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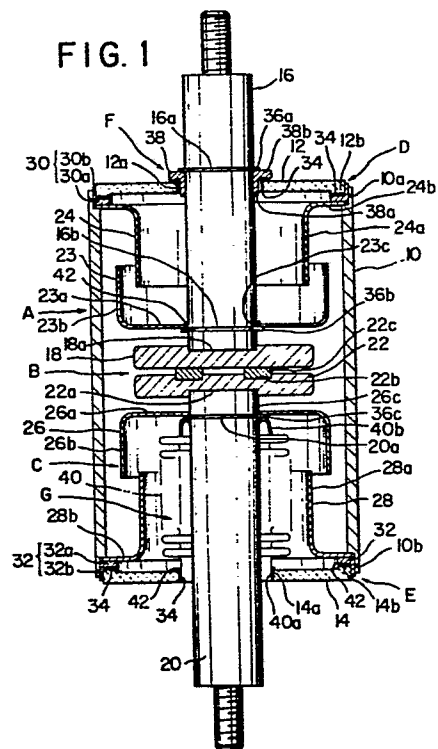
(54) **A vacuum interrupter.**

(57) A vacuum interrupter of the invention includes, substantially an envelope including a cylindrical housing (10) made of a metallic material, a disc-shaped upper end plate (12) made of an inorganic insulating material having an aperture in the center portion thereof and a disc-shaped lower end plate (14) made of an inorganic insulating material having an aperture in the center portion thereof, an electrical contact member including a stationary contact rod (16) inserted into said envelope through said aperture of the upper end plate, a stationary electrical contact (18) secured to said stationary contact rod, a movable contact rod (20) inserted into said envelope through said aperture of the lower end plate and a movable electrical contact (22) secured to said movable contact, a first sealing means for sealing hermetically said upper end plate to said housing and including a first auxiliary sealing member (30) made of a plastic deformable metallic material which is deformable by the thermal stress and a metallized portion provided between said first auxiliary sealing member and said upper end plate, a second sealing member for sealing hermetically said lower end plate to said

housing and including a second auxiliary sealing member (32) made of a plastic deformable metallic material which is deformable by the thermal stress and a metallized portion provided between said second auxiliary sealing member and said lower end plate, first supporting means for supporting and securing hermetically said stationary contact rod to said upper end plate including a metallized portion provided between said upper end plate and said stationary contact rod, and hermetic seal means for sealing movably and hermetically said movable contact rod (20) to said lower end plate including a bellows (40) for securing said movable contact rod to said lower end plate and a metallized portion (34b) provided between said lower end plate and said bellows. According to the present invention, the sealing performance of the envelope is enhanced by using the auxiliary sealing members in the sealing portions of the envelope.

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FIG. 1



A VACUUM INTERRUPTER

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

Vacuum circuit interrupters are, generally,
10 constructed by a highly evacuated envelope, a stationary
electrical contact provided in the envelope, a movable
electrical contact provided in the envelope so as to be
opposite to the stationary electrical contact and shields.
The envelope comprises, substantially, a tubular housing, a
15 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 and a lower end
20 plates to each axial end of a cylindrical insulating having
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 housing a
25 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 to provide
5 an alloy of Fe-Ni is usually employed 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
10 current generated by high current flow of the contact rods.

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

In carrying out the present invention in one form, there is provided a vacuum interrupter and method of making
the vacuum interrupter comprising an evacuated envelope

including a cylindrical housing made of a metallic material and having metallized portions formed at the axial ends thereof and a disc-shaped upper end plate made of inorganic ceramics such as a high alumina contained ceramics or crystallized glass and having an aperture at the center thereof, a stationary electrical contact mounted on an end of a stationary contact rod inserted into said envelope through said aperture of said upper end plate, a movable contact rod inserted into the envelope through the aperture of said lower end plate, a bellows supporting said movable contact rod and made of a metallic material in the form of an austenite stainless steel, having an upper end, the lower end of said bellows is fixed to said lower end plate by means of a brazing material, shielding means for shielding the inner surface of the insulating portion of the envelope, and an auxiliary sealing member for aiding the brazing between the metallic portion and the insulating portion.

