuum at $1060\ ^\circ\text{C}$ for two hours to sinter the moldings to thereby obtain sintered bodies for materials of the electric contacts. Theoretical relative densities of the sintered bodies were about 96 %.

(Comparative embodiment 1)

[0030] As a comparative embodiment, a conventional Cr-Cu-Te sintered body which uses elemental Te was prepared

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in the following manner. Cr powder having a particle size of 80 μ m or less, Cu powder having a particle size of 60 μ m or less and Te powder having a particle size of 45 μ m or less were mixed in a mortar at a mixing rate shown in No. 11 in Table 1 with a V-shaped mixer. The mixed powders were compression-molded and heated to produce a sintered body. Theoretical relative densities of the molding and the sintered body were the same as those in embodiment 1. The theoretical relative densities of the molding are relative values with respect to a theoretical density of Cr-Cu-Cr₂CuTe₄ in Table 1.

Table 1

	No.	Content of Cr (% by volume)	Additive		Electric conductivity of electric contact (IACS %*)	Positions where intermetallic compound is present
			Material	Amount (% by volume)		
Embodiments	1	23	Cr ₂ CuTe ₄	0.02	45	at Cr/Cu interfaces and in Cu matrix
	2	23	Cr ₂ CuTe ₄	0.2	46	at Cr/Cu interfaces and in Cu matrix
	3	23	Cr ₂ CuTe ₄	1.0	44	at Cr/Cu interfaces and in Cu matrix
	4	23	Cr ₂ CuTe ₄	2.0	43	at Cr/Cu interfaces and in Cu matrix
	5	18	Cr ₂ CuTe ₄	0.2	50	at Cr/Cu interfaces and in Cu matrix
	6	45	Cr ₂ CuTe ₄	0.2	32	at Cr/Cu interfaces and in Cu matrix
	7	23	Cr ₂ CuTe ₄	0.01	45	at Cr/Cu interfaces and in Cu matrix
	8	23	Cr ₂ CuTe ₄	3.0	41	at Cr/Cu interfaces and in Cu matrix
	9	15	Cr ₂ CuTe ₄	0.2	52	at Cr/Cu interfaces and in Cu matrix
	10	50	Cr ₂ CuTe ₄	0.2	29	at Cr/Cu interfaces and in Cu matrix
Comparison	11	23	Te	0.05	45	only at the Cr/Cu interfaces

results of conductivity as electrical properties of the resulting sintered bodies of embodiment 1 and comparison 1 are shown in Table 1. The conductivity was measured by an eddy current type measuring instrument. The conductivity is represented as relative values (*IACS %, International Annealed Copper Standard) with respect to conductivity of annealed pure copper (100 %). As shown in Table 1, the conductivity greatly depends on the amount of Cr; the larger the amount of Cr, the smaller the conductivity becomes. On the other hand, the conductivity depends little on the amount of the intermetallic compound; when the amount of Cr is 23 volume %, the conductivity (IACS) was around 45 %, which is almost the same as comparison No. 11. As the amount of the intermetallic compound increases, there is a tendency

that the conductivity becomes smaller.

[0031] The sections of the electric contacts were polished, and positions where the intermetallic compound was present in the sections were observed with a scanning electron microscope and an energy dispersion type X-ray analyzer. The results are shown in Table 1. In the cases where the intermetallic compound was added (except No. 11), the intermetallic compound was dispersed homogeneously in the Cu matrix (in copper crystal grains and grain boundaries of copper crystals), as well as at grain boundaries of Cr particles and Cu matrix. This tendency was the same as the additive amounts of the Cr particles and the intermetallic compounds irrespectively of the additive amounts. On the other hand, in case of addition of elemental Te (No. 11), intermetallic compound was not observed at grain boundaries of Cu grains in the Cu matrix, although the intermetallic compound particles were present at grain boundaries of Cr particles and Cu matrix. This is because the intermetallic compound is formed only when Cr, Cu and Te are present at the grain boundaries of the Cr particles and Cu particles. It has been revealed that in case of addition of elemental Te, the intermetallic compound can not be present in the Cu matrix.

