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(54) **A vacuum interrupter and methods of manufacturing the same.**

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Description

The present invention relates to a vacuum interrupter and, more particularly, a vacuum interrupter manufactured by using a suitable metallic auxiliary sealing material.

Vacuum circuit interrupters are, generally, constructed by a highly evacuated envelope, a stationary electrical contact provided in the envelope, a movable electrical contact provided in the envelope so us to be opposite to the stationary electrical contact and shields. The envelope comprises, substantially, a tubular housing, a pair of end plates. The housing is, generally, fabricated by a cylindrical insulating material, and a pair of metallic end plates used to form the evacuated envelope.

Moreover, the vacuum interrupter is, generally, constructed by the steps of fixing an upper end and a lower end plates to each axial end of a cylindrical insulating housing respectively, mounting a bellows on the lower end plate, inserting a movable contact rod into the bellows, securing a movable electrical contact on the movable contact rod, and incorporating a stationary contact rod having a stationary electrical contact at the bottom thereof to the upper end plate.

In this conventional vacuum interrupter, it is difficult to make the diameter of the envelope large because the envelope is very expensive when a large diameter housing made of glass or ceramics is used as a part of the envelope. Further, material made of an alloy Fe-Ni-Co or an alloy of Fe-Ni is usually employed to provide a vacuum-tight-seal. This vacuum tight-seal is also very expensive as well as having magnetic properties. The vacuum interrupter, therefore, becomes very expensive and of low reliability because the temperature thereof rises due to the eddy current generated by high current flow of the contact rods.

US—A—3 674 958 discloses a vacuum type circuit interrupter which comprises a hollow constant-diameter cylindrical metallic envelope, preferably fabricated of copper, which is provided with integrally formed annular shoulders inside the envelope near its end openings. Stationary and movable contact rods extend into the envelope through the end openings and have contacts brazed to their inner ends. The rods are provided with integrally formed shoulders against which circular or disk-type shields are secured as by brazing. A toroidally shaped substantially flat, preferably high-grade ceramic, insulating member or end plate is disposed at one end opening of the envelope and accommodates the stationary contact rod. A toroidally shaped substantially cylindrical, preferably high-grade ceramic, insulating member or end tube is disposed at the other end opening of the envelope and accommodates the movable contact rod and a flexible sealing means such as a bellows. A first metallic sealing member or ring is joined or sealed at its edges as by welding between one of the annular shoulders of the envelope and the outer peripheral edge of the insulating end plate. Preferably, the sealing member is fabricated of thin Kovar metal or other material having thermal expansion and contraction characteristics similar to the ceramic material of the end plate. A second metallic sealing member or ring in tubular form and of the same composition as the first sealing member is joined or sealed at its edges as by brazing between an opening in the insulating end plate and a shoulder provided on the stationary contact rod. A third metallic sealing member or ring is joined or sealed at its edges as by welding between the other of the annular shoulders of the envelope and the surface of the ceramic end tube.

It is an object of the present invention to provide a highly reliable and high performance vacuum interrupter.

The present invention provides a vacuum circuit interrupter comprising:

a) an evacuated envelope consisting essentially of a cylindrical metal housing, upper and lower electrically insulating end plates secured to the housing by first and second auxiliary sealing members of first and second sealing means, a stationary contact rod, a movable contact rod, and a metal bellow;

b) the upper and lower end plates closing opposite ends of the cylindrical metal housing, each of the upper and lower end plates having a coaxial central aperture;

c) the stationary contact rod coaxially entering the envelope through the central aperture of the upper and plate, the stationary contact rod being fixed to the upper end plate in such a manner as to provide a hermetic seal therewith;

d) the movable contact rod coaxially and movably entering the envelope through the central aperture of the lower end plate without impairing the vacuum within the envelope;

e) stationary and movable electrodes respectively connected to an inner end of the stationary and movable rods in such a manner as to engage each other via an electrical contact portion when the movable rod moves toward the stationary contact rod and disengage from each other when the movable contact rod moves away from the stationary contact rod; and

f) opposite ends of the bellows being respectively fixed to the movable contact rod and to the lower end plate in such a manner as to provide a hermetic seal about the movable contact rod to allow for movement of the movable contact rod without impairing the vacuum within the envelope; characterized in that

said upper and lower end plates have coefficients of thermal expansion differing from that of said housing,

said first and second auxiliary sealing members have coefficients of thermal expansion differing from those of said upper and lower end plates,

said first and second auxiliary sealing members are made of a plastically deformable metallic material, each of which is plastically deformed by thermal stresses generated in a slow cooling process after vacuum brazing, whereby said upper and lower end plates (12, 14) are secured to said housing (10) by means of said first and second auxiliary sealing members (30, 32) in a slow cooling process after vacuum brazing.

An advantage offered by the invention is that by constructing an envelope by employing a housing made of a non-magnetic metallic material, end plates of insulating materials in the form of a ceramics or crystallized glass and auxiliary sealing members made of metallic materials which are deformable due to the thermal stress at the high temperature, it is possible to provide a vacuum power interrupter of which a diameter can be easily and inexpensively made large in order to enhance the performance of the vacuum power interrupter.

The invention also provides a method of manufacturing a vacuum interrupter comprising the steps of:

(a) inserting one end of a bellows made of an austenitic stainless steel into an aperture in the center of a disc-shaped lower insulating end plate,

(b) disposing a second auxiliary metal sealing member on an outer circumferential edge of said lower end plate,

(c) disposing a second auxiliary metal shield on said second auxiliary sealing member,

(d) inserting a movable contact rod through said aperture of the lower end plate and the other end of said bellows,

(e) setting a second main metal shield on the outer peripheral surface of said rod and fixing a movable contact to an inner end of said rod,

(f) fixing a contact ring to said movable contact,

(g) disposing a stationary contact on said contact ring and fixing a stationary contact rod to said contact,

(h) setting a first main metal shield on the outer peripheral surface of said rod,

(i) disposing one end of a metal housing on said second auxiliary metal shield and a first auxiliary shield on the other end of said housing,

(j) disposing a first auxiliary sealing metal member on said shield and disposing an outer circumferential end of an upper insulating end plate having a central aperture on said sealing member,

(k) inserting a third auxiliary sealing metal member between said stationary contact rod and said aperture of said end plate,

(l) disposing brazing material at points of contact between the members making up the vacuum interrupter so as to complete temporary assembly of the vacuum interrupter,

said method of constructing the vacuum interrupter characterized by the further steps of

(m) forming a vacuum envelope by brazing hermetically said temporary assembly of the vacuum interrupter by means of heating and degassing in a vacuum environment at less than 1.333 mPa (10^{-5} Torr) at a temperature between 900°C and 1050°C,

(n) and plastically deforming said first, second umd third auxiliary sealing members by cooling said vacuum environment to a room temperature.

The invention also provides a method of constructing a vacuum interrupter comprising the steps of

(a) disposing one end of a bellows made of an austenitic stainless steel on an inner surface of a disc-shaped lower insulating end plate in the vicinity of an aperture in the center of said lower end plate,

(b) setting a second auxiliary shield on an inner surface of sid lower end plate so that the second auxiliary shield is electrically insulated from the movable contact rod and the housing,

(c) inserting a movable contact rod having a second main arc-shield mounted on the outer surface thereof through said aperture in the lower end plate,

(d) fixing a movable contact to an inner end of said movable contact rod,

(e) fixing a contact ring to said movable contact,

(f) disposing brazing material at points of contact between members making up said vacuum interrupter, thereby completing temporary assembly of a movable portion of the vacuum interrupter,

(g) setting a first auxiliary shield on an inner surface of the upper end plate so that the first auxiliary shield is electrically insulated from the stationary contact rod and the housing,

(h) providing a third auxiliary sealing member on a disc-shaped upper end plate so as to be adjacent to an aperture in the center of said upper end plate,

(i) inserting a stationary contact rod having a first main arc-shield mounted on its outer peripheral surface through said third auxiliary sealing member,

(j) fixing a stationary contact to an inner end of sid stationary contact rod,

(k) disposing brazing material at points of contact between members making up said vacuum interrupter, thereby completing temporary assembly of a stationary portion of the vacuum interrupter,

(l) inserting a first and second auxiliary sealing members into opposite ends of a housing so as to sandwich brazing material therebetween, thereby completing temporary assembly of a housing portion of the vacuum interrupter,

said method of constructing the vacuum interrupter characterized by comprising the further steps of:

(m) brazing said previously assembled movable portion, stationary portion and housing portion by means of heating and degassing in a reducing atmosphere or in a vacuum environment at less than 1.333 mPa (10^{-5} Torr) at a temperature between 900°C and 1050°C,

(n) plastically deforming said first, second and third auxiliary sealing members by cooling said vacuum or reducing environment to room temperature, said method of constructing the vacuum interrupter further characterized by the steps of:

(o) disposing one end of said housing portion on an outer peripheral portion of said lower end plate of said movable portion and disposing an outer peripheral portion of said upper end plate of said stationary portion, on the other end of said housing portion, thereby completing temporary assembly of the vacuum interrupter,

(p) forming a vacuum envelope by brazing hermetically said temporary assembly of the vacuum interrupter by means of reheating and redegassing in a vacuum environment at less than 1.333 mPa (10^{-5} Torr) at a temperature between 500°C and 1050°C,

(q) and plastically deforming said first, second and third auxiliary sealing members by cooling said vacuum environment to room temperature.

Ways of carrying out the invention are described in detail below with reference to drawings which illustrate several specific embodiments, in which:—

Figure 1 is a cross sectional view through a first vacuum interrupter constructed in accordance with the invention.

Figure 2 is an enlarged view of part of the interrupter of Figure 1.

Figure 3 is an enlarged view of another part of the interrupter of Figure 1.

Figure 4 is a graph showing characteristics of metallic materials employed in the vacuum interrupter of the present invention.

Figure 5 is a fragmental sectioned view of another vacuum interrupter constructed in accordance with the present invention.

Figure 6 is an enlarged view of part of a modification of the interrupter shown in Figure 5.

Figure 7 is an enlarged view of part of another modification of the interrupter shown in Figure 5.

Figure 8 is an enlarged view of a partial portion of further modification of the interrupter shown in Figure 5.

Figure 9 is a fragmental sectioned elevational view of a modification of the interrupter of Figure 5.

Figure 10 is a fragmental sectioned elevational view showing another embodiment of the present invention.

Figure 11 is a fragmental sectioned view of another embodiment of a vacuum interrupter accordigg to the present invention.

Figure 12 is a fragmental sectioned view of a further embodiment of a vacuum interrupter according to the present invention.

Figure 13 is a cross sectioned view of part of a modification of the interrupter of Figure 12.

Figure 14 is a cross sectioned view of another modification of the vacuum interrupter of Figure 12.

Figure 15 is a cross sectioned view of a further modification of the vacuum interrupter of Figure 12.

Figure 16 is a fragmental sectioned view of another embodiment of a vacuum interrupter according to the present invention.

Figure 17 is a fragmental sectioned view of a modification of the vacuum interrupter of figure 16.

Figure 18 is a fragmental sectioned view of another embodiment of a vacuum interrupter according to the present invention.

Figure 19 is a fragmental sectioned view of a modification of the vacuum interrupter of Figure 18.

Figure 20 is a fragmental sectioned view of another embodiment of a vacuum interrupter according to the present invention.

Figure 21 is a fragmental sectioned view or a further embodiment of a vacuum interrupter according to the present invention.

Referring to the drawings, particularly to Figures 1 to 3, there is shown as first embodiment a vacuum interrupter in accordance with the present invention. The vacuum interrupter comprises, substantially, an evacuated envelope A including a cylindrical housing 10 made of a non-magnetic material in the form of an austenitic stainless steel, an upper end plate 12 and a lower end plate 14, both of which are made of inorganic materials such as alumina ceramics or crystallized glass, an electrical contact member B including a stationary contact rod 16 supported by the upper end plate 12, a stationary electrical contact 18 secured to the stationary contact rod 16, a movable contact rod 20 supported by the lower end plate 14, a movable electrical contact 22 secured to the movable contact rod 20, and a shielding member C for shielding the internal surface of the end plates 12 and 14.

The vacuum interrupter further comprises first sealing meuns D for sealing hermetically the upper end plate 12 to the housing 10, second sealing means E for sealing hermetically the lower end plate 14, first supporting means F for supporting and securing hermetically the stationary contact rod 16 on the upper end plate 12, and hermetic seal means G for sealing movably and hermetically the movable contact rod 20 on the lower end plate 14.

As is shown in Figure 1, the upper end plate 12 is secured to one end of the housing 10, and the lower end plate 14 is secured to other end of the housing 10 to form the envelope A. In the electrical contact member B, the stationary electrical contact 18 has a circular recess 18a provided in the center portion thereof. An end portion of the stationary contact rod is inserted and secured to the recess 18a. The movable electrical contact 22 is provided with a circular recess 22a in the center portion thereof and a ring-shaped slot 22b on the surface opposed to the stationary electrical contact 18. An end portion of the movable contact rod 20 is inserted in and secured to the recess 18a, and an electrical contact ring 22c is disposed on the slot 22b to form the contact member B.

The shielding member C comprises a first main arc-shield 23 mounted on the stationary contact rod 16, a first auxiliary shield 24 secured on the upper end plate 12, a second main arc-shield 26 mounted on the movable contact rod 20 and a second auxiliary shield 28 secured to the lower end plate 14.

In more detail, axial and circular stepped portions 10a and 10b are provided at inner surfaces of open end portions of the housing 10. A first auxiliary sealing member 30 is fitted between the housing 10 and the upper end plate 12. A second auxiliary sealing member 32 is provided between the housing 10 and the lower end plate 14. The first auxiliary sealing member 30 has a ring-shaped flat portion 30a and a tubular portion 30b formed in one piece with the flat portion 30a. The second auxiliary sealing membr 32 has also a ring-shaped flat portion 32a and a tubular portion 32b formed in one piece with the flat portion 32b. The upper end plate 12 has an aperture 12a provided in the center portion thereof and a tubular portion 12b formed at the peripheral edge portion thereof. The lower end plate 14 has an aperture 14a provided in the center portion thereof and a tubular portion 14b formed at the peripheral edge portion thereof.

As is shown in Figures 1 and 2, first sealing means D comprises the stepped portion 10a of the housing 10, the first auxiliary sealing member 30 fitted in the stepped portion 10a of the housing 10, and the upper end plate 12 disposed on the auxiliary sealing member 30 by means of a metallized portion 34 provided on an end of the tubular portion 12b of the upper end plate 12. The second sealing means E comprises the stepped portion 10b of the housing 10, the second auxiliary sealing member 32 fitted in the stepped portion 10b of the housing 10, and the lower end plate 14 fitted in the auxiliary brazing member 32 by means of a metallized portion 34 provided on an end of the tubular portion of the lower end plate 14.

As is shown in Figures 1 and 2, a clip ring 36a is fitted into an annular slot 16a provided on the circumferential surface of the stationary contact rod 16. The stationary contact rod 16 is inserted into the housing 10 through a third auxiliary sealing member 38. The third auxiliary sealing member 38 is provided with a tubular portion 38a and a flange portion 38b. A metallized portion 34 is provided on the inner surface of the aperture 12a of the upper end plate 12. The tubular portion 38a of the third auxiliary sealing member 38 is inserted into the aperture 12a by way of the metallized portion 34. Accordingly, the first supporting means F comprises the clip ring 36a and the third auxiliary sealing member 38.

As is shown in Figures 1 and 3, the movable contact rod 20 is inserted into a bellows 40. The upper end 40b of the bellows 40 is secured in vacuum-tight seal by means of brazing material 42. The lower end of the bellows 40 is inserted into the aperture 14a of the lower end plate 14 and is secured in vacuum-tight seal by means of a metallized portion 34 and brazing material 42 to form the hermetic seal means G.

In more detail, the cylindrical housing 10 of the envelope A is made of an non-magnetic metallic material in the form of austenitic stainless steel which has high mechanical strength. Both open end portions of the housing 10 are provided with axial stepped portions 10a and 10b located on the inner periphery of the housing 10. The upper end plate 12 is made of an inorganic insulating material in the form of ceramics or crystallized glass and has a ring-shaped projection 12b projecting toward the inner side of the envelope 10. The lower end plate 14 is made of an inorganic insulating material such as ceramics or crystallized glass and has a ring-shaped projection 14b at the edge portion thereof and projecting toward the inner side of the envelope 10. The first auxiliary sealing member 30 is made of a plastically deformable metallic material such as Cu and is provided with a ring-shaped flange portion 30a and a short tubular-shaped projection 30b. As is best shown in Figure 2, the flange portion 30a of the first auxiliary sealing member 30 is disposed on the stepped portion 10a of the housing 10. The flange 24a of the first auxiliary shield 24a is provided between the stepped portion 10a of the housing 10 and the flange 30a of the first auxiliary sealing member 30. The projection 12b of the upper end plate 12 is disposed on the flange portion 30a of the first auxilary sealing member 30 via a metallized portion 34. Brazing material 42 is provided between the stepped portion 10a of the housing 10 and the flange 30a of the first auxiliary sealing member 30 and between the end of the housing 10 and the tubular portion 30b of the first auxiliary brazing member 30. Accordingly, the first sealing means D is comprised by the stepped portion 10a, the ring-shaped projection 12b of the upper end plate 12, the metallized portion 34 provided on the end surface of the projection 12b of the upper end plate 12 and brazing material 42.

As is shown in Figure 1, the second sealing means E comprises, similarly to the first connecting means D, the stepped portion 10b of the housing 10, the second auxiliary sealing member 32 provided in the stepped portion 10b of the housing 10, and the projection 14b of the lower end plate 14 fixed into the second auxiliary sealing member 32 via a metallized portion 34.

As is best shown in Figures 1 and 2, the stationary contact rod 16 is made of Cu, and is inserted into the housing 10 through the aperture 12a of the upper end plate 12 and is secured to the upper end plate 12 by means of the first supporting means F. The first supporting means F comprises the aperture 12a of the upper end plate 12, a third auxiliary brazing member 38 having a tubular portion 38a and a flange portion 38b integrally formed with the tubular portion 38a, which is made of a plastically deformable material in the form of Cu, the upper end plate 12 made of the inorganic insulating material, a metallized portion 34 which is provided on an inner surface of the aperture 12a, and a clamping member in the form of a cover ring 36a fixed into an annular groove 16a of the stationary contact rod 16.

The movable electrical contact 22 has a circular recess 22a, a ring-shaped slot 22b and a ring-shaped contact segment 22c fixed into the slot 22b. The movable contact rod 20 is inserted and fixed in the circular recess 22a of the movable electrical contact 22. As is shown in Figures 1 and 3, the movable contact rod 20 is movably secured to the lower end plate 14 by means of the second supporting means G including bhe bellows 40 mounted on the movable contact rod 20, a clamping member in the form of a cover ring 36c fixed to an annular groove 20a of the movable contact rod 20 and brazing material 42. The upper end of the bellows 40 is secured to the movable contact rod 20. The lower end of the bellows is inserted into the aperture 14a of the lower end plate 14 and is secured to the lower end plate 14 by the metallized portion 34 provided on an inner surface of the aperture 14a and a brazing material 42.

The shielding member C is made of a non-magnetic material in the form of an austentic stainless steel. The main arc-shield 23 comprises a circular flat portion 23a, a tubular portion 23b and an aperture 23c provided at the center portion of the flat portion 23a. The arc-shield 23 is inserted over the stationary contact rod 16 which passes through the aperture 23c and is fixed to a clamping member in the form of a cover ring 36b fixed to an annular slot 16b of the stationary contact rod 16 by means of the brazing material 42. The first auxiliary shield 24 comprises a tubular portion 24a and a flange portion 24b. The flange portion 24b of the first auxiliary shield 24 is secured to the stepped portion 10a of the housing 10. The first auxiliary shield 24 has a smaller diameter than that of the first main arc-shield 23 and is coaxially arranged with respect to the first main arc-shield 23. The second main arc-shield 26 of the shielding member C has a circular flat portion 26a, a tubular portion 26b and an aperture 26c provided at the center portion of the flat portion 26a. The arc-shield 26 is mounted on the movable contact rod 20 by the aperture 26c, cover ring 36c and brazing material 42. The second auxiliary shield 28 has a tubular portion 28a and a flange portion 28b which is secured to the stepped portion 10b of the housing 10.