According to a second aspect of the present invention, therefore, there is provided a method of manufacturing a vacuum interrupter which comprises a step of:

providing a cylindrical housing made of a metallic material in the form of an austenite stainless steel, disposing a disc-shaped upper end plate having an aperture in the center thereof and a disc-shaped lower end plate by means of an auxiliary sealing members which are

made of Cu or Fe, having substantially the same coefficient of thermal expansion as the insulating upper and lower end plates, both of which are made of inorganic insulating materials at the respective axial ends of said housing to
5 form an envelope, mounting a bellows of an austenite stainless steel, having an upper end and a lower end, on the central portion of said lower end plate by means of said brazing material, supporting a movable contact rod of Cu, having an upper and a lower end, at the upper end of
10 said bellows by means of said brazing material,

mounting movable electrical contact made of an alloy including Cu on the upper end of said movable contact rod by means of said brazing material,

inserting a stationary contact rod of Cu, having
15 an upper and a lower ends, in the aperture of said upper end plate by means of said brazing material,

mounting a stationary electrical contact made of an alloy including Cu, at the lower end of said stationary contact rod by means of said brazing material, and

20 heating said inserted brazing material to a brazing temperature range between 900°C and 1050°C while evacuating the envelope at a pressure less than 10^{-5} Torr. in order to melt said brazing material and evacuated gaseous products of brazing.

25 According to a third aspect of the invention, therefore, there is provided a method of constructing a vacuum power interrupter which comprises the steps of:

supporting an upper end plate made of an inorganic insulating material and having an aperture in the center portion thereof horizontally, inserting a stationary contact rod made of Cu into said aperture of the aperture of the upper end plate by means of brazing material, mounting a stationary electrical contact made of an alloy including Cu on an end of said stationary contact rod to form a stationary portion, disposing a lower end portion of a bellows made of an austenite stainless steel on a lower end plate made of an inorganic insulating material, having an aperture in the center portion thereof, by means of a metallized portion and a brazing material, inserting a movable contact rod made of an alloy including Cu into said bellows through said aperture of the lower end plate by means of a brazing material, disposing a movable electrical contact made of Cu on an end portion of said stationary contact to form a movable portion, providing a housing made of a non-magnetic metallic material, mounting a first auxiliary sealing member made of a metallic material which is deformable by the thermal stress at a high temperature among the cooling process after brazing, mounting a second auxiliary sealing member made of a metallic material which is deformable due to the thermal stress in brazing by means of a brazing material to form a housing portion, heating said stationary portion, said movable portion and said housing portion to a brazing temperature range between 900°C and 1050°C while evacuating said stationary portion,

· said movable portion and said housing portion at a pressure
which is less than 10^{-5} Torr. in order to melt said
brazing materials and evacuate gaseous products of brazing,
mounting said brazed stationary portion on said first
5 auxiliary sealing member of the housing portion by way of a
brazing material, mounting said brazed movable portion on
said second auxiliary sealing member of the housing portion
by way of a brazing material and, heating said previously
assembled interrupter to a brazing temperature range
10 between 550°C to 1050°C while evacuating at the envelope at
a pressure which is less than 10^{-5} Torr. in order to melt
said brazing materials and evacuate gaseous products of
brazing.