(Embodiment 2)

[0032] Fig. 1A shows a plan view of the electrode having the electric contact of the electrode according to the present invention, and Fig. 1B shown a cross sectional view of the electrode shown in Fig. 1A. In Figs. 1A and 1B, reference numeral 1 denotes the electric contact, 2 the slit grooves for imparting a driving force to arc, 3 the reinforcing plate made of stainless steel, 5 a solder material for connecting the electric contact with the reinforcing plate, and 44 the center aperture for preventing stagnation of arc that occurs in the center of the electric contact.

[0033] The resulting sintered bodies in embodiment 1 were machined to prepare the electric contacts shown in Figs. 1A and 1B.

[0034] The electric contacts can be manufactured by a method wherein the mixed powders of Cr powder, Cu powder and the intermetallic compound powder are filled in a metal mold having a cavity, which is the inner shape of the electric contact shown in Figs. 1A and 1B; the mixed powders are compression-molded, and compressed molding was heated to sinter the molding. According to this method, the desired electric contact can be manufactured easily without machining after sintering.

[0035] The method of manufacturing the electrode in this embodiment is as follows. The electrode rod 4 made of oxygen free copper and the stainless steel reinforcing plate 3 made of SUS 304 were prepared by machining in advance. Then solders were placed between the electric contact 1 obtained by sintering and machining and the reinforcing plate 3 and between the reinforcing plate 3 and the electrode rod 4, and the assembly was heated to 970 °C for 10 minutes in vacuum of not higher than 8.2×10^{-4} Pa to produce the electrode shown in Figs. 1A and 1B. The electrode was used for a vacuum interrupter having a rated voltage of 7.2 kV, a rated current of 600 A, and a rated interruption current of 20 kA. If a mechanical strength of the electric contact is sufficiently high, the reinforcing plate can be omitted.

(Embodiment 3)

[0036] Using the electrode prepared in embodiment 2, a vacuum interrupter was prepared. The specifications of the vacuum interrupter are of a rated voltage of 7.2 kV, a rated current of 600 A, and a rated interruption current of 20 kA.

[0037] Fig. 2 shows a cross sectional view of a vacuum interrupter to which the present invention was applied. In Fig. 2, 1a and 1b denote a fixed electrode side electric contact and a movable electrode side electric contact respectively. 3a and 3b denote reinforcing plates, 4a and 4b a fixed electrode side electrode rod and a movable electrode side electrode rod, 6a and 6b a fixed electrode and a movable electrode. In this embodiment, the fixed side electric contact and the movable side electric contact are disposed in such a manner that the slit grooves coincide at the contact face.

[0038] The movable side electrode 6a is bonded by soldering to a movable side holder 12 via a movable side shield 8 for preventing dispersion of metal vapor at the time of interruption. These members are sealed by soldering in high vacuum with a fixed side end plate 9a, a movable side end plate 9b and an insulating cylinder 13, and the assembly is electrically connected to an outside conductor by means of a screw 50 of the movable side holder 12 and a screw 51 of the fixed side electrode 6a.

[0039] A shield 7 for preventing metal vapor at the time of interruption is disposed in the cylinder 13 to surround the electrodes, and a guide 11 for supporting a sliding part is disposed between the movable side end plate 9b and the movable side holder 12. A bellows 10 is disposed between the movable side shield 8 and the movable side end plate 9b so that the movable side holder 12 is moved up and down, keeping vacuum to thereby open and close the fixed electrode 6a and the movable electrode 6b.

[0040] As having described above, the vacuum interrupter was assembled using the electric contacts prepared in embodiment 2.

(Embodiment 4)

[0041] A vacuum circuit breaker was assembled using the vacuum interrupter prepared in embodiment 3. Fig. 3 shows the vacuum circuit breaker comprising the vacuum interrupter 14 and an operating mechanism.

[0042] The vacuum circuit breaker is provided with the operating mechanism located at the front side and three epoxy cylinders 15 for bundled three phases in the back side. The vacuum interrupter 4 is operated by means of an operating rod 16 of the operating mechanism.1

[0043] When the circuit breaker is in a closed position, current flows through an upper terminal 17, the electric contacts 1, a collector 18, and a lower terminal 19. A contact force between the electrodes is kept by a contact spring 20 disposed to the insulated operating rod 16. The contact force between the electrodes and the electromagnetic force by a short-circuit current are kept by a supporting lever 21 and a prop 22. When a throwing coil 30 is excited, a plunger 23 pushes up a roller 25 by means of a knocking rod 24 to rotate a main lever 26 in a clockwise direction to thereby close the electrodes, and a supporting lever 2 supports the main lever 26.