Referring now to the material of each component of the vacuum interrupter, the housing 10 is made of a non-magnetic metallic material in the form of an austenitic stainless steel having high mechanical strength. Each of the upper and lower end plates 12 and 14 is made of inorganic insulating material such as an ceramics or a crystallized glass. Metallized portions 34 are made of metal alloy obtained by adding Mo or Mn to Ti (Mn-Ti alloy or Mo-Mn-Ti alloy) having the same coefficient of thermal expansion as that of the end plates 12 and 14, having a brazing temperature between 500°C and 1050°C. The stationary contact rod 16 and the movable contact rod 20 are made of Cu having a brazing temperature between 500°C and 1050°C. The electrical contacts 18 and 22 are made of Cu or of an alloy including Cu. The shielding member C is made of a non-magnetic material in the form of an austenitic stainless stel. The bellows 40 is made of an austenitic stainless steel. Each of the first auxiliary sealing member 30 and the second auxiliary sealing member 32 is made of a plastically deformable material in the form of Cu which is deformed by the thermal stress generated between the metallic housing 10 and the end plates 12 and 14 in slow cooling after brazing and which is employed to enhance the sealing connection between the metallic housing 10 and the upper and lower end plates 12 and 14 having different coefficients of thermal expansion from that of the housing 10. The auxiliary sealing members 30 and 32 can be made of Fe which is also deformed by thermal stress in cooling after brazing. The third auxiliary sealing member 38 is made of Cu which is also deformed by the thermal stress generated by the difference of the coefficient of thermal expansion between the upper end plate 12 and the stationary contact rod 16.

Additionally, the shielding member C can be made of Fe, which is inexpensive, when the vacuum interrupter is to be employed in a relatively low current and low voltage power system.

A method of manufacturing a vacuum interrupter according to the first embodiment of the present invention is now described in conjunection with Figures 1 and 4 of the accompanying drawings.

Referring to Figure 1, the vacuum interrupter is constructed by the steps of disposing firstly the lower end plate 14 horizontally at the axial end of the housing 10 by means of brazing material, mounting the bellows 40 on the lower end plate 14 by means of brazing material 42 so that a tubular portion 40a is inserted into the aperture 14a of the lower end plate 14 by way of the metallized portion 34, fitting the second auxiliary sealing member 32 into projecting portion 14b of the lower end plate 14 by way of the metallized portion 34 and brazing material 42, disposing the flange portion 28b of the second auxiliary shield 28 by way of brazing material 42, fitting the stepped portion 10b of the housing 10 to the second auxiliary sealing member 32 by way of the flange 28b of the shield 28, surrounding the movable contact rod 20 at the upper end 40b of the bellows 40 by means of brazing material 42, supporting the movable contact rod 20 on the bellows 40 by means of the cover ring 36c, inserting the second main arc-shield 26 over the movable contact rod 20 so that the tubular portion 26b is directed toward the lower end plate 14 and the flat portion 26a is fixed to the cover ring 36c by means of brazing material 42, mounting the electrical movable contact 22 on the upper end of the movable contact rod 20 by means of the circular recess 22a and the brazing material 42, disposing the stationary electrical contact 18 at the lower end of the stationary contact rod 16 by means of the circular recess 18a and the brazing material, disposing the first main arc-shield 23 on the stationary contact rod 16 by means of the cover ring 36b and the brazing material 42, disposing the flange 24b of the first auxiliary shield 24 on the stepped portion 10a of the housing 10 by means of brazing material 42, fitting the first auxiliary sealing member 30 into the stepped portion 10a of the housing 10 by means of the flange 24b of the shield 24 and brazing material 42, inserting the stationary contact rod 16 into the aperture 12a of the upper end plate 12, inserting the third auxiliary sealing member 38 over the stationary contact rod 16 so that the tubular portion 38a of the sealing member 38 is fitted into the aperture 12a by way of the metallized portion 34, securing the stationary contact rod 16 to the upper end plate 12 by means of the aperture 12a, the metallized portion 34, the third auxiliary sealing member 38, the cover ring 36a and the brazing material 42, and disposing the upper end plate 12 on the first auxiliary sealing member 30 by means of the metallized portion 34 and brazing material 42. The following steps are further carried out: heating the brazing materials 42 which are inserted between the components of the vacuum interrupter at a brazing temperature which is between 900°C and 1050°C while evacuating at a pressure which is less than 1.333 mPa (10^{-5} Torr). in a vacuum furnace, and letting gases induced by heating each component out of the vacuum interrupter. When the brazing material inserted in each component is melted the respective components of the vacuum interrupter are securely and hermetically fixed each other. Additionally, it is preferable that the heating temperature is high within the range of melting temperature of brazing material and the pressure is less than 1.333 mPa (10^{-5} Torr). The temperature of the vacuum furnace is gradually decreased to room temperature and to allow plastic deformation of the auxiliary sealing members. In this case, the upper limit of the heating temperature for brazing is determined by the temperature of 1083° at which copper melts and the lowest heating temperature for brazing is determined by the temperature of 900°C required for brazing stainless steel. The brazing temperature may be less than 900°C if a Ni plating is provided on the brazing portions such as the housing 10 and the bellows 40 made of austenitic stainless steel.

Figure 4 shows the thermal characteristics of the tensile strength F and the elongation L of Cu and Fe, with respect to temperature T. In Figure 4, a curve A_1 shows the tensile strength of Cu with respect to temperature, and a curve B_1 designates the tensile strength of Fe with respect to temperature. Further, a curve A_2 shows the elongation rate of Cu, and a curve B_2 shows the elongation rate of Fe with respect to temperature. As is shown by the curves A_1, B_1 and A_2, B_2 of Figure 4, the tensile strength of the material made of Cu decreases with the increase of temperature, and the elongation rate decreases and then increases with increase of temperature. Accordingly, it is appreciated that the plastic deformation results from the thermal stress in brazing and thereby the sealing of the junctions of the envelope is achieved, the residual thermal stress being very small, because the tensile strengh of the auxiliary sealing members made of Cu or Fe are very small compared with those of the insulating end plates 12 and 14 made of the inorganic insulating materials such as ceramics or crystallized glass, when the auxiliary sealing members are brazed to the housing 10 and the end plates 12 and 14 at a high temperature greater than 900°C. Accordingly, the high sealing performance and the high mechanical strength of the envelope are obtained by employing the auxiliary sealing member made of Cu, Fe, in spite of the fact that the coefficients of thermal expansion of the end plates 12 and 14 made of inorganic insulating material in the form of ceramics differ from those of the housing 10 made of metallic material such as austenitic stainless steel. It is considered that a high sealing performance between the end plates 12 and 14 and the housing 10 obtained when the associated auxiliary sealing members are made of Fe, results from the coefficient of thermal expansion of the Fe being smaller than that of the Cu in spite of the fact that tensile strength of Fe with respect to temperature is larger than that of Cu as is shown in Figure 4 and that the creep strain rate of Fe is smaller than that of Cu, under a predetermined temperature. Further, a high sealing performance between the end plate 14 and the bellows 40 can be obtained due to the plastic deformation thereof, since the thickness of the bellows 40 is very small (about 0.1—0.2 mm).

From the foregoing description, it will be appreciated that the following advantages can be achieved in the first embodiment of the vacuum interrupter according to the present invention:

Since the auxiliary sealing members which are deformed due to the thermal stress generated in cooling after brazing are employed to connect the end plates made of insulating material to metallic material in the form of the housing and the stationary contact rod, the sealing performance of the interrupter is extremely enhanced by the aid of the auxiliary sealing members.

Since the sealing between the components of the vacuum interrupter and the removal of gas are simultaneously carried out by heating the previously assembled interrupter at a temperature ranging from 900°C to 1050°C in the vacuum furnace, the manufacturing process is simplified and a highly reliable and good performance vacuum interrupter can be obtained.

Figure 5 shows a second vacuum interrupter embodying the present invention. In the second embodiment of the vacuum interrupter, the difference from the first embodiment described above resides in a shielding member C, the second sealing member E, the first securing means F and hermetic seal means G. In Figure 5, the same reference numerals designated in Figure 1 through Figure 3 indicate corresponding parts of the vacuum interrupter and therefore a detailed description of the corresponding parts described above will be omitted.

As shown in Figure 5, a first main arc-shield 44 has a disc-shaped flat portion 44a having approximately the same diameter as that of the stationary electrical contact 18, a tubular portion 44b formed integrally with the flat portion 44a and a curved portion 44c curved rectangularly from the outer edge of the flat portion 44a. The tubular portion of the first main arc-shield 44 is fitted to the stationary contact rod 16. A first auxiliary shield 46 has a circular flat portion 46a, a tubular portion 46b, a flange portion 46d and an aperture 46c provided in the center of the flat portion 46a. The flange portion 46d is secured to a stepped portion 10a of a housing 10. A second main arc-shield 48 comprises, similarly to the first main arc-shield 44, a circular flat portion 48a, a tubular portion 48b and a curved portion 48c. The tubular portion 48b is fitted to a movable contact rod 20. A second auxiliary shield 50 has a disc-shaped flat portion 50a, a tubular portion 50b and an aperture 50c provided at the center portion of the flat portion 50a. An open end of the shield 50 is secured to an internal surface of a lower end plate 14.

A peripheral portion of an upper end plate 12 is disposed on the flange 46d of the shield 46 by means of brazing material. The diameter of the upper end plate 12 is smaller than the inner diameter of the stepped portion 10a of the housing 10. A first auxiliary sealing member 30 has a ring-shaped flat portion 30a and a short tubular portion 30b. The tubular portion 30b is fitted into the stepped portion 10a, and the upper end plate 12 is fitted into the auxiliary sealing member 30 to form the first connecting means E.

A stationary contact rod 16 comprises an upper rod portion 16c and a lower rod portion 16d whose radius is smaller than that of the upper rod portion 16c. Brazing material 42 is inserted about the inner periphery of the upper end plate 12, and between the bottom of upper rod portion 16c and the upper end of the lower rod portion 16d. The lower rod portion 16d is inserted into the envelope A through the aperture 12a of the upper end plate 12 and the stationary contact rod 16 is supported on the end plate 12 by the upper rod portion 16c to form the first securing means F. The lower end of a bellows 40 is fixed to an inner surface of the lower end plate 14 by means of a metallized portion 34. Accordingly, the sealing performance is enhanced, because the mechanical strength of sealing is increased.

Figure 6 through Figure 8 shows modifications of the shielding member C of the vacuum interrupter of Figure 5. As is shown in Figure 6, a tubular portion 50b of a second auxiliary shield 50 is provided with a tapered portion 50d at an open end portion of the tubular portion 50b. By providing the tapered portion 50d, mechanical strength of connection between the shield 50 and a lower end plate 14 is enhanced, because of the thermal stress due to difference of the coefficients of thermal expansion in brazing. In the modified shielding member C, a semi-circular annular slot 50e is provided on a surface of the tubular portion 50b of the second auxiliary shield 50. By the provision of the annular slot 50e in the tubular portion 50b of the shield 50, the thermal stress is reduced in brazing the shield 50 to the lower end plate 14. In the shielding member C shown in Figure 8, a plurality of axial slits 50f are provided on an open end of the tubular portion 50b of the shield 50. According to the shielding member C of Figure 8, thermal stress is eliminated in brazing the shield 50 to the lower end plate 14 by providing the slits 50f in the open end of the tubular portion 50b.

Figure 9 shows a further modification of the vacuum interrupter of Figure 5. As is shown in Figure 9, a second auxiliary shield 50 comprises a circular flat portion 50a, a tubular portion 50b formed integrally with the flat portion 50a, an aperture 50c provided at the center portion thereof and a flange portion 50g curved rectangularly with respect to the tubular portion 50b. The flange portion 50g is secured to a second auxiliary brazing member 32.

The vacuum interrupter of the second embodiment is manufactured by similar steps to those of the manufacturing method of the vacuum interrupter of the first embodiment. Namely, a brazing material is firstly disposed between each component of the vacuum interrupter. Next, the vacuum interrupter previously assembled is located and inserted into a vacuum furnace and thereafter the vacuum interrupter is heated at the brazing temperature which is between 900°C and 1050°C while evacuating at a pressure which is less than 1.333 mPa (10^{-5} Torr). After the brazing material inserted between the components has melted, the temperature of the vacuum furnace is gradually decreased to a predetermined temperature to allow plastic deformation of the auxiliary sealing members and the vacuum furnace is maintained at the predetermined temperature during the given time interval. The temperature of the vacuum furnace is further gradually decreased to room temperature. When the temperature has decreased to the room temperature, the respective components of the vacuum interrupter are securely and hermetically fixed each other.

Referring now to a third vacuum interrupter embodying the invention which is similar to the first and the second embodiments described above, in this third embodiment brazing is executed in two steps, and the difference from the embodiments described above resides in a shielding member, sealing means and securing means. As is shown in Figure 10, a stepped portion 10c is provided at the outer surface of one end of a housing 10. A stepped portion 10d is provided at the outer surface of the other end of the housing 10. A first auxiliary sealing member 30 formed with a tubular shape is fitted and secured by brazing to the stepped portion 10c. An upper end plate 12 is fitted into the first auxiliary sealing member 30 and is hermetically secured to the brazing member 42 by means of a metallic portion 34 to form first sealing means D. A second auxiliary sealing member E formed with a tubular shape is fitted and secured by brazing to the stepped portion 10d of the housing 10. A lower end plate 14 is fitted into the second auxiliary sealing member 32 and is hermetically secured to the second auxiliary sealing member 32 by means of a metallized portion 34 to form second sealing means E. The upper end plate 12 is provided with an aperture 12a at the center portion thereof. A stationary contact rod 16 has an upper rod portion 16c and a lower rod portion 16d of which the diameter is smaller than that of the upper rod portion 16c. A third auxiliary sealing member 38 comprises a first tubular portion 38a, a flat portion curved rectangularly from the first tubular portion 38a and a second tubular portion 38c which has a large diameter and is shorter than the first tubular portion 38a. The first tubular portion 38a of the third auxiliary sealing member 38 is fitted to the lower rod portion 16d of the stationary contact rod 16, and an open end of the second tubular portion 38c of the third auxiliary sealing member 38 is secured to an inner surface of the upper end plate 12 by means of a metallized portion 34 and brazing material to form the first supporting means F.

The shielding member C comprises a cup-shaped first main arc-shield 23 mounted on the stationary contact rod 16, a tubular-shaped first auxiliary shield 24 fixed to an inner surface of the upper end plate 12 by means of a metallized portion 34, and brazing material, a second main arc-shield 26 mounted on a flange 20e of the movable contact rod 20 so as to be directed toward the lower end plate 14 and a tubular-shaped second auxiliary shield 28 fixed to an inner surface of the lower end plate 14 so as to be located coaxially with respect to the second main arc-shield 26. Since the auxiliary shields 24 and 28 are, respectively, secured to the end plates 12 and 14, the voltage potential is maintained at an intermediate value between that of the stationary contact rod 16 and that of the housing 10 and thereby the insulating strength within the envelope A is enhanced.

The materials of the components of the third embodiment according to the present invention are as follows: Each component of the shielding member C is made of an austenitic stainless steel. The auxiliary shields 24 and 28 can also be made of Cu or Fe which is deformed by the thermal stress generated by brazing the auxiliary shield 24 and 28 to the end plates 12 and 14 and cooling gradually or can be made of Fe-Ni-Co alloy or Fe-Ni alloy which has approximately the same coefficient of thermal expansion as that of the inorganic material such as an alumina-ceramics material.

A method of manufacturing a vacuum interrupter according to the third embodiment of the present invention will now be described in conjunction with Figure 10 of the accompanying drawings. For convenience of explanation, the brazing material is not shown in Figure 10. The vacuum interrupter is constructed by the steps of supporting the upper end plate 12 horizontally such that the metallized portions 34 are directed toward the upper direction, disposing the first auxiliary shield 24 on the upper end plate 12 via the metallized portion 34, mounting the third auxiliary sealing member 38 on the upper end plate 12 by means of the metallized portion 34 and brazing material, inserting the stationary contact rod 16 from the lower direction into the first tubular portion of the third auxiliary sealing member 38, mounting the first main arc-shield 23 on the cover ring 36c which is fixed to an annular groove 16b of the stationary contact rod 16 by means of brazing material, and fixing a stationary electrical contact 18 to an end of the stationary contact rod 16.

The following steps are then further effected: The lower end plate 14 is supported horizontally so that the metallized portions 34 is directed toward the upper direction and the second auxiliary shield 28 on the lower end plate 14 via the metallized portion 34. The lower end 40a of the bellows 40 is disposed on the lower end plate 14 by way of the metallized portion 34. Next, the movable contact rod 20 is inserted from the upper side into the bellows 40 and is disposed on the upper end 40b of the bellows 40 by means of the flange 20e and thereafter brazing material is inserted between the upper end 40b and the flange 20e. The second main arc-shield 26 is inserted on the upper end portion of the movable contact rod 20 and is engaged with the flange 20e by means of brazing material. The movable electrical contact 22 is secured to a circular recess 22a of the movable electrical contact 22 by means of brazing material. Lastly, a contact ring 22c is secured in a circular recess 22b of the movable electrical contact 22.

Additionally, the auxiliary shields 24 and 28 of the shielding member C can be made of a plastically deformable metallic material such as Cu or Fe which is deformed in slow cooling and due to the thermal stress generated in brazing, or can be made of Fe-Ni-Co alloy or Fe-Ni alloy which has same coefficient of thermal expansion as that of the inorganic insulating material such as the ceramics. Further, in a method of assembling the stationary side, not limited to the method stated above, the following steps can be carried out: the steps are mounting the first auxiliary shield 24 on the upper end plates 12, inserting the third auxiliary sealing member 38 on the stationary contact rod 16, engaging the first main arc-shield 23 with the cover ring 36c, and supporting the stationary side after inserting the stationary contact rod 16 into the aperture 12a of the upper end plate 12.

The following steps are now effected: previously assembled stationary portion, the movable portion and the metallic housing portion consisting of the metal housing 10 secured to the first and second auxiliary sealing members 30 and 32 at respective ends of the housing 10 are inserted into a vacuum furnace, a hydrogen environmental furnace or a deoxidation environmental furnace and is heated and brazed by the conventional method in order to enhance the activation of the surface of the material made of the austenitic stainless steel and to carry out degassing. Thereafter the temperature of the vacuum furnace is gradually decreased from the brazing temperature to the predetermined temperature, then kept to the predetermined temperature during a predetermined time interval and then the temperature of the vacuum furnace is further decreased to room temperature. A leak test of the hermetically brazed stationary portion, the movable portion and the housing portion are carried out in order to confirm the sealing performance of the stationary and the movable portion. When the sealing performance is good, a second step of brazing is carried out in order to construct the vacuum interrupter. When the sealing performance is wrong, the brazing stated above is again carried out. In the second step of brazing, a temporary assembly of the vacuum interrupter is carried out by fitting the stationary portion and the movable portion to the housing portion. The temporary assembly is heated at a temperature ranging from 500°C to 1050°C at a pressure less than 1.333 mPa (10^{-5} Torr). In the process of the second step, each of said three portions is redegassed and then is brazed at high vacuum. Thereafter, the temperature of the vacuum furnace is decreased to a predetermined temperature to allow plastic deformation of the auxiliary sealing members and the auxiliary shields and is kept during a predetermined time internal at the deformation temperature. The temperature of the vacuum furnace is further decreased from said deformation temperature to room temperature.

Although each of the auxiliary sealing members is brazed to the metallic housing 10 at the first step of brazing in accordance with the manufacturing method described above, it is possible to braze the auxiliary sealing members to the end plates in the first step of brazing. Further, it is possible to carry out the brazing of the stationary portion and the movable portion in the first step of brazing and thereafter to insert the auxiliary sealing members between the metallic housing and the end plates in a previous assembling step which is carried out prior to the second step of brazing.

From the foregoing description, it will now be appreciated that the following advantages as well as the advantages stated above in the description of the embodiments of the present invention can be achieved in vacuum interrupters according to the present invention:

Since a stationary portion, a movable portion and a housing portion are firstly and previously assembled in the first step of brazing and, thereafter, the interrupter is assembled in the second step brazing, a leak check can be performed in the first step of brazing and thereby high reliability of sealing of the junctions is further enhanced.

Figure 11 shows a fourth vacuum interrupter embodying the present invention. The interrupter of this embodiment is characterized in that an evacuated envelope A comprises a housing 10 made of a non-magnetic material such as an austenitic stainless steel, disc-shaped end plates 12 and 14 made of an inorganic insulating material such as a ceramic or crystallized glass secured to end portions of the housing by way of auxiliary sealing members.