The invention as claimed provides:

A vacuum power interrupter comprising in combination;

an envelope including a cylindrical housing made of a metallic material, a disc-shaped upper end plate made of an inorganic insulating material having an aperture in the center portion thereof and a disc-shaped lower end plate made of an inorganic insulating material having an aperture in the center portion thereof;

an electrical contact member including a stationary contact rod inserted into said envelope through said aperture of the upper end plate, a stationary electrical contact secured to said stationary contact rod, a movable contact rod inserted into said envelope through said aperture of the lower end plate and a movable electrical contact secured to said movable contact, both of the stationary contact rod and the movable contact rod are made of Cu;

a shielding member for shielding inner surface of said envelope;

a first sealing means for sealing hermetically said upper end plate to said housing and including a first auxiliary sealing member made of a plastic deformable metallic material which is deformable by the thermal stress and a metallized portion provided between said first auxiliary sealing member and said upper end plate;

a second sealing member for sealing hermetically

said lower end plate to said housing and including a second auxiliary sealing member made of a plastic deformable metallic material which is deformable by the thermal stress and a metallized portion provided between said second
5 auxiliary sealing member and said lower end plate;

first supporting means for supporting and securing hermetically said stationary contact rod to said upper end plate including a metallized portion provided between said upper end plate and said stationary contact
10 rod; and

hermetic seal means for sealing movably and hermetically said movable contact rod to said lower end plate including a bellows for securing said movable contact rod to said lower end plate and a metallized portion
15 provided between said lower end plate and said bellows.

An advantage offered by the invention is that by constructing an envelope by employing a housing made of a
20 non-magnetic metallic material, end plates made 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.

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 vacuum interrupter embodying one form of the invention.

Figure 2 is an enlarged view of a partial portion of the interrupter of Figure 1.

Figure 3 is an enlarged view of a partial portion 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 other embodiment of a vacuum interrupter according to the present

invention.

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

Figure 7 is an enlarged view of a partial portion of other 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 other embodiment of the present invention.

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

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

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

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

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

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

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

Referring to the drawing, particularly to Figures 1 to 3, there is shown as first embodiment of a vacuum interrupter in accordance with the present invention. The vacuum interrupter of the invention comprises, substantially, an evacuated envelope A including a cylindrical housing 10 made of a non-magnetic material in the form of an austenite 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 an internal surface of the end plates 12 and 14.

5 The vacuum interrupter of the invention further comprises first sealing means 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
10 hermetically the stationary contact rod 16 to 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
15 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
20 the stationary contact rod 16 is inserted and secured to the bore 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 opposed surface to the stationary electrical contact 18. An end portion of
25 the movable contact rod 20 is inserted 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 brazing 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 member 32 has also a ring-shaped flat portion 32a and a tubular portion 32b formed in one piece with the flat portion 32a. 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.

10 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.

15 The third auxiliary sealing member 38 is provided with a tubular portion 38a and a flange portion 38b. A metallized portion 34 is provided in an inner surface of the aperture 12a of the upper end plate 12. The tubular portion 38a of the third auxiliary sealing member 38 is

20 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

25 contact rod 20 is inserted into a bellows 40. An upper end 40b of the bellows 40 is secured in vacuum-tight seal by means of a brazing material 42. A 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 34b and a brazing material 42 to form the hermetic seal means G.

5 In more detail, the cylindrical housing 10 of the envelope A is made of a non-magnetic metallic material in the form of the austenite stainless steel which has the high mechanical strength. Both open end portions of the housing 10 are provided with axial stepped portions 10a and
10 10b located inner periphery side 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
15 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 plastic deformable metallic material
20 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
25 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 auxiliary sealing member 30 via a metallized portion 34. The brazing materials 42 are 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 the brazing materials 42.

As is shown in Figure 1, the second sealing means E comprises, similar 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, the projection 14b of the lower end plate 14 is 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 22 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 plastic 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, 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 slot 22a of the movable electrical contact 22. As is shown in Figure 3, the movable contact rod 20 is movably secured to the lower end plate 14 by means of the second supporting means G including the bellows 40 mounted on the movable contact rod 20, a clamping member in the form of a covering ring 36c fixed to an annular groove 20a of the movable contact rod 20 and a brazing material 42. An upper end of the bellows 40 is secured to the movable contact rod 20. A 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 austenite stainless steel. The main arc-shield 23 comprises a circular flat portion 23a, a tubular portion 22b and an aperture 23c provided at the