[0044] When the circuit breaker is in a state for a trip operation, a trip coil 27 is excited and a trip lever 28 trips the prop 22 to rotate the main lever 26 in an anti-clockwise direction to thereby open the electrodes.

[0045] When the circuit breaker is in an open state, a link returns into its original position by a reset spring 29 and the prop 22 engages with the trip lever 28. When a closing coil 30 is excited, the circuit breaker is in a closed stated. Reference numeral 31 denotes an evacuation port.

[0046] Next, performance tests of the vacuum circuit breakers of the embodiment 4 were conducted. As mentioned above, the vacuum interrupter has the specifications of the rated voltage of 7.2 kV, the rated current of 600 A and the rated interruption current of 20 kA. Table 2 shows the test results. Each performance is a relative value with respect to the value of the conventional Cr-Cu-Te sintered body (No. 11) . A trip performance is a reverse number of welding separation force (relative value) after electricity conduction of 28 kA.

Table 2

	No.	Performance test results (Relative values)		
		Maximum interruption current	Voltage withstanding	Separation force
Embodiments	1	1.1	1.1	1.1
	2	1.1	1.1	1.2
	3	1.1	1.2	1.4
	4	1	1.1	1.4
	5	1.3	0.9	1.1
	6	0.9	1.3	1.2
	7	1.1	1.1	1
	8	1	1	1.2
	9	1.4	0.8	1
	10	0.8	1.4	1
Comparison	11	1	1	1

[0047] In Nos. 1 to 4, additive amounts of Cr₂CuTe₄ were changed. As the amount of Cr₂CuTe₄ increases, the maximum interruption current and voltage withstanding performance were the same or better than those of the conventional material (No. 11), and the separation force is apparently improved. This is because the intermetallic compound is dispersed throughout the sintered body so that fracture of the welding becomes easy.

[0048] In Nos. 5 and 6, additive amounts of Cr were changed, while the additive amounts of Cr₂CuTe₄ were the same. As the amount of Cr increases, the electrical conductivity decreases and the maximum interruption current decreases as well. When the amount of Cr as a refractory element is small, the withstanding voltage performance decreases, but there is no problem as a practical matter. Regardless of the additive amounts of Cr, the separation force exhibited excellent values because of homogeneous dispersion of Cr₂CuTe₄. In the case no.6 where the amount of Cr is large, the separation force is worse than that of No. 2 where the amount of Cr₂CuTe₄ because the amount of Cr, Cr being hard and high in electric resistance is relatively large so that resistance between the electric contacts is high and a welded area is large.

[0049] In No. 7, a very small amount of Cr_2CuTe_4 was added, and in No. 8, a relatively large amount of Cr_2CuTe_4 was added. Although the maximum interruption current and the withstanding voltage performance of No. 7 are improved because there is no evaporation of Te by arc heat, the separation force is not improved. In No. 8, though the separation force is improved, a contact resistance increases because an amount of hard Cr_2CuTe_4 is large so that a welded area is large so that improvement of the separation force is small, compared with No. 4. In addition, since the amount of Cr_2CuTe_4 is relatively large, sintering property becomes poorer and electrical conductivity becomes smaller so that the maximum interruption current and the voltage withstanding performance are almost the same as those of the conventional material No. 11. Further, if the amount of Cr_2CuTe_4 is large, an amount of Te becomes large so that advantages of the addition of the ternary intermetallic compound in place of poisonous Te are lost. Accordingly, the additive amount of Cr_2CuTe_4 should preferably be 0.02 to 2 % by volume.

[0050] In Nos. 9 and 10, amounts of Cr were changed. No. 9 contains a small amount of Cr and No. 10 contains a large amount of Cr. No. 9 containing a small amount of Cr as an anti-arc component (arc resistant component) exhibited a low voltage withstanding performance and No. 10 having a low conductivity because of a large amount of Cr exhibited a low maximum interruption current. Accordingly, an amount of Cr is preferably 18 to 45 % by volume.