As is shown in Figure 11, first sealing meuns D comprises a first auxiliary sealing member 30 connected to the housing 10 and the periphery of an upper end plate 12. Second sealing means E includes a second auxiliary sealing member 32, of the same material as the first auxiliary sealing member 30, connected to the housing 10 and the periphery of a lower end plate 14. In more detail, the first auxiliary sealing member 30 comprises a first tubular portion 30b, the outer diameter of which is the same as that of the housing 10, a first flange portion 30a, a second tubular portion 30c formed integrally with the first flange portion 30a and a second flange portion 30d formed integrally with the second tubular portion 30c. The first tubular portion 30b is fixed to an end of the housing 10. The peripheral surface of the upper end plate 12 is fitted into the first tubular portion 30b of the first auxiliary sealing member 30, sandwiching a metallized portion 34 therebetween. The second sealing means E includes a second auxiliary sealing member 32 having a first tubular portion 32b, a first flange portion 32a, a second tubular portion 32c formed integrally with the first tubular portion 32b by way of the first flange 32a, a second flange 32d, and a third tubular portion 32e formed integrally with the second tubular portion by way of the second flange 32d.

A shielding member C includes a first curved auxiliary shield 52 secured to the second flange 30d of the first auxiliary sealing member 30 and a second auxiliary shield 54 which is secured to the second flange 32c and the third tubular portion 32e of the second auxiliary sealing member 32.

Figure 12 shows a modification of the vacuum interrupter of Figure 11. In the interrupter shown in Figure 12, a first auxiliary sealing member 30 of the first sealing means D comprises a first tubular portion 30b and a second tubular portion 30f of diameter smaller than that of the first tubular portion 30b and formed integrally with the first tubular portion by way of a flange portion 30a. The first anular portion 30b is fitted into the housing 10 and secured to the inner surface of the housing by means of brazing. The peripheral surface of an upper end plate 12 is fitted into the second tubular portion 30f and secured by means of brazing to form the first sealing means D. A second sealing means E includes a second auxiliary sealing member 32 having a first tubular portion 32b, a flange portion 32a, and a second tubular portion 32f formed integrally with the first tubular portion 32b via a flange portion 32a, and is secured similarly to the first sealing means D.

Figures 13 through 15 show further modifications of the vacuum interrupter of Figure 11. In the vacuum interrupter of Figure 13, a first auxiliary sealing member 30 includes a flange portion 30a, a first tubular portion 30b, a second flange 30g and a second tubular portion 30f, all which are formed integrally. The first tubular portion 30b fits sealingly within the housing 10, and second flange 30g is secured on an end of the housing 10. An upper end plate 12 is fitted into the second tubular portion 30f, sandwiching therebetween a metallized portion 34, to form the first sealing means D.

A second sealing means E includes a second auxiliary sealing member 32 formed similarly to the first auxiliary sealing member 30 and is constructed similarly to the first sealing means D.

In the vacuum interrupter shown in Figure 14, a first tubular auxiliary sealing member 30 is secured to an outer stepped portion 10c of the housing 10, and an upper end plate 12 fits sealingly within the first tubular auxiliary sealing member 30 and is fixed to an end of the housing 10. Second sealing means E comprises a second tubular auxiliary sealing member 32 secured to an outer stepped portion 10d, and a lower end plate 14 fitted sealingly within the second tubular auxiliary sealing member 32 and fixed to an end of the housing 10.

In the vacuum interrupter of Figure 15, a first auxiliary sealing member 30 has a flange 30a and a tubular portion 30b. The inner end of the flange 30a is secured to an outer stepped portion 10c of the housing 10, and an upper end plate 12 is fitted into and secured to the tubular portion 30b sandwiching therebetween a metallized portion 34, to form first sealing means D. Second sealing means E includes a second auxiliary sealing member 32 which comprises a flange 32a and a tubular portion 32b, and which is formed as described for the first sealing means D.

In accordance with the vacuum interrupter of the fourth embodiment, mechanical strength against mechanical shock generated during operation is greatly increased, since the sealing portions are provided with curved stress-absorbing portions.

Figure 16 shows a fifth vacuum interrupter embodying the present invention. The vacuum interrupter of this embodiment is characterized in that auxiliary sealing members are secured hermetically to both end portions of a metallic housing and are further secured to insulating end plates hermetically. As is shown in Figure 16, a first auxiliary sealing member 30 comprises a first flange portion 30a, a first tubular portion 30b connected to the outer edge of the first flange 30a, a second flange 30g formed perpendicularly with respect to the first tubular portion 30b, and a second tubular portion 30c connected to the second flange 30g. An end of a metallic housing 10 is secured to the first flange 30a. An end of a ring-shaped projection 12b of an upper end plate 12 is secured to the second flange 30g of the first auxiliary sealing member 30, sandwiching therebetween a metallized portion 34 to form the first sealing means D. A second auxiliary sealing member 32 is formed similarly to the first auxiliary sealing member 30. An end of the housing 10 is secured to a first flange 32a of the second auxiliary sealing member 32, and a ring-shaped projection 14b of a lower end plate 14 is secured to a second flange 32f, sandwiching therebetween a metallized portion 34 to form the second sealing means E. A first supporting means F includes a U-shaped third auxiliary sealing member 38 for sealingly connecting a stationary contact rod 16 to an inner surface of the upper end plate 12. A shielding member C includes a first curved auxiliary shield 52 which is secured to a second tubular portion 30c of the first auxiliary sealing member 30 by means of spot welding, and a second curved auxiliary shield 54 which is secured to a second tubular portion 32e of the second auxiliary sealing member 32 by means of spot welding.

Figure 17 shows a modification of the vacuum interrupter of Figure 16. The differences between the vacuum interrupter of Figure 17 and the vacuum interrupter of Figure 16 reside in the shape of an auxiliary sealing member for aiding the positioning of auxiliary shields. As is shown in Figure 17, a first auxiliary sealing member 30 has a ring-shaped flange 30a and a curved portion 30c curved inwardly and formed integrally with the flange 30a. An end of a housing 10 is secured to the flange 30a of the first auxiliary sealing member 30, and an end 30b of the curved portion 30c is secured to an end surface of a ring-shaped projection 12b of an upper end plate 12 by means of a metallized portion 34 secured by brazing to form the first sealing means D. A second auxiliary sealing member 32 comprises a ring-shaped flange 32a and a curved portion 32c curved inwardly and formed integrally with the flange 32a. The flange 32a is, similar to the first auxiliary sealing member 30, secured to an end of the housing 10 and an end 32b of the curved portion 32c of the second auxiliary sealing member 32 is secured to an end of a ring-shaped projection 14b of a lower end plate 14 by means of brazing so that the lower end plate 14 is spaced apart from the housing 10, in order to form second sealing means E. A shielding member C includes a first auxiliary shield 52 which is curved inwardly and a second auxiliary shield 54 curved inwardly. One end of the shield 52 is fixed to the inner surface of the tubular portion 30b of the first auxiliary sealing member 30 by brazing or spot welding. One end of the shield 54 is secured to the inner surface of the tubular portion 32b of the second sealing member 32 by brazing or spot welding.

In the vacuum interrupter shown in Figures 16 and 17, mechanical stress occurring during operation of the vacuum interrupter is relieved as well as thermal stress due to brazing, and high reliability of sealing and high performance of the vacuum interrupter can be achieved, since the auxiliary sealing members have the curved stress-absorbing portions. Further, the diameter of the housing can be increased inexpensively and easily, and brazing material can be provided easily in the assembly, since the ends of the housing and the end plates are hermetically connected by means of the auxiliary sealing members.

Figure 18 shows a sixth vacuum interrupter embodying the present invention. In the vacuum power interrupter of Figure 18, auxiliary sealing members are provided with at least one curved portion for absorbing the mechanical stress generated by operation of the vacuum interrupter or by thermal stress during brazing. One end of the auxiliary sealing member is secured to an end portion of the housing by means of brazing, and other end of the auxiliary sealing member is fastened to an end plate.

In more detail, a cylindrical housing 10 is made of a non-magnetic metallic material such as an austenitic stainless steel of which the mechanical strength is relatively large. The housing 10 has a flange 10e curved toward the axis of the housing 10. A first auxiliary sealing member 30 comprises a flange portion 30a, a tubular portion 30b curved at right angles with respect to the flange portion 30a, and a curved portion 30h curved into a semi-circular shape. One end of the housing 10 is inserted into the tubular portion 30b of the first auxiliary sealing member 30. One end of the curved portion 30h is secured to the end of a projection 12b provided on the rim of an upper end plate 12, sandwiching a metallized portion 34 therebetween. Accordingly, the first sealing means D comprises the first auxiliary sealing member 30 having the flange portion 30a, the first tubular portion 30b extending at right angles and the semi-circular curved portion 30h, the end of the housing 10, which is inserted into the tubular portion 30b of the first auxiliary sealing member 30, and the rim of the upper end plate 12 to which the end of the curved portion 30h of the first auxiliary sealing member 30 is secured. The second sealing means E comprises an end of the housing 10, a second auxiliary sealing member 32 having a ring-shaped flange portion 32a, a tubular portion 32b having a diameter smaller than that of the flange portion 32a, and a curved portion 32h formed integrally with the flange portion 32a and the tubular portion 32b, and an end of a projection 14b which is secured to an end of the tubular portion 32b of the second auxiliary sealing member 32. First supporting means for supporting and securing hermetically a stationary contact rod includes a cup-shaped third auxiliary sealing member 38 and a ring-shaped metallized portion 34 provided on an upper surface of the upper end plate 12. One end of the third auxiliary sealing member 38 is fixed to a lower rod portion 16d of the stationary contact rod 16. The other rod of the auxiliary sealing member 38 is secured to the upper surface of the upper end plate 12 by means of the metallized portion 34 to support the stationary contact rod 16. Each of the auxiliary sealing members is made of a metal, such as Cu or Fe which is deformed by the thermal stress generated by slow cooling after brazing.

A shielding member C comprises a first main arc-shield 56 mounted on the stationary contact rod 16, a first auxiliary shield 58 provided coaxially with respect to the first main arc-shield 56, a second main arc-shield 60 mounted on a movable contact rod 20 and a second auxiliary shield 62 provided coaxially with respect to the second main arc-shield 60. The first main arc-shield 56 comprises a first tubular portion 56a fixed to the lower rod portion 16d and secured to a stationary electrical contact 18, a ring-shaped flat portion 56b formed integrally with the first tubular portion 56a and a second tubular portion 56c formed integrally with the flat portion 56b and directed toward the upper end plate. The second main arc-shield 60 is formed by a first tubular portion 60a fitted to the movable contact rod 20 and fastened to a movable electrical contact 22, a ring-shaped flat portion 60b formed integrally with the first annular portion 60a and a second annular portion 60c formed integrally with the flat portion 60b and directed toward the lower end plate 14.

The first auxiliary shield 58 includes a first tubular portion 58a having an outer diameter smaller than that of the first main arc-shield, a first flange portion 58b extending outwards from the first tubular portion 58a, a second tubular portion 58c formed integrally with an outer edge of the first flange portion 58b, a second flange portion 58d extending outwards from the second tubular portion 58c and having an outer diameter larger than that of the flange 10e of the housing 10 and a tubular projection 58e projecting from the outer edge of the second flange portion 58d. The second tubular portion 58c of the first auxiliary shield 58 is mounted on the housing 10 by inserting the second tubular portion 58c into the flange 10e of the housing 10 and engaging the second flange portion 58d with the outer surface of the flange 10e of the housing 10. The upper end plate 12 fits into the corner between the second flange portion 58d and the projection 58e of the second auxiliary shield 58. The second auxiliary shield 62 has a first portion 62a having a smaller diameter than that of the second main arc-shield 60 and being coaxially located with the second main arc-shield 60, a flange portion 62b extending outwards from the first tubular portion 62a and a second tubular portion 62c formed integrally with the flange 62b. The second tubular portion 62c is inserted into the tubular portion 32c of the second auxiliary sealing member 32 and is secured to the tubular portion 32c of the second auxiliary sealing member 32 by means of spot welding. The shielding member C is made of an austenitic stainless steel.

In the vacuum interrupter of the sixth embodiment, since each of the auxiliary sealing members is provided with at least one curved portion, the impact force applied to the housing during operation of the vacuum interrupter is absorbed by the curved portion of the auxiliary member; similarly, thermal stress is absorbed by the curved portion. Since mechanical stress and thermal stress are eliminated, the diameter of the housing can be increased inexpensively and easily.

Figure 19 designates a modification of the interrupter of Figure 18. As is shown in Figure 19, a shielding member C includes an approximately disc-shaped first auxiliary shield 64 having an inner curved portion 64a which has a smaller diameter than that of the flange 10e of housing 10. The first auxiliary shield 64 is made of an austenitic stainless steel and is fixed to the flange portion 10e by brazing. The second auxiliary shield 28 has a ring-shaped flange portion 28b affixed to a second auxiliary sealing member 32 of second sealing means E.

The second auxiliary sealing member 32 of the second sealing means E has a flange portion 32a, a first tubular portion 32b formed integrally with the flange portion 32a and a circular projection 32g projecting from the outer edge of the flange portion 32a and having a larger diameter than the housing 10. One end of the tubular portion 32b is affixed to the upper surface of a lower end plate 14 by means of a metallized portion 34. An end of the housing 10 is secured to the flange portion 32a of the second auxiliary sealing member 32 to form the second sealing means E.

Second supporting means G comprises a bellows 40. The upper end 40b of which is secured to a movable contact rod 20 and the lower end 40a of which is inserted into an aperture 14a provided in the central portion of the disc-shaped lower end plate 14 and brazed to a fourth auxiliary sealing member 66 located in the aperture 14a. The fourth auxiliary sealing member 66 is made of a metallic material such as Cu or Fe and is U-shaped. An end of the fourth auxiliary sealing member 66 is secured to a metallized portion 34 provided on a ring-shaped projection, which projection is fixed on the inner surface of the lower end plate 14 near the aperture 14a by brazing. In the vacuum interrupter shown in Figure 19, the same advantages as those of Figure 18 can be achieved.

Figure 20 shows a seventh vacuum interrupter embodying the present invention. In the vacuum power interrupter of Figure 20, ring-shaped metallized portions 34 are provided on the central and peripheral projections 12c and 12b of the outside surface of an upper end plate 12 and on the central and peripheral projections 14c and 14b of the inside surface of a lower end plate 14. A first auxiliary sealing member 30 is fitted to the upper end plate 12 so that a flange portion 30a engages with the projection 12b formed in an edge portion of the upper end plate by way of the metallized portion 34 and a tubular portion 30b is fitted to the outer edge surface of the upper end plate 12. The tubular portion 30b of the first auxiliary sealing member 30 is fitted and secured to a stepped portion 10a of a housing 10 to form a first sealing means D.

A second auxiliary sealing member 32 is fitted and secured to the lower end plate 14 such that a flange portion 32a engages with the projection 14b of the lower end plate 14 by way of the metallized portion 34 and a tubular portion 32b is fitted to the outer edge surface of the lower end plate 14. The tubular portion 32b of the second auxiliary sealing member 32 is fitted and secured to a stepped portion 10b of the housing to form the second sealing means E. In the vacuum interrupter shown in Figure 20, it is easy to provide brazing material between the components of the vacuum interrupter and to perform the assembly, because the upper end plate 12 and the lower end plate 14 are aligned in the same direction.

Figure 21 shows an eighth vacuum interrupter embodying the present invention. In this embodiment, a part of a shielding member C is made of a metallic material which is plastically deformed by the thermal stress generated in cooling after brazing and is employed in an auxiliary sealing member to aid sealing between the metallic housing and the insulating end plates.

In more detail, the shielding member C comprises a first main arc-shield 23 mounted on a stationary contact rod 16, a first auxiliary shield 70, a second main arc-shield 26 mounted on a movable contact rod 20 and a second auxiliary shield 72. The first auxiliary shield 70 is made of a metallic material, such as Cu or Fe, which is plastically deformed by thermal stress in slow cooling after brazing. The first auxiliary shield 70 comprises a tubular portion 70a and a flange portion 70b extending outwards from the tubular portion 70a. One end of the flange portion 70b of the first auxiliary shield 70 is disposed between a stepped portion 10a of a housing 10 and an upper end plate 12 to be employed as a first auxiliary sealing member 30 of first sealing means D. The second shield 72 is made of the same material as that of the first auxiliary shield 70. The second auxiliary shield 72 is formed by a tubular portion 72a and a flange portion 72b outwardly extending from the tubular portion 72a. An end portion of the flange portion 72b is fitted between a stepped portion 10b of the housing 10 and a lower end plate 14 and is also employed as a second auxiliary sealing member 32 of second sealing means E.

In the vacuum interrupter of Figure 21, the number of elements of the vacuum interrupter is reduced and thereby the construction of the vacuum interrupter is simplified, since a part of element of the shielding member C is made of a metallic material such as Cu or Fe which is plastically deformed by thermal stress in cooling after brazing and is employed as the auxiliary sealing member for aiding the sealing of the vacuum interrupter. It is easy to position the auxiliary shield in the envelope, because the auxiliary shields are fitted between the end plates and the end portions of the housing.

Although the stepped portions are provided in order to secure the shields in the embodiment stated above, the stepped portions may be omitted and stepped portions may be provided on end portions of the shields in order to secure the shields.

Claims

1. A vacuum circuit interrupter comprising:

a) an evacuated envelope (A) consisting essentially of a cylindrical metal housing (10), upper and lower electrically insulating end plates (12, 14) secured to the housing (10) by first and second auxiliary sealing members (30, 32) of first and second sealing means (D, E), a stationary contact rod (16), a movable contact rod (20), and a metal bellows (40);

b) the upper and lower end plates (12, 14) closing opposite ends of the cylindrical metal housing (10), each of the upper and lower end plates (12, 14) having a coaxial central aperture (12a, 14a);

c) the stationary contact rod (16) coaxially entering the envelope (A) through the central aperture (12a) of the upper end plate (12), the stationary contact rod (16) being fixed to the upper end plate (12) in such a manner as to provide a hermetic seal therewith;

d) the movable contact rod (20) coaxially and movably entering the envelope (A) through the central aperture (14a) of the lower end plate (14) without impairing the vacuum within the envelope (A);

e) stationary and movable electrodes (18, 22) respectively connected to an inner end of the stationary and movable rods (16, 20) in such a manner as to engage each other via an electrical contact portion (22c) when the movable rod (20) moves toward the stationary contact rod (16) and disengage from each other when the movable contact rod (20) moves away from the stationary contact rod (16); and

f) opposite ends of the bellows (40) being respectively fixed to the movable contact rod (20) and to the lower end plate (14) in such a manner as to provide a hermetic seal about the movable contact rod (20) to allow for movement of the movable contact rod (20) without impairing the vacuum within the envelope (A); characterized in that

said upper and lower end plates (12, 14) have coefficients of thermal expansion differing from that of said housing (10),

said first and second auxiliary sealing members (30, 32) have coefficients of thermal expansion differing from those of said upper and lower end plates (12, 14),

said first and second auxiliary sealing members (30, 32) are made of a plastically deformable metallic material, each of which is plastically deformed by thermal stresses generated in a slow cooling process after vacuum brazing, whereby said upper and lower end plates (12, 14) are secured to said housing (10) by means of said first and second auxiliary sealing members (30, 32) in a slow cooling process after vacuum brazing.

2. A vacuum interrupter as claimed in claim 1, wherein said first and second auxiliary sealing members (30, 32) are made of Cu. (Figs. 1—21).

3. A vacuum interrupter as claimed in claim 1, wherein said first and second auxiliary sealing members (30, 32) are made of Fe.

4. A vacuum interrupter as claimed in claim 1, wherein said first and second sealing means (D, E) each comprise a stepped portion (10a, 10b) formed in the inner surface of a corresponding end of said housing (10), the first and second auxiliary sealing members (30, 32) each has a ring-shaped flange portion (30a, 32a) and a tubular portion (30b, 32b) fitted into said stepped portion (10a, 10b) of said housing (10), and a ring-shaped projection (12b, 14b) formed in the outer edge of each of said disc-shaped upper and lower end plates (12, 14) and secured to said flange portion (30a, 32a) of said first and second auxiliary sealing members (30, 32) by means of the metallized portion (34). (Figs. 1, 2, 5, 20, 21).

5. A vacuum interrupter as claimed in claim 1, further comprises first supporting means (F) for hermetically supporting said stationary contact rod (16) in contact with said upper end plate (12), said first supporting means (F) including a third auxiliary sealing member (38) made of a non-magnetic material which is deformed by thermal stresses generated in the slow cooling process after vacuum brazing. (Figs. 1, 2, 10, 12, 16—19, 21).

6. A vacuum interrupter as claimed in claim 5, wherein said third auxiliary sealing member (38) is made of Cu. (Figs. 1, 2, 10, 12, 16—19).

7. A vacuum interrupter as claimed in claim 5, wherein said third auxiliary sealing member (38) is made of Fe.

8. A vacuum interrupter as claimed in claim 5, wherein said third auxiliary sealing member (38) of the first supporting means (F) comprises a tubular portion (38a) inserted into and secured hermetically to the aperture (12a) of said upper end plate (12) by the metallized portion (34). Figs. 1, 2).