center portion of the flat portion 23a. The arc-shield 23 is inserted to the stationary contact rod 16 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 22 and is coaxially provided with respect to the first main arc-shield 22. 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 the 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 austenite stainless steel having the high mechanical strength. Each of the upper and lower end plates 12 and 14 is made of the inorganic insulating material such as a 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 600°C and 100°C . The stationary contact rod 16 and the movable contact rod 20 are made of Cu having a brazing temperature between 600°C and 1000°C . The electrical contacts 18 and 22 are made of Cu. The shielding member C is made of a non-magnetic material in the form of an austenite stainless steel. The bellows 40 is made of an austenite stainless steel. Each of the first auxiliary sealing member 30 and the second auxiliary sealing member 32 is made of a plastic deformable material in the form of Cu which is deformable by the thermal stress generated between the metallic housing 10 and the end plates 12 and 14 in slow cooling after the 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 the 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 deformable by the thermal stress in cooling after brazing. Further, the auxiliary sealing members 30 and 32 can be made of Fe-Ni-Co alloy or Fe-Ni alloy, which has the approximately same coefficient of thermal expansion with that of the end plates 12 and 14, in case that the housing 10 is made of Cu or Fe which is deformable by the thermal stress generated in slow cooling

after the brazing. The third auxiliary sealing member 38 is made of Cu which is also deformable 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. Further, the third auxiliary brazing member 38 can be made of Fe-Ni-Co alloy or the Fe-Ni alloy, as in the case of the first and second auxiliary sealing members 30 and 32. Additionally, the shielding member C can be made of the inexpensive Fe when the vacuum interrupter is employed to the 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 conjunction with Figures 1 to 4 of the accompanying drawings.

Referring to Figure 1, the vacuum power 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 the brazing material, mounting the bellows 40 on the lower end plate 14 by means of the brazing material 42 such that a tubular portion 40a is inserted into the aperture 14a of the lower end plate 14 by way of the metallized portion 34b, 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 the brazing material 42, disposing the flange portion 28b of the second auxiliary shield 28 by way of the 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 40a 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 to the movable contact rod 20 such 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 groove 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 22 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 the brazing material 42, fitting the first auxiliary sealing member 30 into the stepped portion 10b of the housing 10 by means of the flange 24b of the shield 24 and the 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 to the stationary contact rod 16 such that the

tubular portion 38a of the brazing member 38 is fitted into the aperture 12a by way of the metallized portion 34a, securing the stationary contact rod 16 to the upper end plate 12 by means of the aperture 12a, the metallized portion 34a, the third auxiliary brazing 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 the brazing material 42. The following steps are further carried out: heating the brazing materials 42 which are inserted into between each component of the vacuum power interrupter at the brazing temperature which is between 950°C and 1050°C while evacuating at the pressure which is less than 10^{-5} Torr. in a vacuum oven, and letting gases induced by heating each component out of the vacuum power interrupter. When the brazing material inserted in each component is melted the respective components of the vacuum power interrupter are securely and hermetically fixed each other. Additionally, it is preferable that heating temperature is high within the range of melting temperature of brazing material and the pressure is less than 10^{-5} Torr. The temperature of the vacuum furnace is gradually decreased to the room temperature and the vacuum power interrupter assembled is maintained at the room temperature during predetermined time interval. In this case, the upper limit of the heating temperature is determined by 1053°C of copper melting temperature, and lowest heating

temperature is determined by 900°C of brazing temperature of stainless steel. The highest heating temperature may be less than 900°C by providing the Ni plating on the brazing portions such as the housing 10 and the bellows 40 made of the austenite stainless steel.