[0051] As having discussed above, the electric contacts can provide vacuum interrupters and vacuum circuit breakers having a reduced separation force for welded contacts, as well as excellent current interruption performance and voltage withstanding performance and the operating mechanism of electric contacts can provide vacuum interrupters and vacuum circuit breakers can be downsized.

(Embodiment 5)

[0052] The vacuum interrupter prepared in embodiment 3 was installed in a vacuum switch other than the vacuum circuit breaker. Fig. 4 shows a load break switch of a pad mounted transformer that installed the vacuum interrupter prepared in embodiment 3.

[0053] The load break switch comprises a plurality of pairs of vacuum interrupters 14 disposed in an outer vacuum container 32, which is vacuum sealed. The vacuum interrupters correspond to main circuit switches. The outer vacuum container 32 is provided with an upper plate 33, a lower plate 34 and side plates 35. Peripheries of the plates are welded, and the switch is assembled with other equipments.

[0054] The upper plate 33 has an upper through holes 36, and the periphery of each hole is provided with an insulating upper base 37 to cover each upper hole 36. A columnar movable side electrode rod 4b is inserted reciprocatingly (up and down movement) through a circular space formed in the center of each upper base 37. That is, each upper through hole 36 is stopped up (closed) with the upper base 37 and the movable side electrode rod 4b.

[0055] An end of the movable side electrode rod 4b (the upper side) in the axial direction is connected to an operator (electromagnetic operator) disposed outside of the outer vacuum container 32. The upper plate 33 is provided reciprocatedly with outer bellows 38 along the periphery of each upper through hole 36. One end of each of the outer bellows 38 in the axial direction is fixed to a lower side of the upper plate 33, and the other end in the axial direction is mounted on an outer circumference of each of the movable side electrode rods 4b. That is, in order to make the outer vacuum container 32 air-tight, the outer bellows 38 is disposed to the periphery of each upper through hole 36 in the axial direction of the movable side electrode rods 4b. In addition, the upper plates 33 are provided with an evacuation pipe (not shown), through which the outer vacuum container is evacuated to vacuum.

[0056] On the other hand, the lower plate 34 is provided with lower through holes 39, and an insulating bushing 40 is fixed to a periphery of each lower through hole 39 to cover each of the lower through holes. Circular lower bases 41 are fixed to the bottom of the insulating bushings 40. A columnar fixed side electrode rod 4a is inserted into each of the circular spaces at the center of the lower bases 41. That is, the lower through holes 39 formed in the lower plates 34 are stopped up with the insulating bushings 40, the lower bases 41 and the fixed side electrode rods 4a. One end (lower side) of the fixed side electrode rods in the axial direction is connected to a cable (distribution wires) disposed outside of the outer vacuum container 32.

[0057] The vacuum interrupters 14 corresponding to the main circuit switches of the load break switches are contained in the outer vacuum container 32. Each of the movable side electrode rods 4b is connected to each other by means of a flexible conductor having two curved portion 42. the flexible conductors 42 are constituted by alternately laminating a plurality of copper plates and a plurality of stainless steel plates, each having two curved portions in their longitudinal direction. The flexible conductor 42 is provided with through holes 43 through which the movable side electrode rods 4b are inserted.

[0058] As explained above, the vacuum interrupter prepared in embodiment 3 can be applied to the load break switch for the pad mounted transformer, as well as other vacuum switches such as vacuum switches.