9. A vacuum interrupter as claimed in claim 5, wherein said third auxiliary sealing member (38) comprises a first tubular portion (38a) secured to a stationary contact rod (16), a ring-shaped flat portion (38b) formed integrally with said first tubular portion (38a) and a second tubular portion (38c) formed integrally with said flat portion (38b) and secured to an inner surface of said upper end plate (12) by means of a metallized portion (34). (Figs. 10, 12, 16, 21, 17).

10. A vacuum interrupter as claimed in claim 1, wherein said first and second sealing means (D, E) each comprise a stepped portion (10c, 10d) provided in the outer surface of a corresponding end of said housing (10), tubular first and second auxiliary sealing members (30, 32) each of which is secured to a corresponding stepped portion (10c, 10d) of said housing (10) and the outer circumferential surfaces of the upper and lower

end plates (12, 14), each secured to the inner surface of a corresponding one of the first and second auxiliary sealing members (30, 32) by means of a metallized portion (34). (Figs. 10, 14, 15).

11. A vacuum interrupter as claimed in claim 1, further comprising a shielding member (C) consisting of a first main arc-shield (23, 44, 56) mounted on said stationary contact rod (16) by means of a brazing material and a first auxiliary shield (24, 46, 52, 58) fixed to said first sealing member (30) of said first sealing means (D), a second main arc-shield (26, 48, 60) mounted on said movable contact rod (20), and a second auxiliary shield (28, 50, 54, 62) secured to said second auxiliary sealing member (32) of said second sealing means (E), each of said shields being made of a non-magnetic material such as austenitic stainless steel. (Figs. 1, 11, 16, 17).

12. A vacuum interrupter as claimed in claim 11, wherein said first and second auxiliary shields (24, 28; 46, 50; 52, 54; 58, 62; 70, 72) each have a tubular portion secured to the inner surface of a corresponding one of the lower and upper end plates (12, 14). (Figs. 5—8, 10, 12, 17, 18, 21).

13. A vacuum interrupter as claimed in claim 1, wherein each of said first and second auxiliary sealing members (30, 32) has a first flange portion (30a, 32a) secured to one end of the housing, as well as an axially inwardly extending first tubular portion (30b, 32b), a second flange portion (30g, 32f) and a second tubular portion (30c, 32e), and said first and second auxiliary shields (52, 54) are each secured to a second tubular portion (30c, 32e) of the corresponding auxiliary sealing member (30, 32). (Fig. 16).

14. A vacuum interrupter as claimed in claim 1, wherein sach of said first and second auxiliary sealing members (30, 32) comprises a first tubular portion (30b, 32b) secured to the inner surface of a corresponding end of said housing (10) and a second tubular portion (30f, 32f) secured to the outer circumferential surface of the associated end plate (12, 14). (Fig. 12).

15. A vacuum interrupter as claimed in claim 14, wherein each of said first and second auxiliary sealing members (30, 32) further houses a corresponding second flange portion (30g, 32f) secured to the associated end of said housing (10). (Fig. 13).

16. A vacuum interrupter as claimed in claim 1, wherein each of said first and second auxiliary sealing members (30, 32) has a curved portion (30c, 32c), one end of which is secured to a ring-shaped projection (12, 14b) of said end plate (12, 14), and a flange portion (30a, 32a) secured to one end of said housing (10). (Fig. 17).

17. A vacuum interrupter as claimed in claim 1, wherein said first auxiliary sealing member (30) comprises a tubular portion (30b) secured to the outer circumferential surface of said housing (10), a flange portion (30a) extending inwardly from said tubular portion (30b) and a stress-absorbing portion (30h) curving inwardly from said flange portion (30a) and secured to the upper surface of the upper end plate (12). (Fig. 18, 19).

18. A vacuum interrupter as claimed in claim 1, wherein said bellows (40) is associated with a fourth auxiliary sealing member (66) which is deformed by the thermal stresses generated in the slow cooling process after brazing. (Fig. 19).

19. A vacuum interrupter as claimed in claim 1, further comprising a shielding member (C) having an approximately disc-shaped shield (64) having an inner curved portion (64a) and having a smaller diameter than the housing (10), said shield (64) being mounted on one end of said housing (10). (Fig. 19).

20. A vacuum interrupter as claimed in any one of claims 11, 12 or 19, wherein said shielding member (C) comprises a shield (70, 72) made of a metal which is deformed by the thermal stresses generated in the slow cooling process after vacuum brazing. (Fig. 21).

21. A method of manufacturing a vacuum interrupter comprising the steps of:

(a) inserting one end (40a) of a bellows (40) made of an austenitic stainless steel into an aperture (14a) in the center of a disch-shaped lower insulating end plate (14),

(b) disposing a second auxiliary metal sealing member (32) on an outer circumferential edge (14b) of said lower end plate (14),

(c) disposing a second auxiliary metal shield (28) on said second auxiliary sealing member (32),

(d) inserting a movable contact rod (20) through said aperture (14a) of the lower end plate (14) and the other end (40b) of said bellows (40),

(e) setting a second main metal shield (26) on the outer peripheral surface off said rod (20) and fixing a movable contact (22) to an inner end of said rod (20),

(f) fixing a contact ring (22c) to said movable contact (22),

(g) disposing a stationary contact (18) on said contact ring (22c) and fixing a stationary contact rod (16) to said contact (18),

(h) setting a first main metal shield (23) on the outer peripheral surface of said rod (16),

(i) disposing one end of a metal housing (10) on said second auxiliary metal shield (28) and a first auxiliary shield (24) on the other end of said housing (10),

(j) disposing a first auxiliary sealing metal member (30) on said shield (24) and disposing an outer circumferential end (12b) of an upper insulating end plate (12) housing a central aperture (12a) on said sealing member (30),

(k) inserting a third auxiliary sealing metal member (38) between said stationary contact rod (16) and said aperture (12a) of said end plate (12),

(l) disposing brazing material at points of contact between the members making up the vacuum interrupter so as to complete temporary assembly of the vacuum interrupter,

said method of constructing the vacuum interrupter characterized by the further steps of

(m) forming a vacuum envelope (A) by brazing hermetically said temporary assembly of the vacuum interrupter by means of heating and degassing in a vacuum environment at less than 1.333 mPa (10^{-5} Torr) at a temperature between 900°C and 1050°C,

(n) and plastically deforming said first, second and third auxiliary sealing members (30, 32, 38) by cooling said vacuum environment to a room temperature.

22. A method of constructing a vacuum interrupter comprising the steps of

(a) disposing one end (40a) of a bellows (40) made of an austenitic stainless steel on an inner surface of a disc-shaped lower insulating end plate (14) in the vicinity of an aperture (14a) in the center of said lower end plate (14) so that the second auxiliary shield (28) is electrically insulated from the movable contact rod (20) and the housing (20),

(b) setting a second auxiliary shield (28) on an inner surface of said lower end plate (14),

(c) inserting a movable contact rod (20) having a second main arc-shield (26) mounted on the outer surface thereof (20) through said aperture (14a) in the lower end plate (14),

(d) fixing a movable contact (22) to an inner end of said movable contact rod (20),

(e) fixing a contact ring (22c) to said movable contact (22),

(f) disposing brazing material at points of contact between members making up said vacuum interrupter, thereby completing temporary assembly of a movable portion of the vacuum interrupter,

(g) setting a first auxiliary shield (24) on an inner surface of the upper end plate (12) so that the first auxiliary shield (24) is electrically insulated from the stationary contact rod (16) and the housing (10),

(h) providing a third auxiliary sealing member (38) on a disc-shaped upper end plate (12) so as to be adjacent to an aperture (12a) in the center of said upper end plate (12),

(i) inserting a stationary contact rod (16) having a first main arc-shield (23) mounted on its outer peripheral surface through said third auxiliary sealing member (38),

(j) fixing a stationary contact (18) to an inner end of said stationary contact rod (16),

(k) disposing brazing material at points of contact between members making up said vacuum interrupter, thereby completing temorary assembly of a stationary portion of the vacuum interrupter,

(l) inserting a first and second auxiliary sealing members (30, 32) into opposite ends of a housing (10) so as to sandwich brazing material therebetween, thereby completing temporary assembly of a housing portion of the vacuum interrupter,

said method of constructing the vacuum interrupter characterized by comprising the further steps of:

(m) brazing said previously assembled movable portion, stationary portion and housing portion by means of heating and degassing in a reducing atmosphere or in a vacuum environment at less than 1.333 mPa (10^5 Torr) at a temperature between 900°C and 1050°C,

(n) plastically deforming said first, second and third auxiliary sealing members (30, 32, 38) by cooling said vacuum or reducing environment to room temperature,

said method of constructing the vacuum interrupter further characterized by the steps of:

(o) disposing one end of said housing portion on an outer peripheral portion of said lower end plate (14) of said movable portion and disposing an outer peripheral portion of said upper end plate (12) of said stationary portion on the other end of said housing portion, thereby completing temporary assembly of the vacuum interrupter,

(p) forming a vacuum envelope (A) by brazing hermetically said temporary assembly of the vacuum interrupter by means of reheating and redegassing in a vacuum environment at less than 1.333 mPa (10^5 Torr) at a temperature between 500°C and 1050°C,

(q) and plastically deforming said first, second and third auxiliary sealing members (30, 32, 38) by cooling said vacuum environment to room temperature.

Patentansprüche

1. Vakuum-Stromkreisschalter mit:

a) eine evakuierten Umhüllung (A), bestehend im wesentlichen aus einem zylindrischen Metallgehäuse (10), oberen und unteren elektrisch isolierenden Endplatten (12, 14), die an dem Gehäuse (10) durch erste und zweite Hilfs-Dichtteile (30, 32) von ersten bzw. zweiten Dichtmitteln (D, E) befestigt sind, einem stationären Kontaktstab (16), einem bewegbaren Kontaktstab (20), und einem Metallbalg (40);

b) wobei die obere und die untere Endplatte (12, 14) entgegengestezt liegende Enden des zylindrischen Metallgehäuses (10) abschließen, jede der oberen und unteren Endplatten (12, 14) einen koaxialen zentralen Durchbruch (12a, 14a) besitzt;

c) der stationäre Kontaktstab (16) koaxial in die Umhüllung (A) durch den zentralen Durchbruch (12a) der oberen Endplatte (12) eintritt, der stationäre Kontaktstab (16) an der oberen Endplatte (12) in solcher Weise befestigt ist, daß eine luftdichte Abdichtung mit dieser geschaffen ist;

d) der bewegbare Kontaktstab (20) koaxial und beweglich in die Umhüllung (A) durch den zentralen Durchbruch (14a) der unteren Endplatte (14) ohne Beeinträchtigung des Vakuums innerhalb der Umhüllung (A) eintritt;

e) stationäre bzw. bewegbare Elektroden (18, 22) jeweils mit einem inneren Ende des stationären bzw. bewegbaren Stabes (16, 20) in solcher Weise verbunden sind, daß sie aneinander über einen elektrischen Kontaktabschnitt (22c) anliegen, wenn der bewegbare Stab (20) sich zu dem stationären Kontaktstab (16) hin bewegt, und sich voneinander lösen, wenn der bewegbare Kontaktstab (20) sich von dem stationären Kontaktstab (16) weg bewegt; und

f) entgegengesetzt liegende Enden des Balges (40) jeweils an dem bewegbaren Kontaktstab (20) bzw. an der unteren Endplatte (14) in solcher Weise befestigt sind, daß eine hermetische Abdichtung um den bewegbaren Kontaktstab (20) geschaffen ist und eine Bewegung des bewegbaren Kontaktstabes (20) ohne Beeinträchtigung des Vakuums innerhalb der Umhüllung (A) erlaubt ist; dadurch gekennzeichnet, daß

die oberen und unteren Endplatten (12, 14) thermische Ausdehnungskoeffizienten besitzen, die sich von dem des Gehäuses (10) unterscheiden,

die ersten und zweiten Hilfsdichtglieder (30, 32) thermische Aushenungskoeffizienten besitzen, die sich von denen der oberen und unteren Endplatten (12, 14) unterschieden,

die ersten und zweiten Hilfsdichtglieder (30, 32) aus einem plastisch verformbaren metallischen Material gemacht sind, wobei jedes derselben durch thermische Spannungen plastich verformt ist, die bei einem langsamen Abkühlvorgang nach Vakuum-Hartlöten erzeugt sind, wodurch die oberen und unteren Endplatten (12, 14) an dem Gehäuse (10) mittels der ersten und zweiten Hilfsdichtglieder (30, 32) in einem langsamen Abkühlvorgang nach Vakuum-Hartlöten verbunden sind.

2. Vakuumschalter nach Anspruch 1, wobei die ersten und zweiten Hilfsdichtglieder (30, 32) aus Cu gemacht sind (Figuren 1—21).

3. Vakuumschalter nach Anspruch 1, wobei die ersten und zweiten Hilfsdichtglieder (30, 32) aus Fe gemacht sind.

4. Vakuumschalter nach Anspruch 1, wobei das erste und das zweite Dichtmittel (D, E) jeweils einen an der Innenfläche eines entsprechenden Endes des Gehäuses (10) ausgebildeten gestuften Abschnitt (10a, 10b) umfassen, das erste und das zweite Hilfsdichtglied (30, 32) jeweils einen ringförmigen Flanschabschnitt (30a, 32a) und einen in den gesteuften Abschnitt (10a, 10b) des Gehäuses (10) eingepaßten rohrförmigen Abschnitt (30b, 32b) besitzt und einen in der Außenkante jeder der schiebenförmigen oberen und unteren Endplatten (12, 14) ausgebildeten ringförmigen Vorsprung (12b, 14b), der an dem Flanschabschnitt (30a, 32a) der ersten und zweiten Hilfsdichtglieder (30, 32) mittels des metallisierten Abschnittes (34) befestigt ist (Figuren 1, 2, 5, 20, 21).

5. Vakuumschalter nach Anspruch 1, der weiter erste Stützmittel (F) zum hermetischen Abstützen des stationären Kontaktstabes (16) in Berührung mit der oberen Endplatte (12) aufweist, wobei die ersten Stützmittel (F) ein drittes Hilfsdichtglied (38) enthalten, das aus einem nicht magnetischen Material gemacht ist, welches durch bei dem langsamen Abkühlvorgang nach Vakuum-Harlöten erzeugte thermische Spannungen verformt ist (Figuren 1, 2, 10, 12, 16—19, 21).

6. Vakuumschalter nach Anspruch 5, bei dem das dritte Hilfsdichtglied (38) aus Cu gemacht ist (Figuren 1, 2, 10, 12, 16—19).

7. Vakuumschalter nach Anspruch 5, bei dem das dritte Hilfsglied (38) aus Fe gemacht ist.

8. Vakuumschalter nach Anspruch 5, bei dem das dritte Hilfsdichtglied (38) der ersten Stützmittel (F) einen in den Durchbruch (12a) der oberen Endplatte (12) eingesetzten und hermetisch durch den metallisierten Abschnitt (34) daran befestigten rohrförmigen Abschnitt (38a) umfaßt (Figuren 1, 2).

9. Vakuumschalter nach Anspruch 5, bei dem das dritte Hilfsdichtelement (38) einen ersten rohrförmigen, an einem stationären Kontaktstab (16) befestigten Abschnitt (38a), einen ringförmigen ebenen, integral mit dem ersten rohrförmigen Abschnitt (38a) ausgebildeten Abschnitt (38b) und einen zweiten rohrförmigen, integral mit dem ebenen Abschnitt (38b) ausgebildeten Abschnitt (38c) umfaßt, der an einer Innenfläche der oberen Endplatte (12) mittels eines metallisierten Abschnittes (34) befestigt ist (Figuren 10, 12, 16, 21, 17).

10. Vakuumschalter nach Anspruch 1, bei dem die ersten und zweiten Dichtmittel (D, E) jeweils einen an der Außenfläche eines korrespondierenden Endes des Gehäuses (10) vorgesehenen gestuften Abschnitt (10c, 10d) umfassen, rohrförmige erste und zweite Hilfsdichtglieder (30, 32), von denen jedes an einem entsprechenden gestuften Abschnitt (10c, 10d) des Gehäuses (10) und der Außenumfangsfläche der oberen bzw. unteren Endplatten (12, 14) befestigt ist, welche jeweils an der Innenfläche eines entsprechenden der ersten oder zweiten Hilfsdichtglieder (30, 32) mittels eines metallisierten Abschnittes (34) befestigt ist (Figuren 10, 14, 15).

11. Vakuumschalter nach Anspruch 1, weiter umfassend ein Schirmteil (C), bestehend aus einem ersten Haupt-Bogenschirm (23, 44, 56), der mittels eines Hartlötmateriales an dem ersten stationären Kontaktstab (16) angebracht ist, und einem ersten, an dem ersten Dichtglied (30) des ersten Dichtmittels (D) befestigten Hilfsschirm (24, 46, 52, 58), einem zweiten, an dem bewegbaren Kontaktstab (20) angebrachten Haupt-Bogenschirm (26, 48, 60) und einem zweiten, an dem zweiten Hilfsdichtglied (32) des zweiten Dichtmittels (E) befestigten Hilfsschirm (28, 50, 54, 62), wobei jeder Schirm aus einem nicht magnetischen metallischen Material wie einem austenitischen Edelstahl gefertigt ist (Figuren 1, 11, 16, 17).

12. Vakuumschalter nach Anspruch 11, bei dem der erste und der zweite Hilfsschirm (24, 28; 46, 50; 52, 54; 58, 62; 70, 72) jeweils einen an der Innenfläche einer entsprechenden von den unteren und oberen Endplatten (12, 14) befestigten rohrförmigen Abschnitt besitzt (Figuren 5—8, 10, 12, 17, 18, 21).

13. Vakuumschalter nach Anspruch 1, bei dem jedes der ersten und zweiten Hilfsdichtglieder (30, 32) einen an einem Ende des Gehäses befestigten ersten Flanschabschnitt (30a, 32a) wie auch einen

sich axial nach innen erstreckenden ersten rohrförmigen Abschnitt (30b, 32b), einen zweiten Flanschabschnitt (30g, 32f) und einen zweiten rohrförmigen Abschnitt (30c, 32e) besitzt und die ersten und zweiten Hilfsschirme (52, 54) jeweils an einem zweiten rohrförmigen Abschnitt (30c, 32e) des entsprechenden Hilfsdichtgliedes (30, 32) befestigt sind (Figur 16).

14. Vakuumschalter nach Anspruch 1, bei dem jedes der ersten und zweiten Hilfsdichtglieder (30, 32) einen an der Innerfläche eines entsprechenden Endes des Gehäuses (10) befestigten ersten rohrförmigen Abschnitt (30b, 32b) und einen an der Außenumfangsfläche der zugehörigen Endplatte (12, 14) befestigten zweiten rohrförmigen Abschnitt (30f, 32f) besitzt (Figur 12).

15. Vakuumschalter nach Anspruch 14, bei dem jedes der ersten und zweiten Hilfsdichtglieder (30, 32) weiter einen entsprechenden, an dem zugehörigen Ende des Gehäuses (10) befestigten zweiten Flanschabschnitt (30g, 32f) aufnimmt (Figur 13).

16. Vakuumschalter nach Anspruch 1, bei dem jedes der ersten und zweiten Hilfsdichtglieder (30, 32) einen gekrümmten Abschnitt (30c, 32c) besitzt, von dem ein Ende an einem ringförmigen Forsatz (12b, 14b) der Endplatte (12, 14) befestigt ist, und einen an einem Ende des Gehäuses (10) befestigten Flanschabschnitt (30a, 32a) (Figur 17).

17. Vakuumschalter nach Anspruch 1, bei dem das erste Hilfsdichtglied (30) einen an der Außenfangsfläche des Gehäses (10) befestigten rohrförmigen Abschnitt (30b), einen sich von dem rohrförmigen Abschnitt (30b) nach innen erstreckenden Flanschabschnitt (30a) und einen spannungsaufnehmenden, von dem Flanschabschnitt (30a) nach innen gekrümmten und an der oberen Fläche der oberen Endplatte (12) befestigten Abschnitt (30h) besitzt (Figur 18, 19).

18. Vakuumschalter nach Anspruch 1, bei dem der Balg (40) einem vierten Hilfsdichtglied (66) zugeordnet ist, welches durch die bei dem langsamen Abkühlvorgang nach dem Hartlöten erzeugten thermischen Spannungen verformt ist (Figur 19).

19. Vakuumschalter nach Anspruch 1, weiter ein Schirmglied (C) umfassend mit einem annähernd scheibenförmigen Schirm (64), der einen inneren gekrümmten Abschnitt (64a) besitzt und einen kleineren Durchmesser als das Gehäuse (10), wobei der Schirm (64) an einem Ende des Gehäuses (10) angebracht ist (Figur 19).