Figure 4 shows the thermal characteristics of the tensile strength F and the expansion U of Cu and Fe, with respect to the temperature T . In Figure 4, a curve A_1 shows the tensile strength of the Cu with respect to the temperature, and a curve B_1 designates the tensile strength of the Fe with respect to the temperature. Further, a curve A_2 shows the expansion rate of Cu, and a curve B_2 shows the expansion rate of Fe with respect to the 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 increment of temperature, and the expansion rate decreases and then increases with the increment of the temperature. Accordingly, it is appreciated that the deformability is performed due to the thermal stress in brazing and thereby the sealing of the junctions of the envelope is secured and that the residual thermal stress is very small, because the tensile strength the auxiliary sealing members made of Cu or Fe are very small comparing with that of the insulating end plates 12 and 14 made of the inorganic insulating materials such as the ceramics or the glass, when the auxiliary sealing members are brazed to the housing 10 and the end plates 12

and 14 at the high temperature less 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, Fe-Ni-Co alloy or Fe-Ni alloy, in spite that the coefficients of the thermal expansion of the end plates 12 and 14 made of the inorganic insulating material in the form of ceramics differ from that of the housing 10 made of the metallic material such as the austenite stainless steel, Cu or Fe. It is considered that the high sealing performance between the end plates 12 and 14 and the housing 10 is obtained when the housing 10 is made of Fe, because the coefficient of thermal expansion of the Fe is smaller than that of the Cu in spite that tensile strength of the Fe with respect to the 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 the predetermined temperature. Further, the 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) and the thermal stress thereof is smaller than that of the lower end plate 14.

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 deformable due to the thermal stress generated in cooling after the brazing are employed to connect the end plates made of insulating materials to the metallic materials in the form of the housing and the stationary contact rod, the
5 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 the gas generated in brazing are simultaneously carried out by heating the
10 previously assembled interrupter at the temperature ranging from 900°C to 1050°C in the vacuum oven, the manufacturing process is simplified as well as high reliable and good performance vacuum interrupter can be
15 obtained.

Figure 5 shows the second embodiment of the vacuum interrupter in accordance with the present invention. In the second embodiment of the vacuum interrupter, the difference from the first embodiment
20 stated above resides in a shielding member C, the second sealing means 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 power interrupter and
25 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 an approximately 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 46d 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, similar 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 46c of the shield 46 by means of a brazing material. A diameter of the upper end plate 12 is smaller than an 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 along the edges of the central aperture 12a of the upper end plate 12, 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 to the end plate 12 by the upper rod portion 16c to form the first securing means F. A 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 show modifications of the shielding member C of the vacuum power 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 50c at an open end portion of the tubular portion 50c. By providing the tapered portion 50d, mechanical strength of connection between the shield 50 and a lower end plate 14 is enhanced, because the thermal stress due to difference of the coefficient of thermal

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expansion in brazing. In the modification of the 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 to the tubular portion 50c 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, the thermal stress is eliminated in brazing the shield 50 to the lower end plate 14 by providing the slits 50 in the open end of the tubular portion 50c.

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 the same steps as that 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 power interrupter.

Next, the vacuum interrupter previously assembled is located and inserted into a vacuum furnace and thereafter the vacuum power interrupter is heated at the brazing temperature which is between 900°C and 1050°C while
5 evacuating at the pressure which is less than 10^{-5} Torr. After the brazing material inserted in each component is melted, the temperature of the vacuum furnace is gradually decreased to a predetermined temperature and is maintained the vacuum furnace to the predetermined temperature during
10 the given time interval. The temperature of the vacuum furnace is further gradually decreased to a room temperature. When the temperature is decreased to the room temperature, the respective components of the vacuum interrupter are securely and hermetically fixed each other.

15 Referring now to a third embodiment according to the vacuum power interrupter which is similar to that of the first and the second embodiments stated above, in this embodiment brazing is executed in two steps, and the difference from the embodiment described above resides in a
20 shielding member, sealing means and securing means. As is shown in Figure 10, a stepped portion 10c is provided at an outer surface of one end of a housing 10. A stepped portion 10d is provided at an outer surface of other end of the housing 10. A first auxiliary sealing member 30 is
25 formed with a tubular shape and is fitted and secured to the stepped portion 10c via a metallized portion 34. An upper end plate 14 is fitted into the first auxiliary