[0059] 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

- 5
1. An electric contact made of a sintered alloy consisting essentially of chromium, copper and Te, wherein the sintered alloy is composed of copper matrix and a chromium phase, and wherein particles of a ternary intermetallic compound consisting of chromium, copper and tellurium are present in grains and at grain boundaries of the copper matrix, and interfaces between the chromium phase and the copper matrix.
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 2. The electric contact according to claim 1, wherein the intermetallic compound is at least one of Cr_2CuTe_4 and $\text{Ce}_4\text{Cu}_2\text{Te}_7$.
 - 15
 3. The electric contact according to claim 1 or 2, wherein a content of chromium is 18 to 45 volume % per the volume of the electric contact.
 - 20
 4. The electric contact according to one of the preceding claims, wherein an amount of the intermetallic compound is 0.02 to 2 % by volume per the electric contact.
 - 25
 5. The electric contact according to one of the preceding claims, wherein the sintered alloy is free from elemental tellurium.
 6. A method of manufacturing an electric contact comprising mixing powder of chromium, powder of copper and powder of a ternary intermetallic compound consisting of chromium, copper and tellurium, compression-molding the mixed powder in a mold, and heating the compression molding to a temperature lower than the melting point of copper to thereby sinter the molding.
 - 30
 7. The method of manufacturing an electric contact according to claim 6, wherein the mixing of the powders is carried out in vacuum, inert gas atmosphere or reducing gas atmosphere.
 - 35
 8. The method of manufacturing an electric contact according to claim 6 or 7, wherein the powder of the ternary intermetallic compound is prepared by mixing powder of chromium, powder of copper and powder of tellurium in a stoichiometric relation to give one of Cr_2CuTe_4 and $\text{Ce}_4\text{Cu}_2\text{Te}_7$, compression molding the mixed powder, heating the mixed powders at a temperature lower than the melting point of the intermetallic compound to synthesize the intermetallic compound by reaction of the powders, and crushing the resulting intermetallic compound.
 - 40
 9. The method of manufacturing an electric contact according to claim 6, 7 or 8, wherein the powder of the ternary intermetallic compound is prepared by mixing powder of Cu_2Te and Cr_2Te_3 , compression molding the mixed powders, heating the compression molding at a temperature lower than the melting point of the ternary intermetallic compound to synthesize the intermetallic compound, and crushing the resulting intermetallic compound.
 - 45
 10. The method of manufacturing an electric contact according to any one of claims 8 and 9, wherein the mixing of the powders is carried out in vacuum, inert gas atmosphere or reducing gas atmosphere.
 - 50
 11. The method of manufacturing an electric contact according to one of claim 6 to 10, wherein a particle size of the chromium powder is not larger than $104\ \mu\text{m}$, and particle sizes of the copper powder and the intermetallic compound powder are not larger than $61\ \mu\text{m}$.
 - 55
 12. The method of manufacturing an electric contact according to one of claims 6 to 11, wherein the electric contact is free from elemental tellurium.
 13. An electrode of a disc shape having a center aperture formed at the center thereof, and a plurality of slit grooves that penetrate the disc, the slit grooves extending towards an outer periphery of the disc in not-contact with the center aperture, and an electrode rod is connected to the disc at a side opposite to an arc generating face, wherein the disc is the electric contact according to any one of claims 1 to 4.
 14. A vacuum interrupter comprising a pair of a fixed side electrode and a movable side electrode, both being disposed in a vacuum container, wherein at least one of the fixed side electrode and the movable side electrode is an electrode

according to claim 13.

5 15. A vacuum circuit breaker comprising a vacuum interrupter provided with a pair of fixed side electrode and movable side electrode disposed in a vacuum container, conductor terminals each being connected to the fixed side electrode and the movable side electrode and connected to outside of the vacuum container and an opening and closing means for driving the movable electrode, wherein the vacuum interrupter is a vacuum interrupter according to claim 14.

10 16. A vacuum switch comprising a plurality of vacuum interrupters disposed in a vacuum container, each of the vacuum interrupters having a pair of a fixed side electrode and a movable side electrode, and an opening-closing means for the movable side electrodes, wherein the plurality of the vacuum interrupters are electrically connected with a conductor, and the vacuum interrupters are the vacuum interrupters according to claim 14.