20. Vakuumschalter nach einem der Ansprüche 11, 12 oder 19, bei dem das Schirmglied (C) einen aus Metall bestehenden Schirm (70, 72) enthält, welcher durch die bei dem langsamen Abkühlvorgang nach Vakuum-Hartlöten erzeugten thermischen Spannungen verformt ist (Figur 21).

21. Verfahren zur Herstellung eines Vakuumschalters mit den Schritten:

(a) Einsetzen eines Endes (40a) eines Balges (40) aus austenitischem Edelstahl in einen Durchbruch (14a) in der Mitte einer scheibenförmigen unteren isolierenden Endplatte (14),

(b) Anordnen eines zweiten Hilfs-Metall-Dichtgliedes (32) an einer Außenumfangskante (14b) der unteren Endplatte (14),

(c) Anordnen eines zweiten Hilfs-Metall-Schirmes (28) an dem zweiten Hilfs-Dichtglied (32),

(d) Einsetzen eines bewegbaren Kontakstabes (20) durch den Durchbruch (14a) der unteren Endplatte (14) und das andere Ende (40b) des Balges (40),

(e) Ansetzen eines zweiten Haupt-Metall-Schirmes (26) an die Außenumfangsfläche des Stabes (20) und Befestigen eines bewegbaren Kontaktes (22) an einem inneren Ende des Stabes (20),

(f) Befestigen eines Kontaktringes (22c) an dem bewegbaren Kontakt (22),

(g) Anordnen eines stationären Kontakt (18) an dem Kontaktring (22c) und Befestigen eines stationären Kontaktstabes (16) an dem Kontakt (18),

(h) Ansetzen eines ersten Haupt-Metall-Schirmes (23) an die Außenumfangsfläche des Stabes (16),

(i) Anordnen eines Endes eines Metallgehäuses (10) an dem zweiten Hilfs-Metall-Schirm (28) und eines ersten Hilfsschirmes (24) an dem anderen Ende des Gehäuses (10),

(j) Anordnen eines ersten Hilfsdichtungs-Metall-Gliedes (30) an dem Schirm (24) und Anordnen eines Außenfangsendes (12b) einer oberen isolierenden Endplatte (12) mit einem zentralen Durchbruch (12a) an dem Dichtglied (30),

(k) Einsetzen eines dritten Hilfsdichtungs-Metall-Gliedes (38) zwischen dem stationären Kontaktstab (16) und dem Durchbruch (12a) der Endplatte (12),

(l) Anordnen von Hartlötmaterial an Berührungsstellen zwischen den den Vakuumschalter bildenden Gliedern, um so die zweitweilige Anordnung des Vakuumschalters zu vervollständigen, wobei das Aufbauverfahren des Vakuumschalters gekennzeichnet wird durch die weiteren Schritte

(m) Ausbilden einer Vakuumumhüllung (A) durch hermetisches Hartlöten der zweitweiligen Anordnung des Vakuumschalters mittels Erhitzen und Entgasen in einer Vakuumumgebung von weniger als 1,333 mPa (10^{-5} Torr) bei einer Temperatur zwischen 900°C und 1050°C,

(n) und plastisches Verformen der ersten, zweiten und dritten Hilfsdichtglieder (30, 32, 38) durch Abkühlen der Vakuumumgebung auf eine Raumtemperatur.

22. Verfahren zum Aufbauen eines Vakuumschalters mit den Schritten

(a) Anordnen eines Endes (40a) eines Balges (40) aus austenitischem Edelstahl an einer Innenfläche einer scheibenförmigen unteren isolierenden Endplatte (14) in der Nachbarschaft eines Durchbruches (14a) in der Mitte der unteren Endplatte (14), so daß der zweite Hilfsschirm (28) von dem bewegbaren Stab (20) und dem Gehäuse (10) elektrisch isoliert ist,

(b) Ansetzen eines zweiten Hilfsschirmes (28) an eine Innenfläche der unteren Endplatte (14),

(c) Einsetzen eines beweglichen Kontaktstabes (10) mit einem an der Außenflächen desselben (20) angebrachtem zweiten Haupt-Bogenschirm (26) durch den Durchbruch (14a) in der unteren Endplatte (14),

(d) Befestigen eines bewegbaren Kontaktes (22) an einem inneren Ende des bewegbaren Kontaktstabes (20),

(e) Befestigten eines Kontaktringes (22c) an dem bewegbaren Kontakt (22),

(f) Anordnen von Hartlötmaterial an Berührungsstellen zwischen den Vakuumschalter bildenden Gliedern, um dadurch die zeitweilige Anordnung eines bewegbaren Anteiles des Vakuumschalters zu vervollständigen,

(g) Ansetzen eines ersten Hilfsschirmes (24) an eine Innenfläche der oberen Endplatte (12), so daß der erste Hilfsschirm (24) elektrisch von dem stationären Kontaktstab (16) und dem Gehäuse (10) isoliert ist,

(h) Vorsehen eines dritten Hilfs-Dichtgliedes (38) an einer scheibenförmigen oberen Endplatte (12), so, daß es einem Durchbruch (12a) in der Mitte der oberen Endplatte (12) benachbart ist,

(i) Einsetzen eines stationären Kontaktstabes (16) mit einem an dessen Außenumfangsfläche angebrachten ersten Haupt-Bogenschirm (23) durch das dritte Hilfsdichtglied (38),

(j) Befestigen eines stationären Kontaktes (18) an einem inneren Ende des stationären Kontaktstabes (16),

(k) Anordnen von Harlötmaterial an Berührungsstellen zwischen den Vakuumschalter bildenden Gliedern, um dadurch die zeitweilige Anordnung eines stationären Anteiles des Vakuumschalters zu vervollständigen,

(l) Einsetzen eines ersten und eines zweiten Hilfsdichtgliedes (30, 32) in entgegengesetzt liegende Enden eines Gehäuses (10) so, daß Hartlötmaterial dazwischen eingeschlossen ist, um dadurch die zeitweilige Anordnung eines Gehäuseanteiles des Vakuumschalters zu vervollständigen, wobei das Aufbauverfahren für den Vakuumschalter gekennzeichnet wird durch folgende weitere Schritte:

(m) Hartlöten des vorher zusammengestellten bewegbaren Anteiles, stationären Anteiles und Gehäuseanteiles mittels Erhitzen und Entgasen in einer reduzierenden Atmosphäre oder in einer Vakuumumgebung von weniger als 1,333 mPa (10^{-5} Torr) bei einer Temperatur zwischen 900°C und 1050°C,

(n) plastiches Verformen des ersten, zweiten und dritten Hilfsdichtgliedes (30, 32, 38) durch Abkühlen der Vakuum oder der reduzierenden Umgebung auf Raumtemperatur, wobei das Verfahren zum Aufbau des Vakuumschalters weiter gekennzeichnet ist durch die Schritte:

(o) Anordnen eines Endes des Gehäuseabschnittes an einem Außenumfangsabschnitt der unteren Endplatte (14) des bewegbaren Abschnittes und Anordnen eines Außenumfangsabschnittes der oberen Endplatte (12) des stationären Abschnittes an dem anderen Ende des Gehäuseabschnittes, um dadurch die zeitweilige Anordnung des Vakuumschalters zu vervollständigen,

(p) Ausbilden einer Vakuumumhüllung (A) durch hermetisches Hartlöten der zweitweiligen Anordnung des Vakuumschalters mittels neuerlichen Erhitzens und neuerlichen Entgasens in einer Vakuumumgebung von weniger als 1,333 mPa (10^{-5} Torr) bei einer Temperatur zwischen 500°C und 1050°C,

(q) und plastisches Verformen des ersten, zweiten und dritten Hilfsdichtgliedes (30, 32, 38) durch abkühlen der Vakuumumgebung auf Raumtemperatur.

Revendications

1. Interrupteur de circuit dans le vide, comprenant:

a) une enveloppe (A) dans laquelle on a fait le vide, essentiellement composée d'un boîtier métallique cylindrique (10), de fonds isolants de l'électricité, supérieur et inférieur (12, 14), fixés au boîtier (10) par des premier et deuxième éléments d'étanchéité auxiliaires (30, 32) appartenant à un premier et un deuxième dispositifs d'étanchéité (D, E), une tige de contact fixe (16), un tige de contact mobile (20) et un soufflet métallique (40);

b) les fonds supérieur et inférieur (12, 14) fermant les extrémités opposées du boîtier métallique cylindrique (10), chacun des fonds, supérieur et inférieur (12, 14), présentant une ouverture centrale coaxiale (12*a*, 14*a*);

c) la tige de contact fixe (16) pénétrant coaxialement dans l'enveloppe (A) à travers l'ouverture centrale (12*a*) du fond supérieur (12), la tige de contact fixe (16) étant fixée au fond supérieur (12) de manière à établir un joint étanche avec celui-ci;

d) la tige de contact mobile (20) pénétrant coaxialement et avec liberté de mouvement dans l'enveloppe (A) à travers l'ouverture centrale (14*a*) du fond inférieur (14) sans nuire au vide régnant à l'intérieur de l'enveloppe (A);

e) des électrodes fixe et mobile (18, 22) respectivement connectées aus extremités intérieures de tiges de contact fixe et mobile (16, 20) de manière à entrer en contact entre elles avec interposition d'une partie de contact électrique (22*c*) lorsque la tige mobile (20) se rapproche de la tige de contact fixe (16) et à s'écarter l'une de l'autre lorsque la tige de contact mobile (20) s'éloigne de la tige de contact fixe (16); et

(f) les extrémités opposées du soufflet (40) et étant respectivement fixées à la tige de contact mobile (20) et au fond inférieur (14) de manière à établir un joint étanche autour fe la tige de contact mobile (20) pour permettre le mouvement de la tige de contact mobile (20) sans nuire au vide régnant à l'intérieur de l'enveloppe (A); caractérisé en ce que

lesdits fonds supérieur et inférieur (12, 14) possèdent des coefficients de dilatation thermique différents de celui dudit boîtier (10),

lesdits premier et deuxième éléments d'étanchéité auxiliaires (30, 32) possèdent des coefficients de dilatation thermique différentes de ceux des fonds supérieur et inférieur (12, 14),

ledit premier et ledit deuxième éléments d'étanchéité auxiliaires (30, 32) sont faits d'une matière métallique susceptible de déformation plastique, chacun d'eux subissant une déformation plastique sous l'effet des contraintes thermiques engendrées dans un processus de refroidissement lent après brasage sous vide, de sorte que lesdits fonds supérieur et inférieur (12, 14) sont fixés audit boîtier (10) au moyen desdits premier et deuxième éléments d'étanchéité auxiliaires (30, 32) dans un processus de refroidissement lent après brasage sous vide.

2. Interrupteur dans le vide selon la revendication 1, dans lequel lesdits premier et deuxième éléments d'étanchéité auxiliaires (30, 32) sont faits de Cu. (Figures 1 à 21).

3. Interrupteur dans le vide selon la revendication 1, dans lequel lesdits premier et deuxième éléments d'étanchéité auxiliaires (30, 32) sont faits de Fe.

4. Interrupteur dans le vide selon la revendication 1, dans lequel lesdits premier et deuxième dispositifs d'étanchéité (D, E) comprennent une partie étagée (10*a*, 10*b*) formée dans la surface intérieure d'une extrémité correspondante dudit boîtier (10), lesdits premier et deuxième éléments d'étanchéité auxiliaires (30, 32) possèdent chacun une partie collerette annulaire (30*a*, 32*a*) et une partie tubulaire (30*b*, 32*b*) emboîtées dans ladite partie étagée (10*a*, 10*b*) dudit boîtier (10) et un relief annulaire (12*b*, 14*b*), formé sur le bord extérieur de chacun desdits fonds supérieur et inférieur en forme de disque (12, 14) et fixé à ladite partie collerette (30*a*, 32*a*) desdits premier et deuxième éléments d'étanchéité auxiliaires (30, 32) au moyen de la partie métallisée (34). (Figures 1, 2, 5, 20, 21).

5. Interrupteur dans le vide selon la revendication 1, qui comprend en outre un premier dispositif de montage (F) servant à donner appui à joint étanche à ladite tige de contact fixe (16) en contact avec ledit fond supérieur (12), ledit premier dispositif de montage (F) comprenant un troisième élément d'étanchéité auxiliaire (38) fait d'une matière non magnétique qui est déformée par les contraintes thermiques engendrées dans le processus de refroidissement lent après le brasage sous vide. (Figures 1, 2, 10, 12, 16—19, 21).

6. Interrupteur dans le vide selon la revendication 5, dans lequel ledit troisième élément d'étanchéité auxiliaire (38) est fait de Cu. (Figures 1, 2, 10, 12, 16—19).

7. Interrupteur dans le vide selon la revendication 5, dans lequel ledit troisième élément d'étanchéite auxiliaire (38) est fait de Fe.

8. Interrupteur dans le vide selon la revendication 5, dans lequel ledit troisième élément d'étanchéité auxiliaire (38) comprend une partie tubulaire (38*a*) insérée (38) comprend une partie tubulaire (38*a*) insérée dans l'ouverture (12*a*) dudit font supérieur (12) et fixée hermétiquement à cette ouverture par la partie métallisée (34). (Figures 1, 2).

9. Interrupteur dans le vide selon la revendication 5, dans lequel ledit troisième élément d'étanchéité auxiliaire (38) comprend une première partie tubulaire (38*a*) fixée à une tige de contact fixe (16), une partie plate annulaire (38*b*) formée d'une seule pièce avec ledite première partie tubulaire (38*a*) et une deuxième partie tubulaire (38*c*) formée d'une seule pièce avec ladite partie plate (38*b*) et qui est fixée à la surface intérieure dudit font supérieur (12) au moyen d'une partie métallisée (34). (Figures 10, 12, 16, 21, 17).

10. Interrupteur dans le vide selon la revendication 1, dans lequel lesdits premier et deuxième dispositifs d'étanchéité (D, E) comprennent chacun une partie étagée (10*c*, 10*d*) prévue dans la surface extérieure de l'extrémité correspondante dudit boîtier (10), des premier et deuxième éléments d'étanchéité auxiliaires tubulaires (30, 32) dont chacun est fixé à la partie étagée correspondante (10*c*, 10*d*) dudit boîtier (10), et les surfaces circonférentielles extérieures desdits fonds supérieure et inférieur (12, 14), fixées chacune à la surface intérieure d'un, correspondant, des premier et deuxième éléments d'étanchéité auxiliaires (30, 32) au moyen d'une partie métallisée (34). (Figures 10, 14, 15).

11. Interrupteur dans le vide selon la revendication 1, comprenant en outre un dispositif d'écran (C) composé d'un premier écran pare-arc principal (23, 44, 56), monté sur ladite tige de contact fixe (16) au moyen d'une matière de brasure, et d'un premier écran auxiliaire (24, 46, 52, 58) fixé audit premier élément d'etanchéité (30) dudit premier dispositif d'étanchéité (D), d'un deuxième écran pare-arc principal (26, 48, 60) monté sur ladite tige de contact mobile (20) et d'un deuxième écran auxiliaire (28, 50, 54, 62) fixé audit deuxième élément d'étanchéité auxiliaire (32) dudit deuxième dispositif d'étanchéité (E), chacun desdits écrans étant fait d'une matière métallique non magnétique telle qu'un acier inoxydable austénitique. Figures 1, 11, 16, 17).

12. Interrupteur dans le vide selon la revendication 11, dans lequel lesdits premier et deuxième écrans auxiliaires (24, 28; 46, 50; 52, 54; 58, 62; 70, 72) possèdent chacun une partie tubulaire fixée à la surface intérieure de l'un, correspondant, desdits fonds supérieur et inférieur (12, 14).

13. Interrupteur dans le vide selon la revendication 1, dans lequel chacun desdits premier et deuxième éléments d'étanchéité auxiliaires (30, 32) possède une première partie collerette (30*a*, 32*a*) fixée à une extrémité du boîtier, ainsi qu'une première partie tubulaire (30*b*, 32*b*) s'étendant axialement vers l'intérieur, une deuxième partie collerette (30*g*, 32*f*) et une deuxième partie tubulaire (30*c*, 32*e*), et lesdits premier et deuxième écrans auxiliaires (52, 54) sont fixés

chacun à une deuxième partie tubulaire (30*c*, 32*e*) de l'élément d'étanchéite auxiliaire correspondant (30, 32). (Figure 16).

14. Interrupteur dans le vide selon la revendication 1, dans lequel chacun des premier et deuxième éléments d'étanchéité auxiliaires (30, 32) comprend une première partie tubulaire (30*b*, 32*b*) fixée à la surface intérieure de l'extrémité correspondante dudit boîtier (10) et une deuxième partie tubulaire (30*e*, 32*f*) fixée à la surface circonférentielle extérieure du fond (12, 14) qui lui est associé. (Figure 12).

15. Interrupteur dans le vide selon la revendication 14, dans lequel chacun des premier et deuxième éléments d'étanchéité auxiliaires (30, 32) comprend en outre une deuxième partie collerette correspondante (30*g*, 32*f*) fixée à l'extrémité associée dudit boîtier (10). (Figure 13).

16. Interrupteur dans le vide selon la revendication 1, dans lequel chacun desdits premier et deuxième éléments d'étanchéité auxiliaires (30, 32) comprend une partie recoubée (30*c*, 32*c*) dont une extrémité est fixée à un relief annulaire (12*b*, 14*b*) dudit fond (12, 14) et une partie collerette (30*a*, 32*a*) fixée à une extrémité dudit boîtier (10). (Figure 17).

17. Interrupteur dans le vide selon la revendication 1, dans lequel ledit premier élément d'étanchéité auxiliaire (30) comprend une partie tubulaire (30*b*) fixée à la surface circonférentielle extérieure dudit boîtier (10), une partie collerette (30*a*) qui s'étend vers l'intérieur à partir de ladite partie tubulaire (30*b*) et une partie d'absorption des contraintes (30*h*) qui s'incurve vers l'intérieur à partir de ladite partie collerette (30*a*) et est fixée à la surface supérieure du fond supérieur (12). (Figure 18, 19).

18. Interrupteur dans le vide selon la revendication 1, dans lequel ledit soufflet (40) est associé à un quatrième élément d'étanchéité auxiliaire (66) qui se déforme sous l'effet des contraintes thermiques engendrées dans le processus de refroidissement lent après brasage. (Figure 19).

19. Interrupteur dans le vide selon la revendication 1, comprenant en outre un dispositif d'écran (C) comprenant un écran (64) approximativement en forme de disque qui possède une partie intérieure recourbée (64*a*) et présente un plus petit diamètre que le boîtier (10), ledit écran (64) étant monté sur une extrémité dudit boîtier (10). (Figure 19).

20. Interrupteur dans le vide selon l'une quelconque des revendications 11, 12 et 19, dans lequel ledit dispositif d'écran (C) comprend un écran (70, 72) fait d'un métal qui se déforme dans le processus de refroidissement lent après brasage sous vide. (Figure 21).

21. Procédé de fabrication d'un interrupteur dans le vide, comprenant les phases consistant à:

a) insérer une extrémité (40*a*) d'un soufflet (40) fait d'un acier inoxydable austènitique dans une ouverture 14*a* ménagée au centre d'un fond inférieur isolant (14) en forme de disque,

b) disposer une deuxième élément d'étanchéité métallique auxiliaire (32) sur un bord circonférentiel extérieur (14b) dudit fond inférieur (14),

c) disposer un deuxième écran métallique auxiliaire (28) sur ledit deuxième élément d'étanchéité auxiliaire (32),

d) insérer une tige de contact mobile (20) à travers ladite ouverture (14*a*) du fond inférieur (14) et à travers l'autre extrémité (40b) dudit soufflet (40),

(e) monter un deuxième écran métallique principal (26) sur la surface périphérique extérieure de ladite tige (20) et fixer un contact mobile (22) sur l'extrémité intérieure de ladite tige (20),

f) fixer un anneau de contact (22*c*) audit contact mobile (22),

g) disposer une contact fixe (18) sur ledit anneau de contact (22*c*) et fixer une tige de contact fixe (16) audit contact (18),

h) monter un premier écran métallique principal (23) sur la surface périphérique extérieure de ladite tige (16),

i) disposer une extrémité d'un boîtier métallique (10) sur ledit deuxième écran métallique auxiliaire (28) et un premier écran auxiliaire (24) sur l'autre extrémité dudit boîtier (10),

j) disposer un premier élément d'étanchéité auxiliaire métallique (30) sur ledit écran (24) et disposer une extrémité circonférentielle extérieure (12*b*) d'un fond isolant supérieur (12) présentant une ouverture centrale (12*a*) sur ledit élément d'étanchèité (30),

k) insérer un troisième élément d'étanchéité auxiliaire métallique (38) entre ladite tige de contact fixe (16) et ladite ouverture (12*a*) dudit font (12),

l) disposer de la matière de brasure aux points de contact les éléments qui composent l'interrupteur dans le vide de manière à compléter l'assemblage temporaire de l'interrupteur dans le vide,

ledit procédé de construction de l'interrupteur dans le vide étant caractérisé par les phases additionnelles consistant à:

m) former une enveloppe à vide (A) en brasant hermétiquement ledit assemblage temporaire de l'interrupteur dans le vide, par chauffage et dégazage dans un environnement de vide de moins de 1,333 mPa (10^{-5} Torr) à une température comprise entre 900°C et 1050°C,

n) et imprimer une déformation plastique auxdits premier, deuxième et troisième éléments d'étanchéité auxiliaires (30, 32, 38) par refroidissement dudit environnement de vide à la température ambiante.