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FIG. 1A

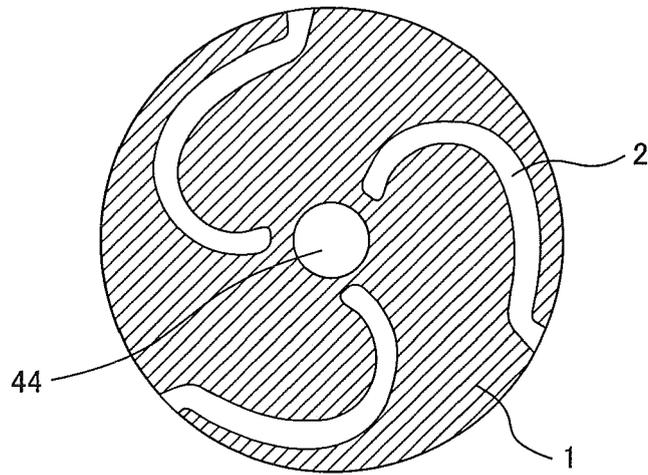


FIG. 1B

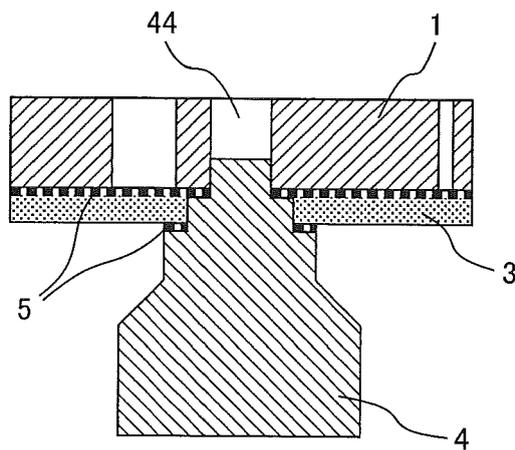


FIG. 2

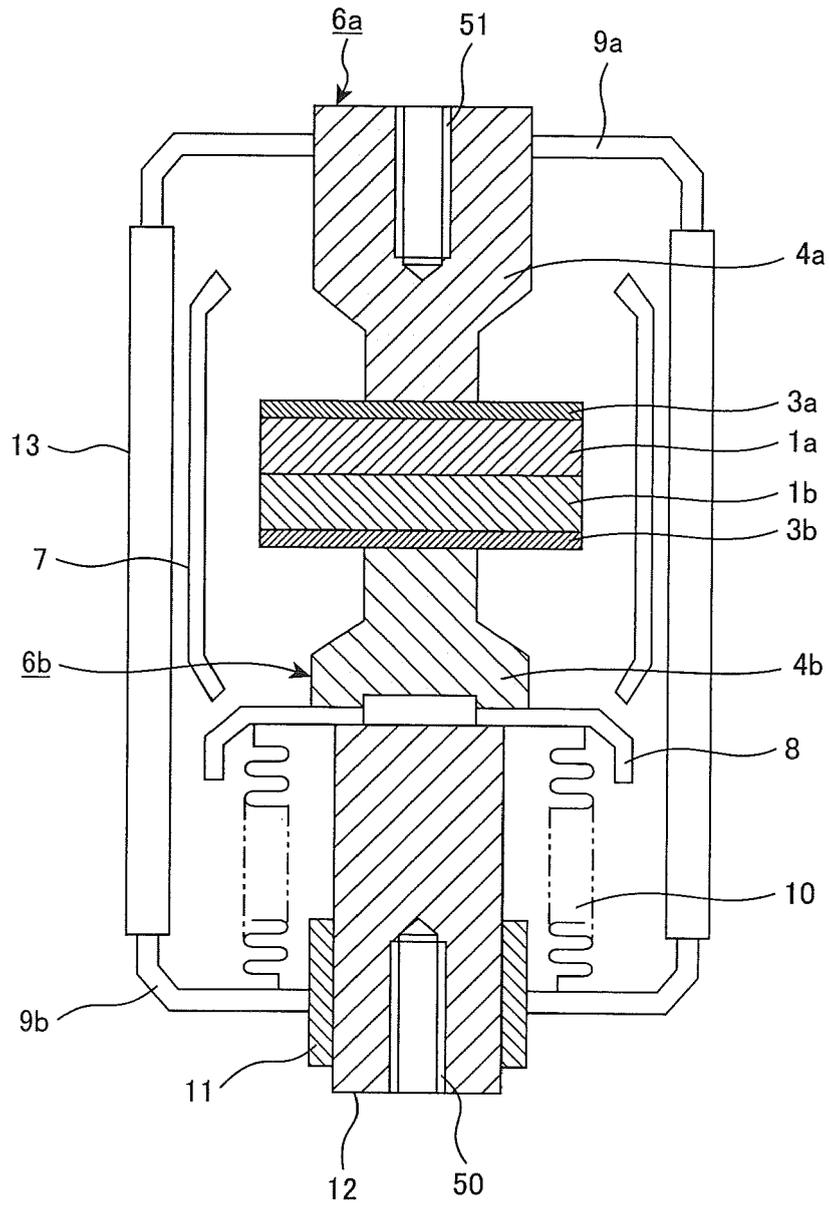


FIG. 3

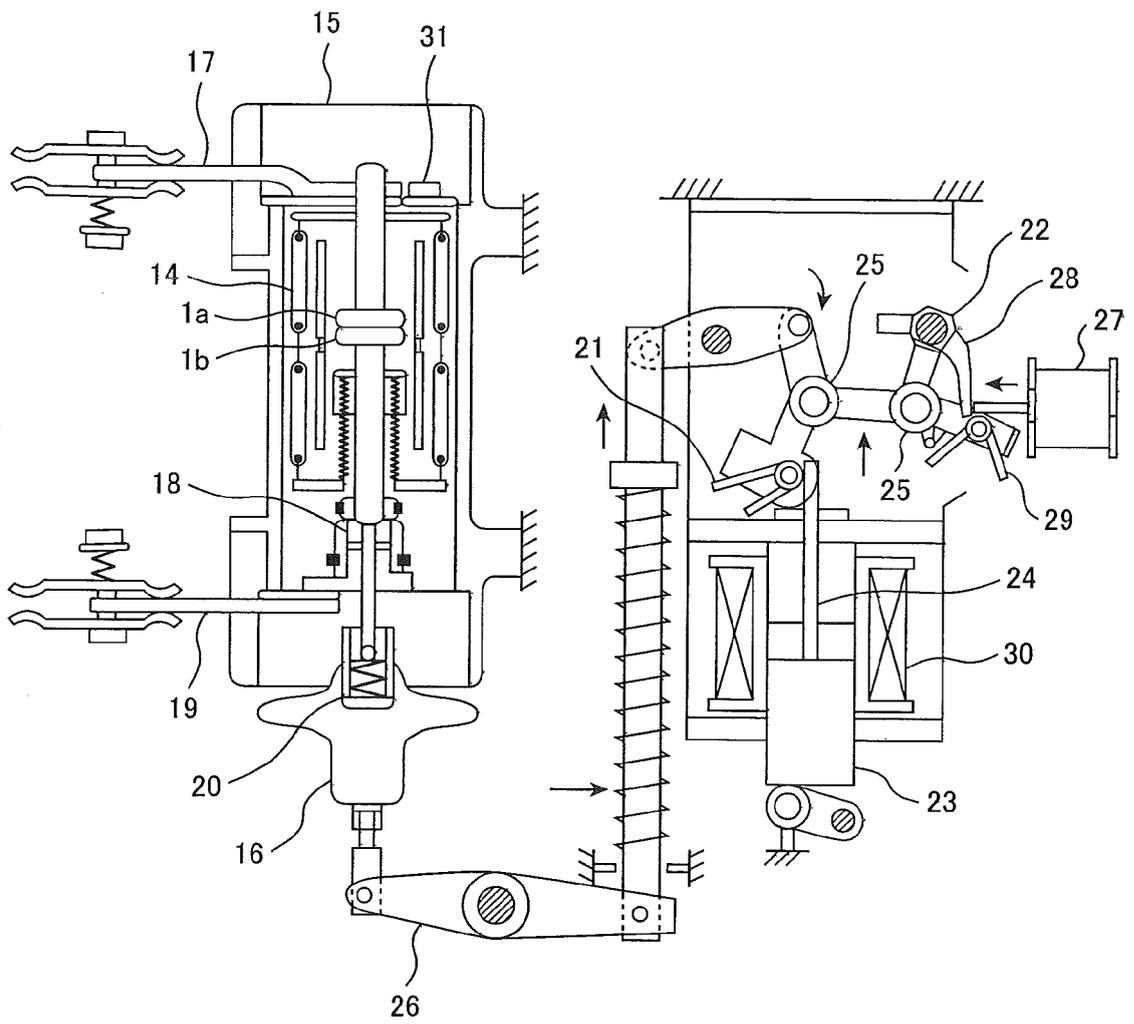
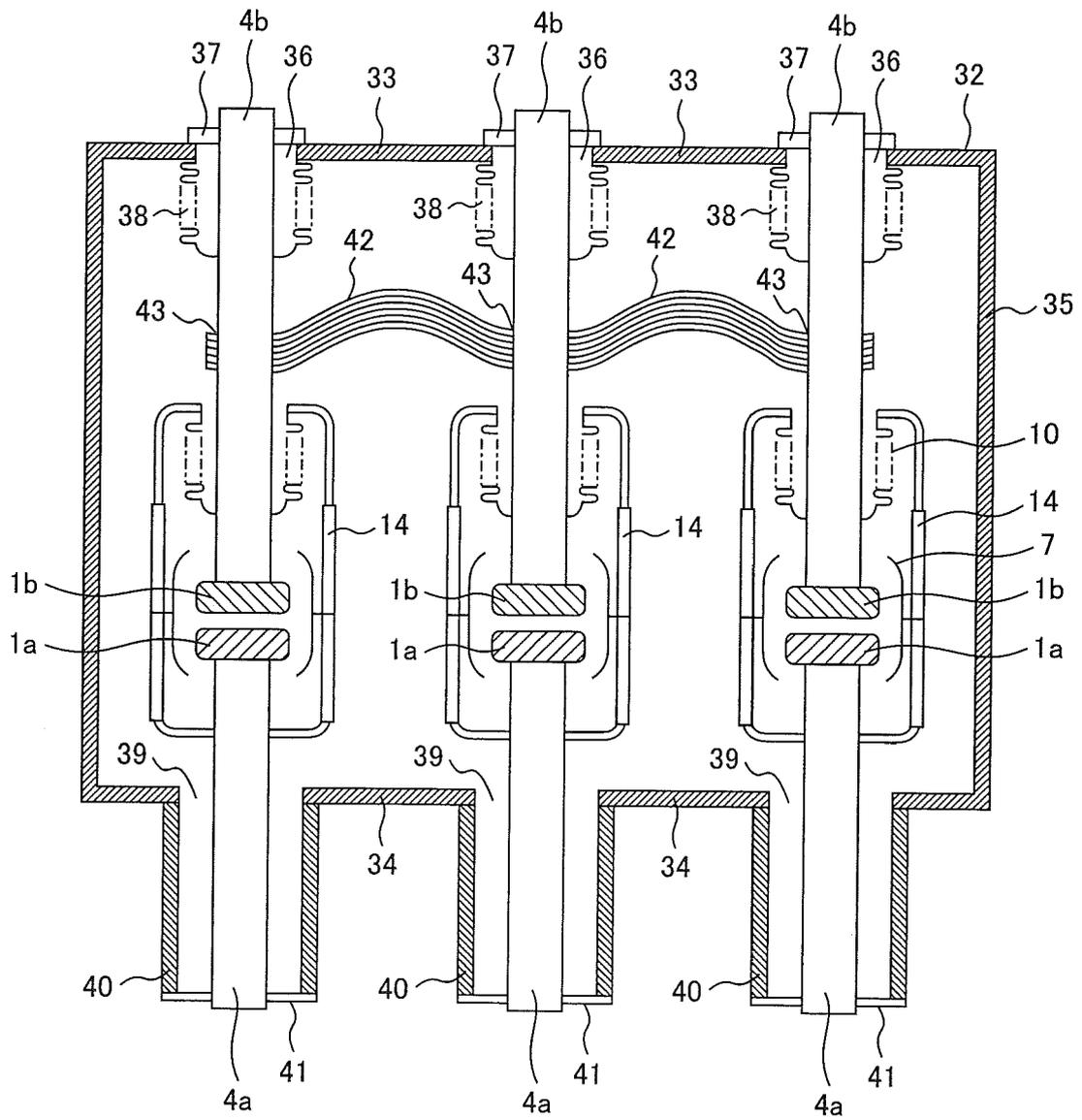


FIG. 4





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