22. Procédé de construction d'un interrupteur dans le vide comprenant les phases consistant à:

a) disposer une extrémité (40*a*) d'un soufflet (40) fait d'un acier inoxydable austénitique sur une surface intérieure d'un fond isolant inférieur en forme de disque (14), dans le voisinage d'une ouverture (14*a*) ménagée au centre dudit fond inférieur (14),

b) monter un deuxième écran auxiliaire (28) sur la surface intérieure dudit fond inférieur (14) de manière que le deuxième écran auxiliaire (28) soit isolé électriquement de la tige de contact mobile (20) et du boîtier (10),

c) insérer une tige de contact mobile (20) portant un deuxième écran pare-arc principal (26) monté sur sa surface extérieure (20) à travers ladite ouverture (14*a*) du fond inférieur (14),

d) fixer un contact mobile (22) à l'extrémité intérieure de ladite tige de contact mobile (20),

e) fixer un anneau de contact (22*c*) audit contact mobile (22),

f) disposer de la matière de brasure aux points de contact entre des éléments qui composent ledit interrupteur dans le vide, en complétant ainsi l'assemblage temporaire d'une partie mobile de l'interrupteur dans le vide,

g) monter un premier écran auxiliaire (24) sur la surface intérieure du fond supérieur (12) de manière que le premier écran auxiliaire (24) soit isolé électriquement de la tige de contact fixe (16) et du boîtier (10),

h) prévoir un troisième élément d'étanchéité auxiliaire (38) sur un fond supérieur en forme de disque (12) de manière qu'il soit adjacent à une ouverture (12*a*) ménagée au centre dudit fond supérieur (12),

i) insérer une tige de contact fixe (16) portant un premier écran pare-arc principal (23) monté sur sa surface périphérique extérieure à travers ledit troisième élément d'étanchéité auxiliare (38),

j) fixer un contact fixe (18) sur une extrémité intérieure de ladite tige de contact fixe (16),

k) disposer de la matière de brasure aux points de contact entre des éléments qui composent ledit interrupteur dans le vide, pour compléter ainsi l'assemblage temporaire d'une partie fixe de l'interrupteur dans le vide,

l) insérer un premier et un deuxième éléments d'étanchéité auxiliaires (30, 32) dans les extrémités opposées d'un boîtier (10) de manière à prendre la matière de brasure en interposition entre ces éléments et ces extrémités, pour compléter ainsi l'assemblage temporaire de la partie boìtier de l'interrupteur dans le vide,

ledit procédé de construction de l'interrupteur dans le vide étant caractérisé en ce qu'il comprend les phases additionnelles consistant à:

m) braser ladite partie mobile, ladite partie fixe et ladite partie boîtier préalablement assemblées, par chauffage et dégazage dans une atmosphère réductrice ou dans un environnement de vide de moins de 1,333 mPa (10^{-5} Torr) à une température comprise entre 900°C et 1050°C,

n) imprimer une déformation plastique auxdits premier, deuxième et troisième éléments d'étanchéité auxiliaires (30, 32, 38) par refroidissement dudit environnement de vide ou réducteur à la température ambiante,

ledit procédé de construction de l'interrupteur dans le vide étant en outre caractérisé par les phases consistant à:

o) disposer une extrémité de ladite partie boîtier sur une partie périphérique extérieure dudit fond inférieur (14) de ladite partie mobile et disposer une partie périphique extérieure dudit fond supérieur (12) de ladite partie fixe sur l'autre extrémité de ladite partie boîtier, pour compléter ainsi l'assemblage temporaire de l'interrupteur dans le vide,

p) former une enveloppe à vide (A) en brasant ledit assemblage temporaire de l'interrupteur dans le vide à joint étanche, par réchauffage et redégazage dans un environnement de vide de moins de 1,333 mPa (10^{-5} Torr) à une température comprise entre 500°C et 1050°C,

q) imprimer une déformation plastique auxdits premier, deuxième et troisième éléments d'étanchéité auxiliaires (30, 32, 38) par refroidissement dudit environnement de vide à la température ambiante.

FIG. 1

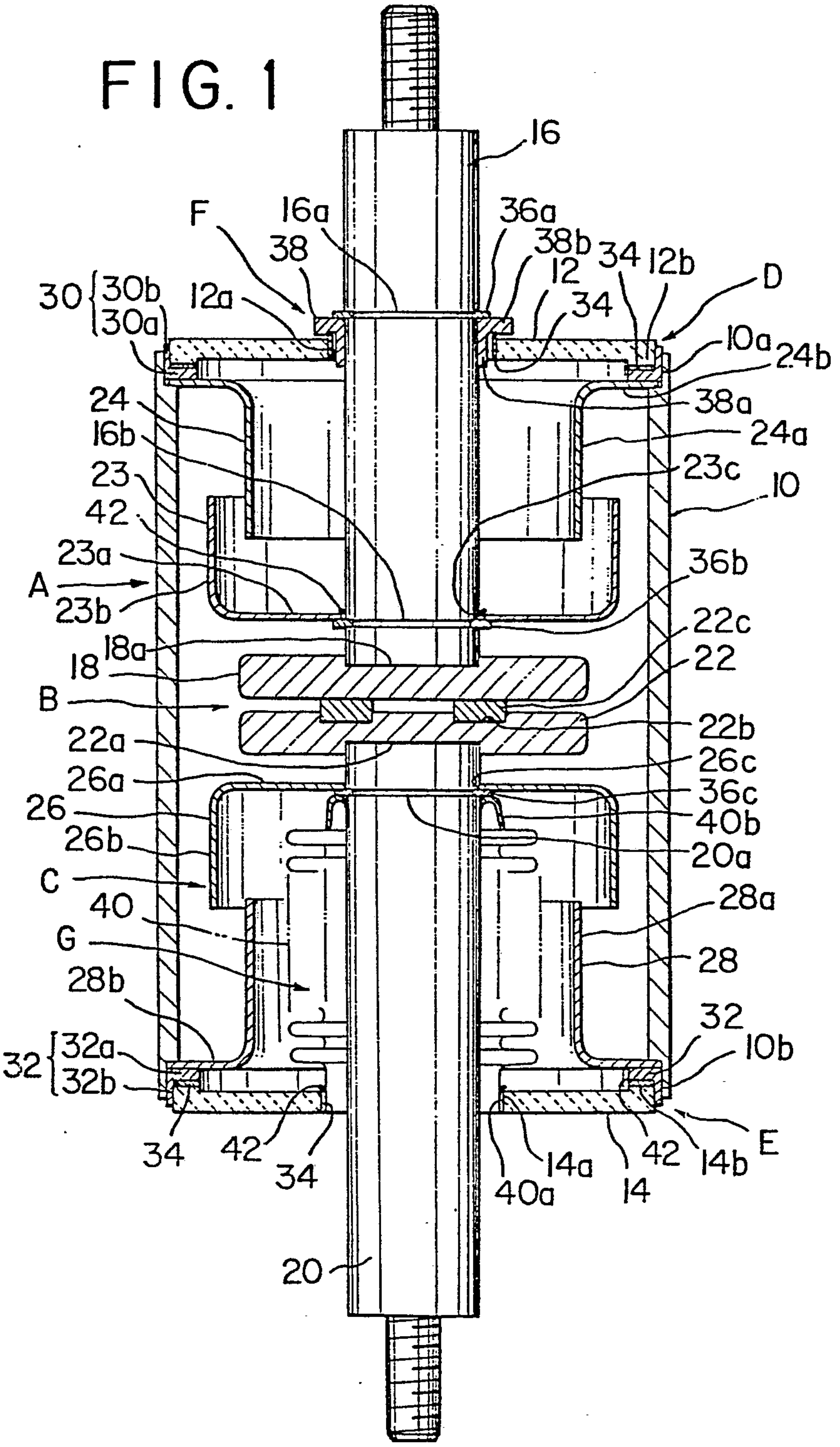

16
F
16a
36a
38
38b
34
12b
D
30
30b
30a
12a
12
34
10a
24b
38a
24
24a
16b
23c
23
10
42
23a
36b
A
23b
22c
18a
18
22
B
22b
22a
26c
26a
36c
26
40b
26b
20a
C
28a
40
G
28
28b
32
32a
10b
32
32b
E
34
42
34
14a
42
14b
40a
14
20

FIG. 2

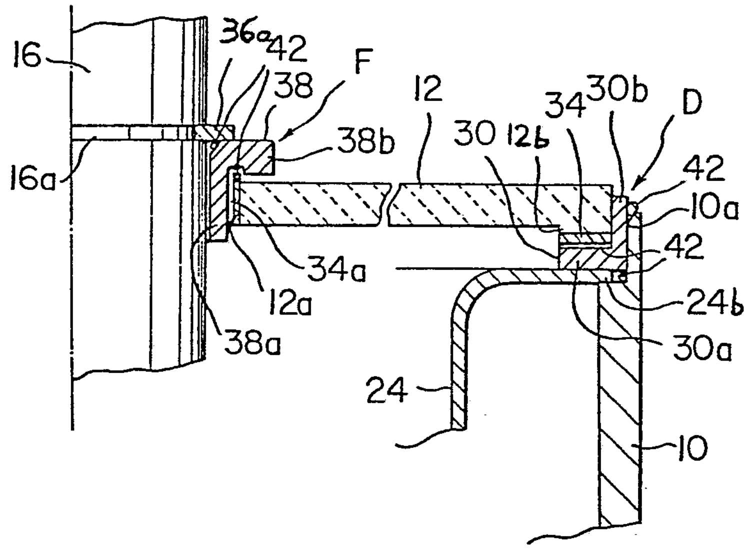

16
16a
36a
42
38
F
38b
12
30
12b
34
30b
D
42
10a
42
24b
30a
34a
12a
38a
24
10

FIG. 3

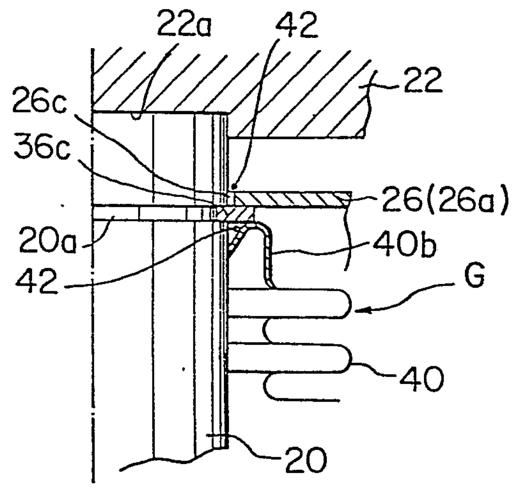

22a
42
22
26c
36c
26(26a)
20a
40b
42
G
40
20

FIG. 4

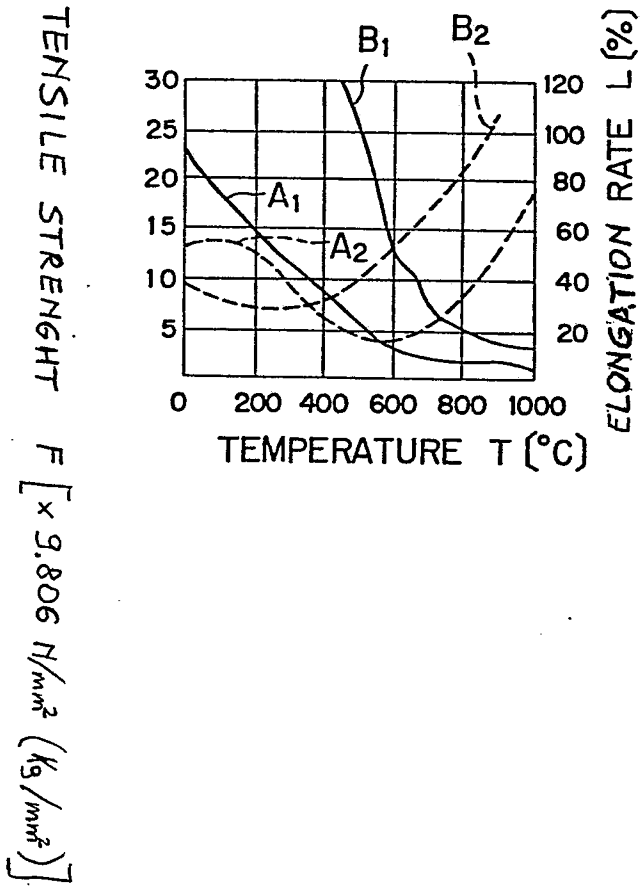

TENSILE STRENGHT F [x 9.806 N/mm² (kg/mm²)]
B1
B2
A1
A2
30
25
20
15
10
5
120
100
80
60
40
20
0
200
400
600
800
1000
TEMPERATURE T (°C)
ELONGATION RATE L (%)

FIG. 5

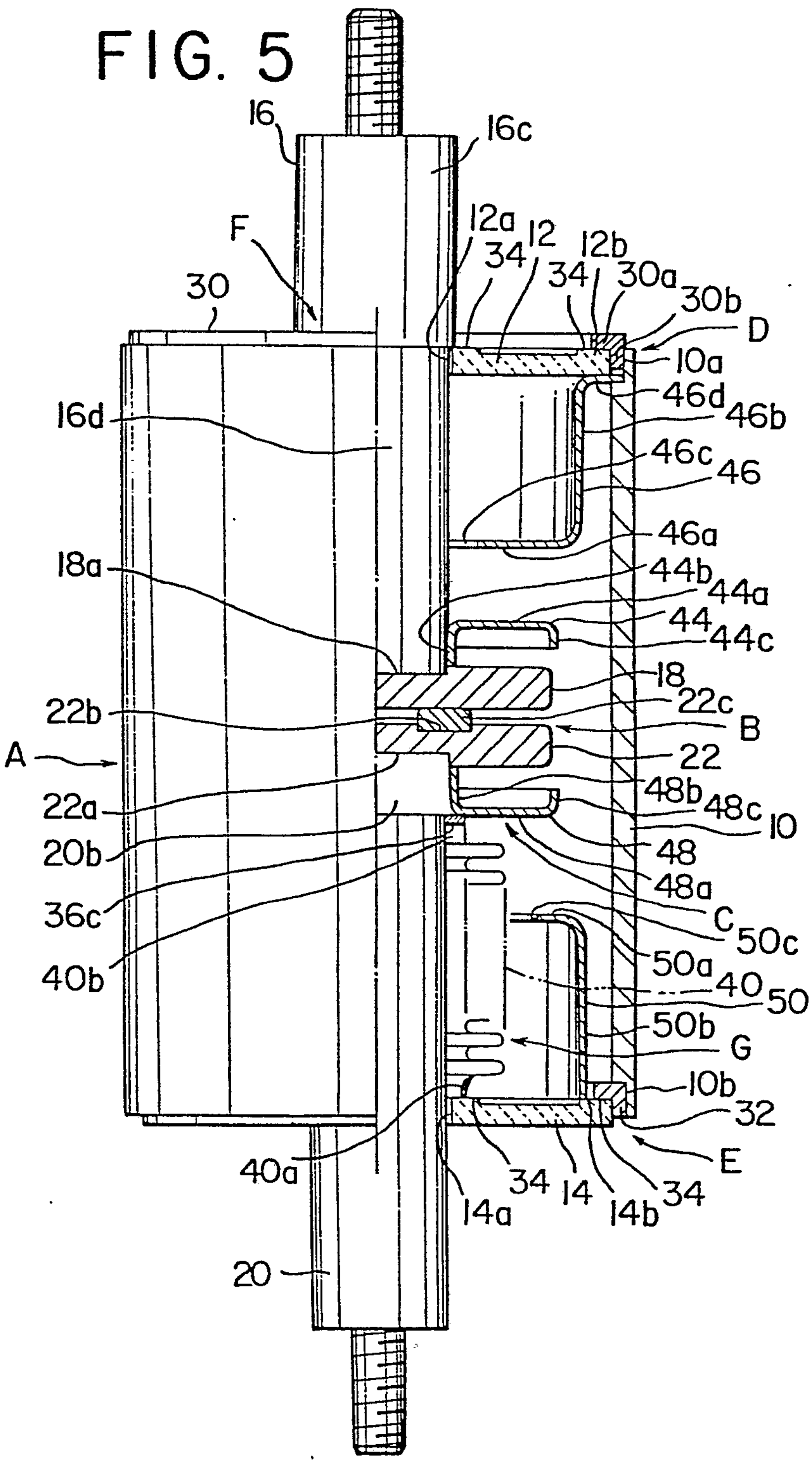

16
16c
F
12a
34
12
12b
34
30a
30b
30
D
10a
46d
46b
16d
46c
46
46a
18a
44b
44a
44
44c
18
22c
22b
B
A
22
22a
48b
48c
10
20b
48
48a
36c
C
50c
50a
40
50
40b
50b
G
10b
32
40a
E
34
14
34
14a
14b
20

FIG. 6

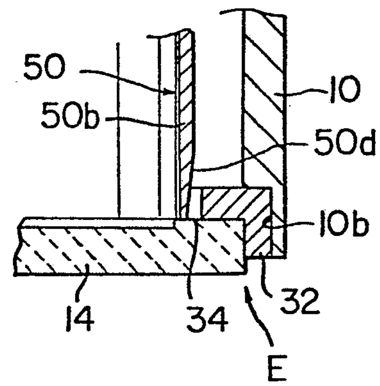


FIG. 7

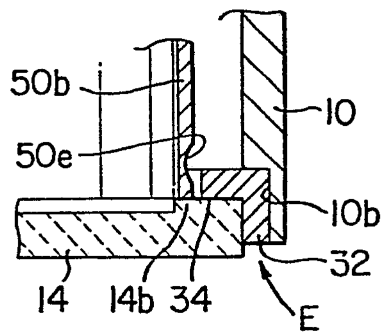


FIG. 8

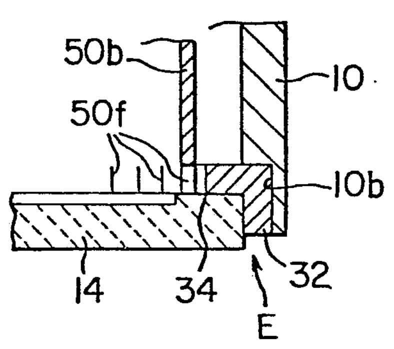


FIG. 9

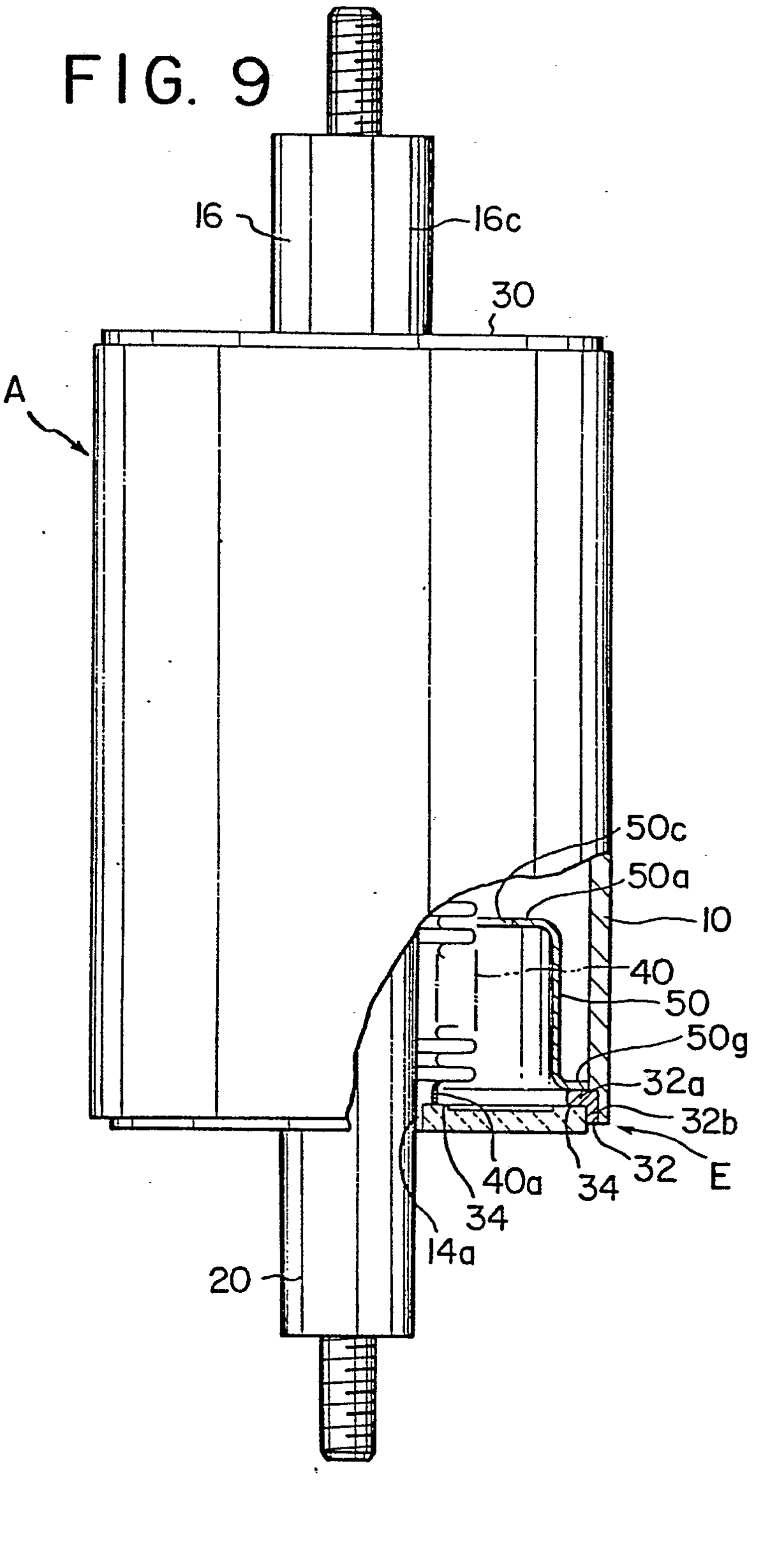
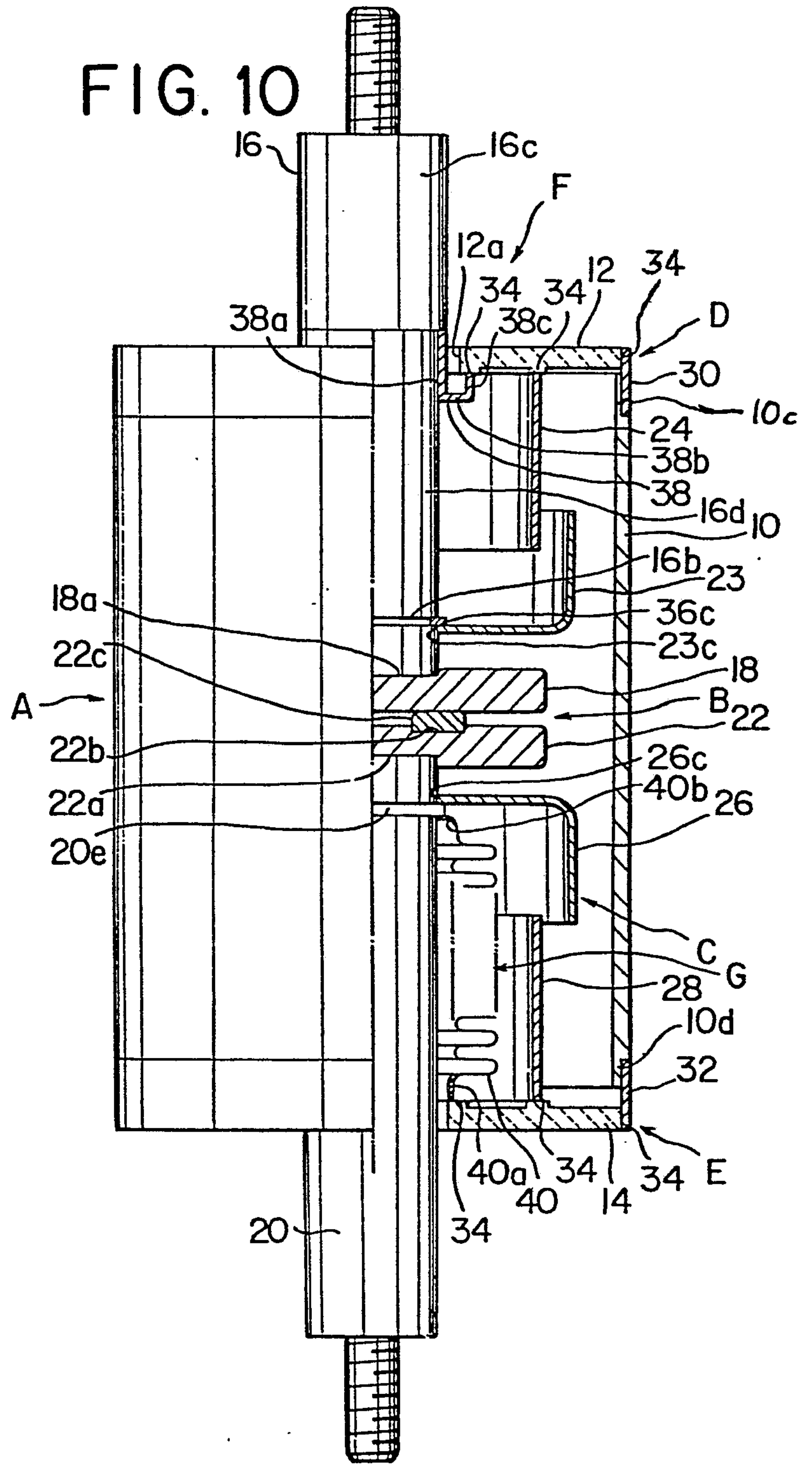


FIG. 10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16c
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34
D
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38c
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10c
24
38b
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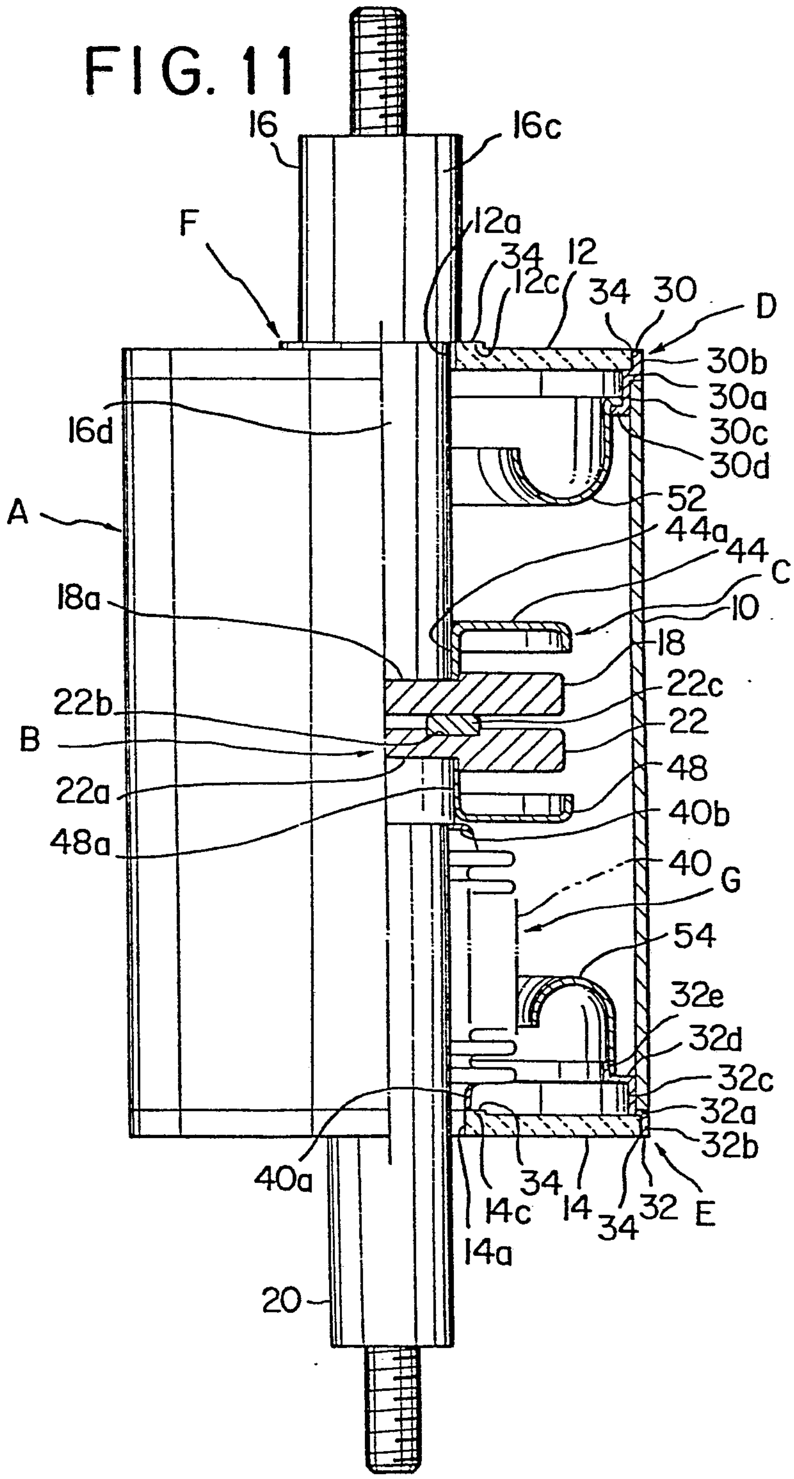
16d
10
16b
23
18a
36c
23c
18
22c
A
B
22
22b
26c
40b
22a
26
20e
C
G
28
10d
32
40a
34
34
E
40
14
20
34

FIG. 11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16c
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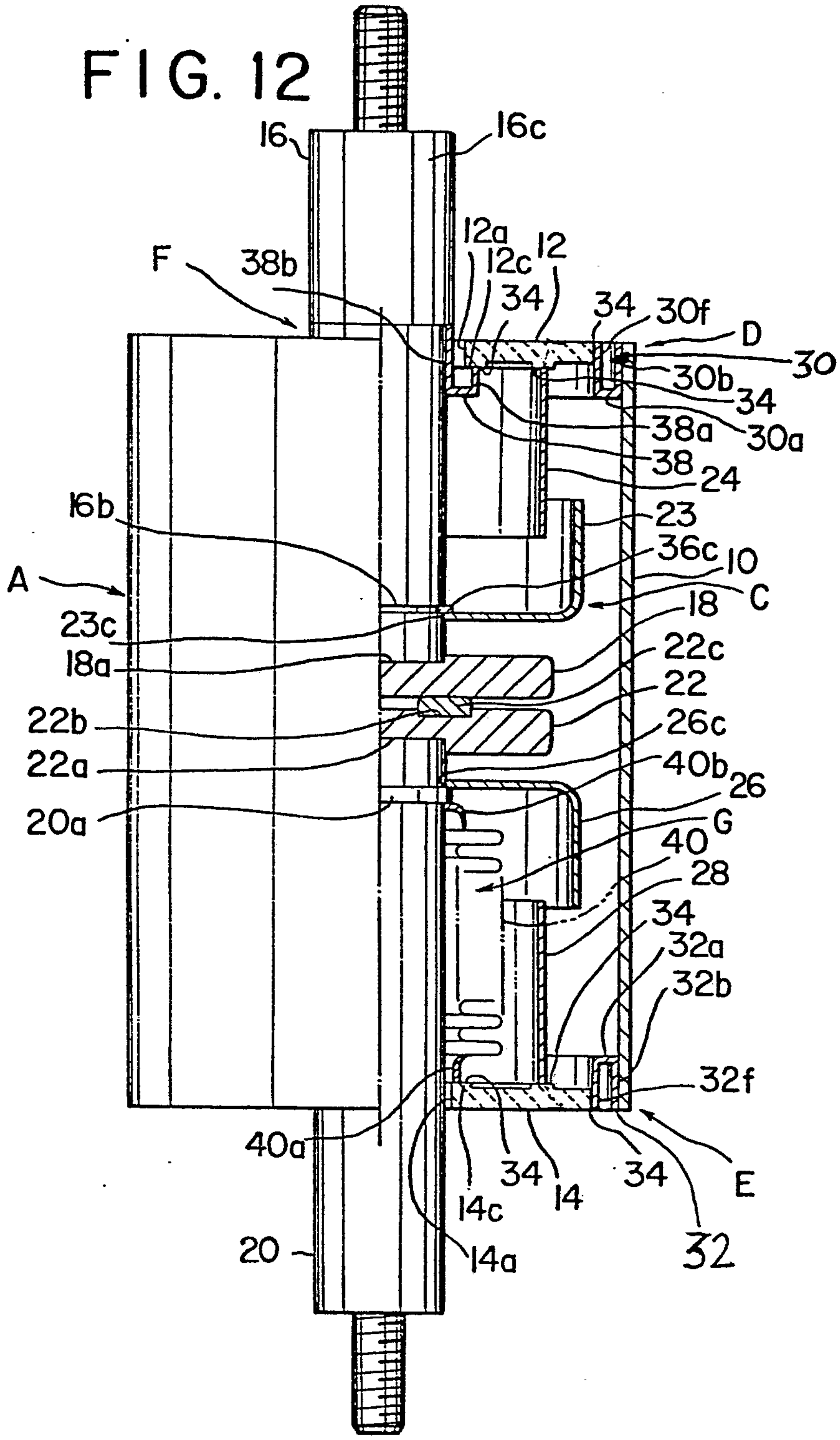
12
12c
34
30
D
30b
30a
30c
30d
16d
52
A
44a
44
C
10
18a
18
22c
22b
22
B
48
22a
40b
48a
40
G
54
32e
32d
32c
32a
32b
40a
34
14
34
32
E
14c
14a
20

FIG. 12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16c
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12c
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F
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34
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D
30
30b
34
30a
38a
38
24
16b
23
36c
10
A
C
23c
18
18a
22c
22
22b
26c
22a
40b
26
20a
G
40
28
34
32a
32b
32f
40a
34
14
34
E
14c
14a
20
32

FIG. 13

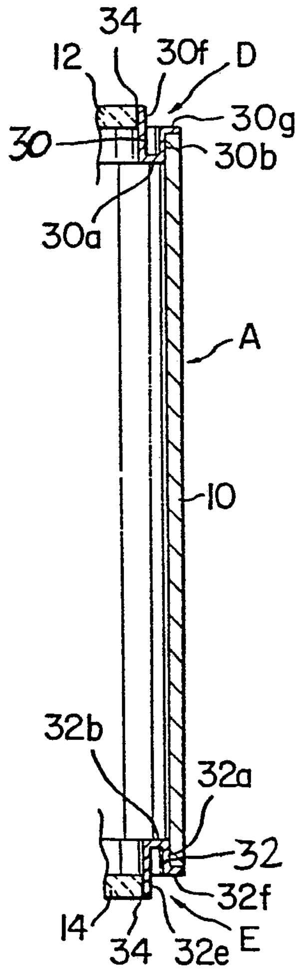


FIG. 14

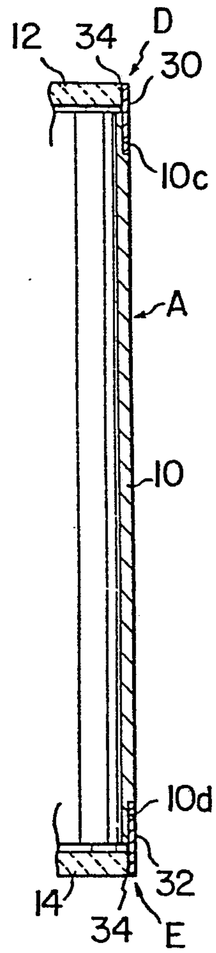


FIG. 15

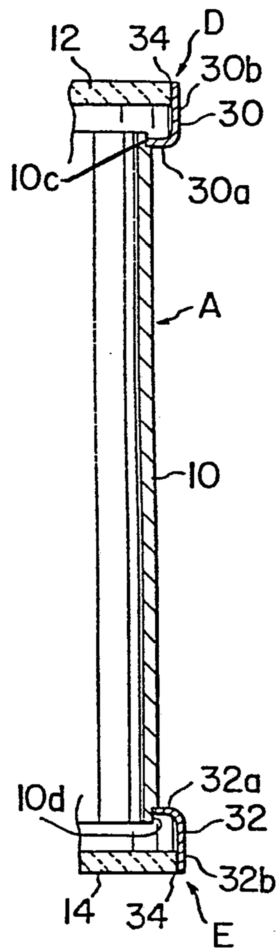
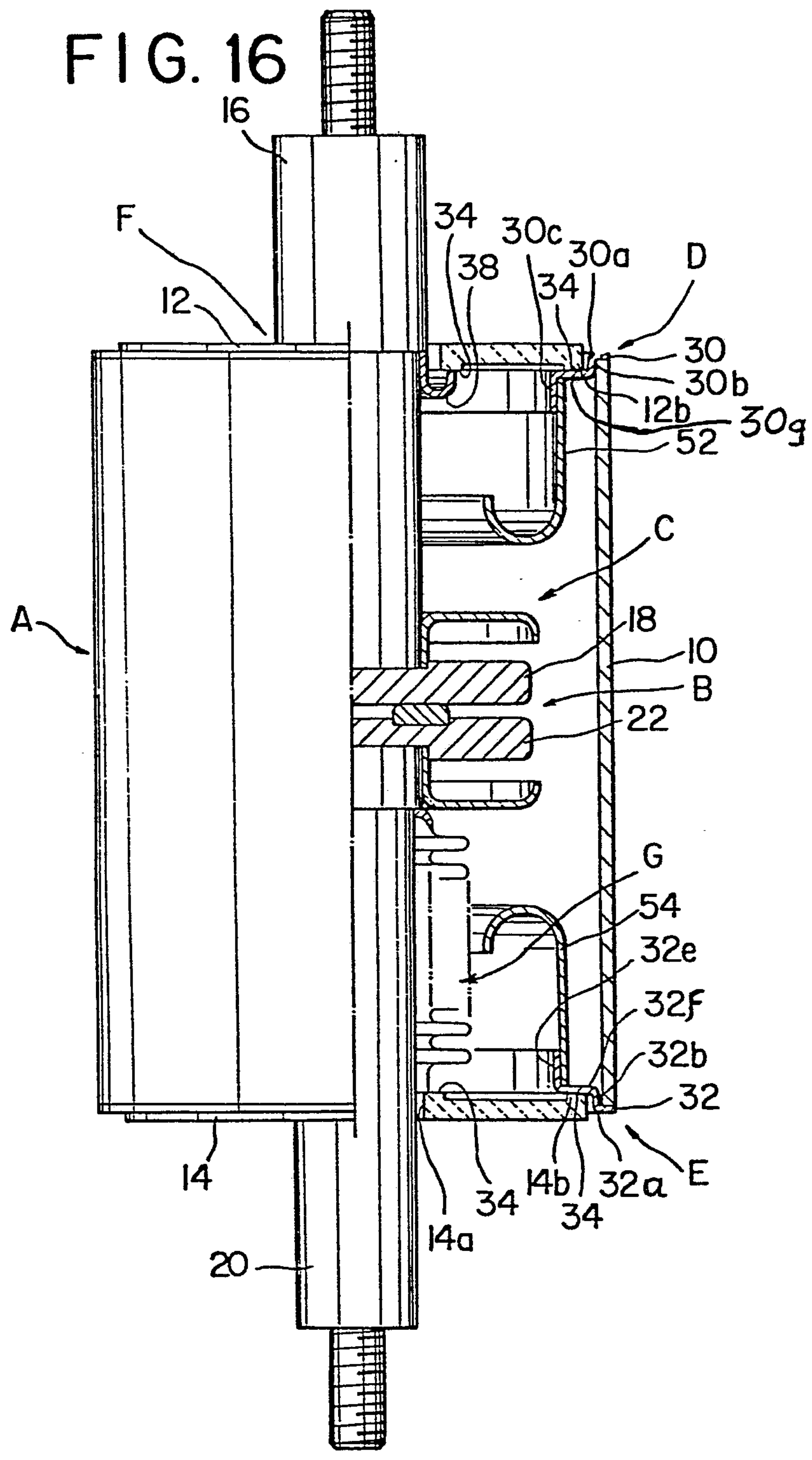


FIG. 16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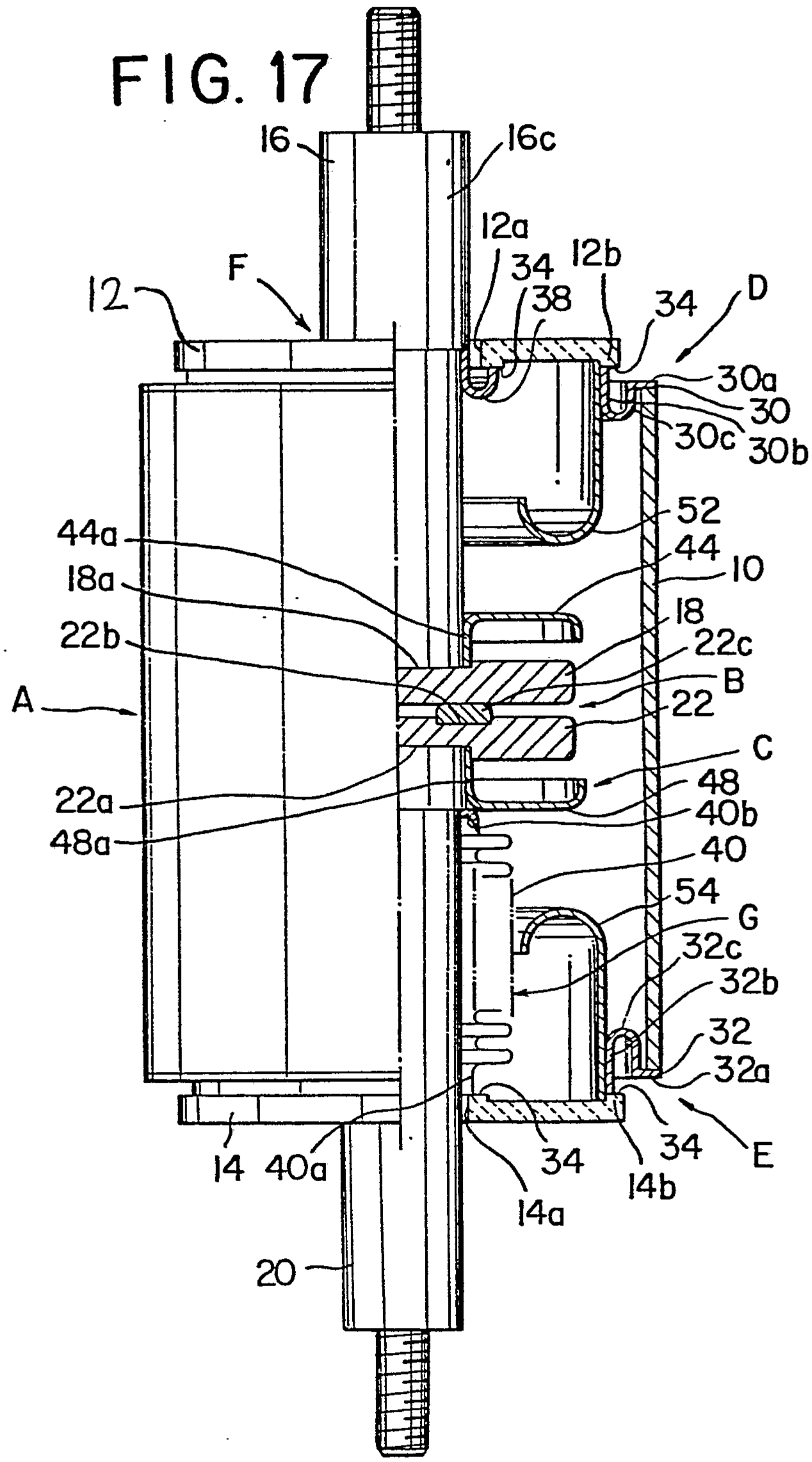
F
12
34
38
30c
30a
34
D
30
30b
12b
30g
52
C
A
18
10
B
22
G
54
32e
32f
32b
32
E
14
34
14b
34
32a
14a
20

FIG. 17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D
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30b
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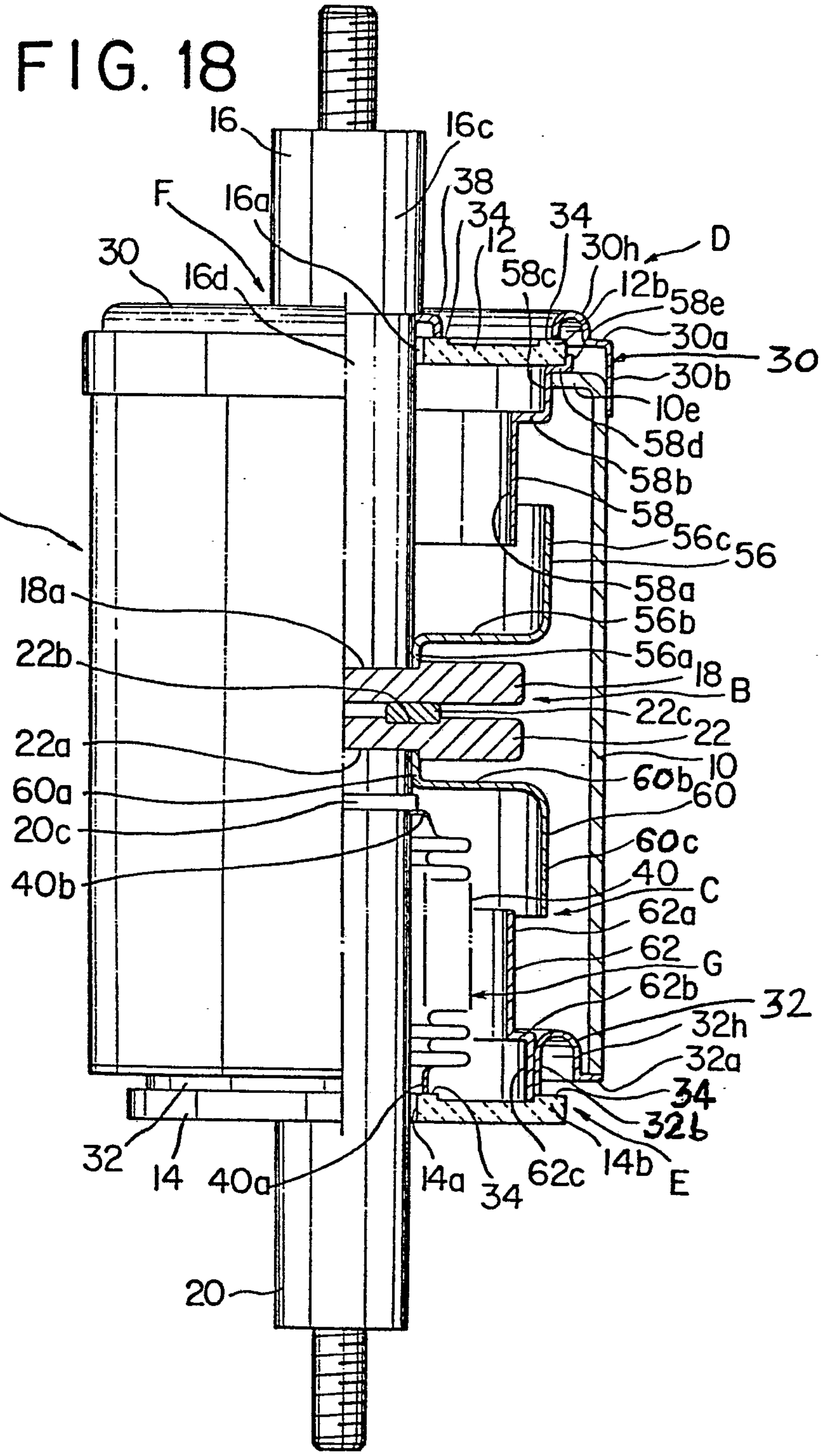
44
10
18a
18
22b
22c
B
A
22
C
22a
48
40b
48a
40
54
G
32c
32b
32
32a
14
40a
34
34
E
14b
14a
20

FIG. 18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16a
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34
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D
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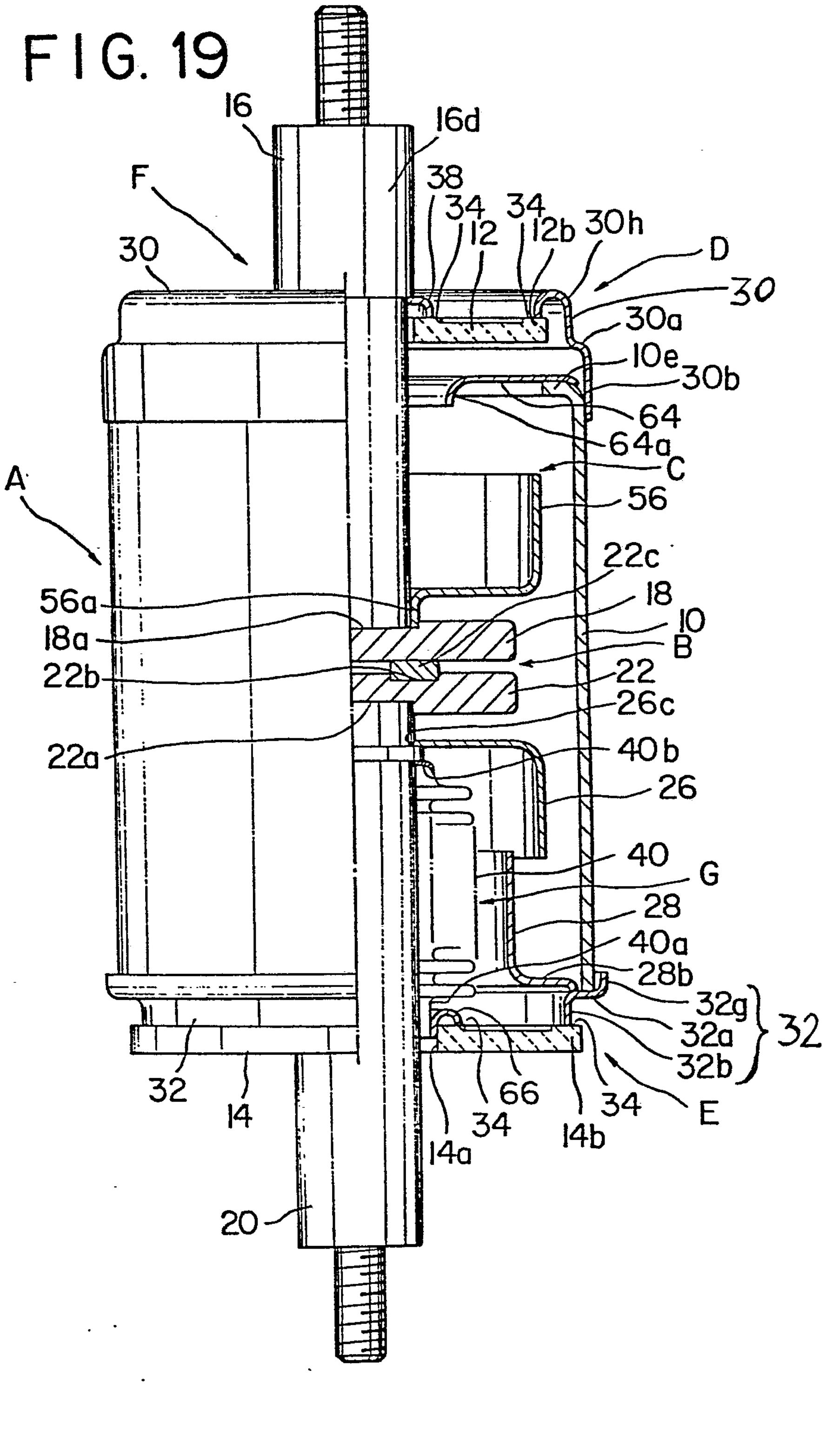
16d
58c
12b
58e
30a
30
30b
10e
58d
A
58b
58
56c
56
58a
18a
56b
22b
56a
18
B
22c
22
22a
10
60a
60b
60
20c
60c
40b
40
C
62a
62
G
62b
32
32h
32a
34
32b
32
14
40a
14a
34
62c
14b
E
20

FIG. 19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38
34
34
12
12b
30h
D
30
30
30a
10e
30b
64
64a
C
A
56
22c
56a
18
18a
10
B
22b
22
26c
22a
40b
26
40
G
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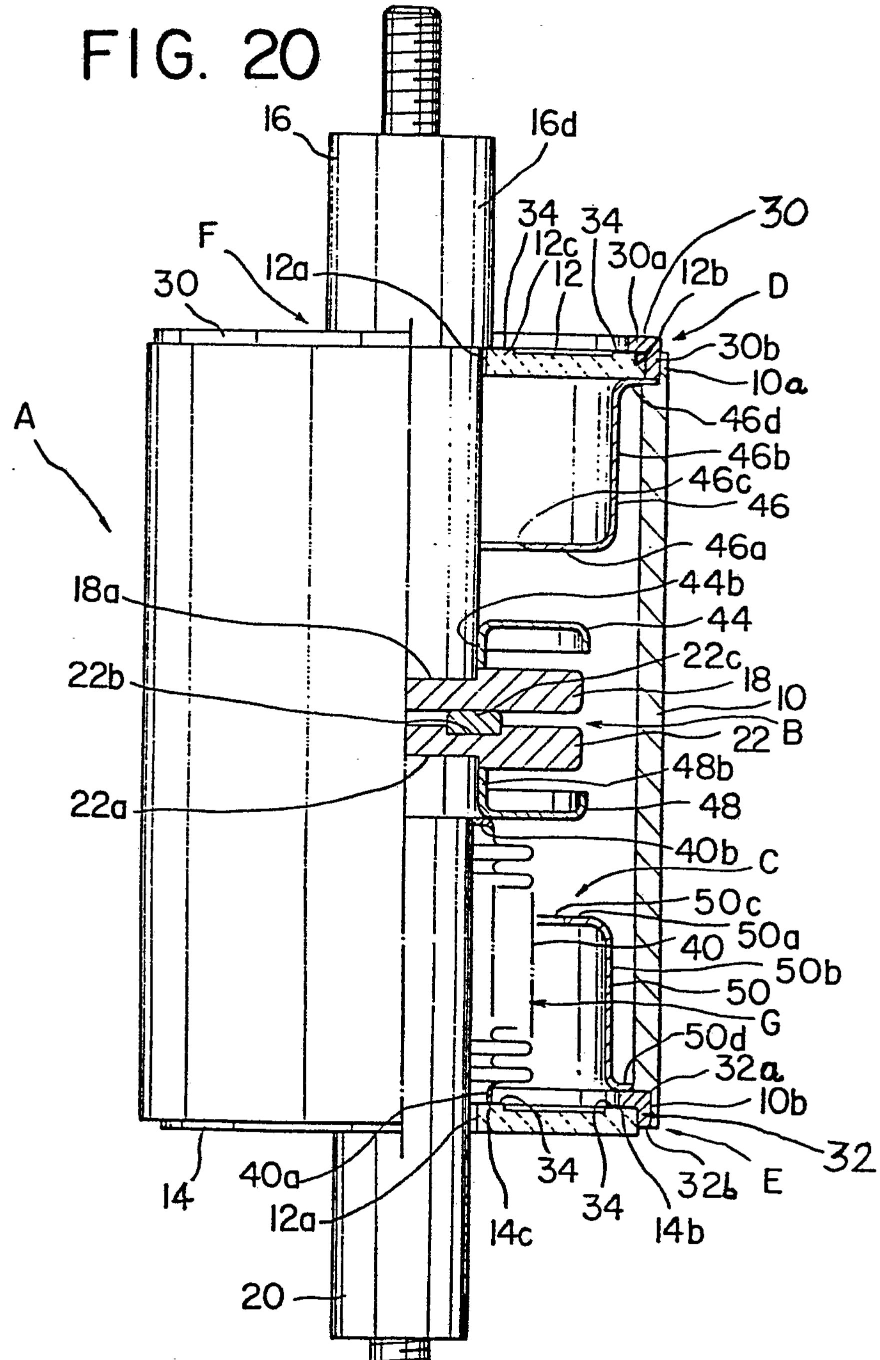
40a
28b
32g
32a
32
32b
32
14
66
34
34
E
14a
14b
20

FIG. 20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16d
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34
12c
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12b
D
F
12a
12
30
30b
10a
A
46d
46b
46c
46
46a
18a
44b
44
22c
18
10
22b
B
22
22a
48b
48
40b
C
50c
50a
40
50b
50
G
50d
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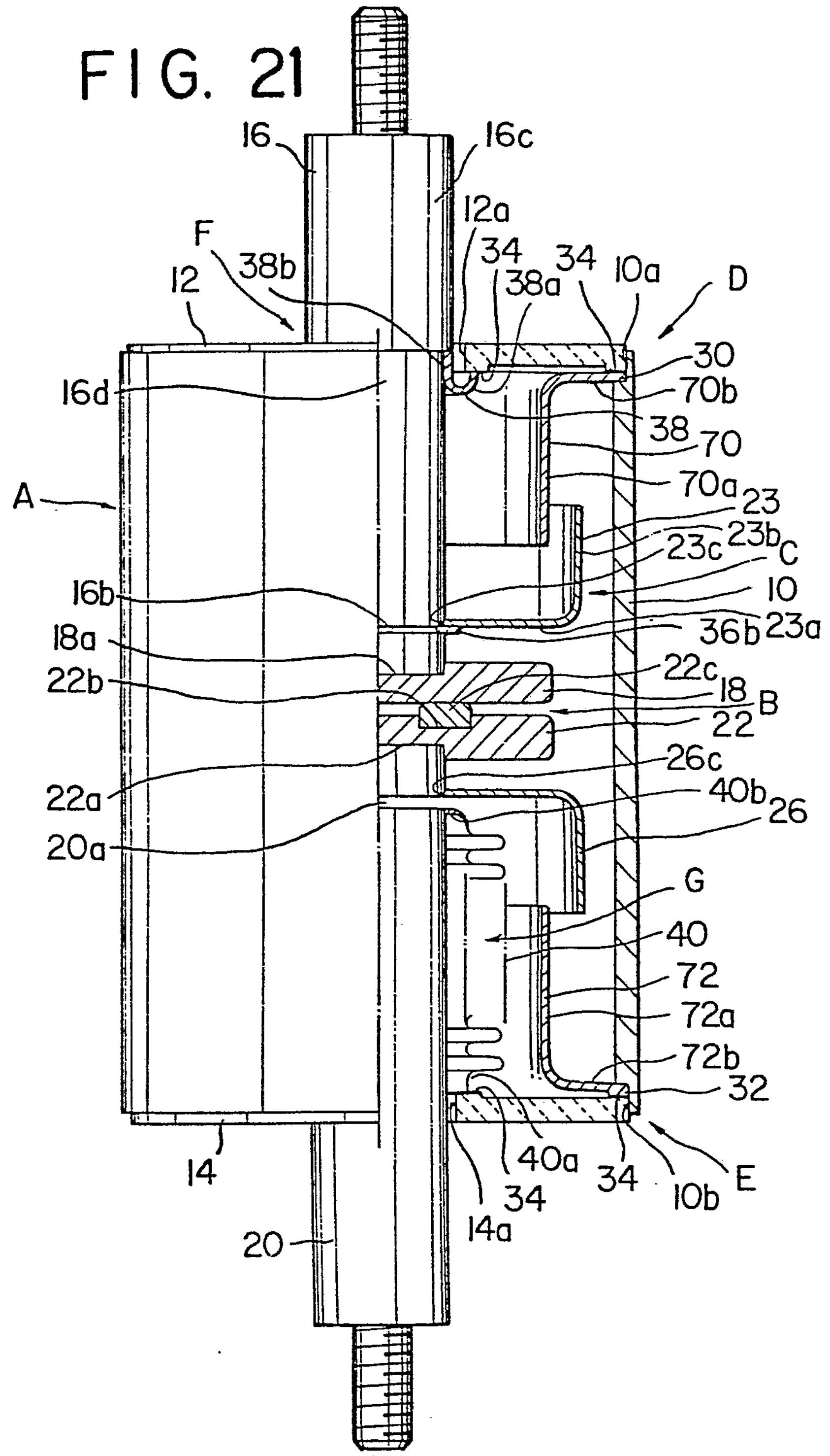
10b
32
E
32b
14
40a
34
34
14b
12a
14c
20

FIG. 21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16c
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D
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38b
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16d
70b
38
70
70a
A
23
23b
23c
C
16b
10
18a
36b
23a
22c
22b
18
B
22
26c
22a
40b
26
20a
G
40
72
72a
72b
32
14
40a
34
34
10b
E
14a
20