sealing member 30 and is hermetically secured to the brazing member 42 by means of a metallized portion 34 to form first sealing means D. A second auxiliary sealing member E is formed with a tubular shape and is fitted and secured to the stepped portion 10d of the housing 10 via a metallized portion 34. 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 42 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 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 14 by means of a metallized portion 34 and a 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 a 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 26 are, respectively, secured to the end plates 12 and 14, the voltage potential is maintained to 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 austenite stainless steel. The auxiliary shields 24 and 28 can also be made of Cu or Fe which is deformable by the thermal stress generated by brazing the auxiliary shield 24 and 28 to the end plates 12 and 14 in gradual cooling or can be made of Fe-Ni-Co alloy or Fe-Ni alloy which has the approximately same coefficient of thermal expansion as that of the inorganic material such as an alumina-ceramics.

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 on the upper end plate 12 via the metallized portion 34, mounting the third auxiliary sealing member 38 to the upper end plate 12 by means of the metallized portion 34 and the 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 22 on the cover ring 36c which is fixed to an annular groove 16b of the stationary contact rod 16 by means of the 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. The bellows 40 is disposed on the lower end plate 14 by way of the metallized portion 42. Next, the movable contact rod 20 is inserted from the upper side into the bellows 40 and is disposed on the upper end 40a of the bellows 40 by means of the flange 20e and thereafter the brazing material is inserted between the upper end 40a and

the flange 20e. The second main arc-shield 26 is inserted to the upper end portion of the movable contact rod 20 and is engaged with the flange 20e by means of the brazing material. The movable electrical contact 22 is secured to
5 a circular recess 22a of the movable electrical contact 22 by means of the 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
10 the shielding member C can be made of a plastic deformable metallic material such as Cu or Fe which is deformable 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
15 the inorganic insulating material such as the ceramics. Further, another method of assembling the stationary side is not limited to the method stated above, the following steps can be carried out: The step is that mounting the auxiliary shield 24 on the upper end plates 12, inserting
20 the third auxiliary sealing member 38 to the stationary contact rod 16, engaging the first main arc-shield 23 with the cover ring 12c, and supporting the stationary side after inserting the stationary contact rod 16 into the aperture 12a of the upper end plate 12.

25 The following steps are now effected: Each of the previously assembled stationary portion, the movable portion and the metallic housing portion is inserted into

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the vacuum furnace, a hydrogen environmental furnace or a deoxidation environmental furnace and is heated by the conventional method in order to enhance the activation of the surface of the material made of the austenite stainless steel and to carry out the degassing. Thereafter the temperature of each the vacuum furnace is gradually decreased to the brazing temperature and is kept to the predetermined temperature during a predetermined time interval. The temperature of the vacuum furnace is further decreased to the room temperature. The leak test of the 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, 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, the temporary construction of the vacuum interrupter is carried out by fitting the stationary portion and the movable portion to the housing portion. The temporarily assembled is heated at the temperature ranging from 500°C to 1050°C at the pressure less than 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 and is kept during a predetermined time interval at the deformation

temperature. The temperature of the vacuum furnace is further decreased from said deformation temperature to the room temperature.

Although each of the auxiliary brazing members is
5 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
10 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 previous assembling which is carried out prior to the second step of brazing.

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

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

Figure 11 shows a fourth embodiment of the vacuum

power interrupter according to 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 glass secured to end portions of the housing by way of auxiliary sealing members.

As is shown in Figure 11, first sealing means D comprises a first auxiliary sealing member 30 made of a metallic material such as an austenitic stainless steel 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 annular portion 30b, the outer diameter of which is the same as that of the housing 10, a first flange portion 30a, a second annular portion 30c formed integrally with the first flange portion 30a and a second flange portion 30d formed integrally with the second annular portion 30c. The first annular 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 annular 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 annular portion 32b, a first flange portion 32a, a second annular portion 32c formed integrally with the first annular portion 32b by way of the first flange 32a, a second flange 32d, and a third annular portion 32e formed integrally with the second annular 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 annular portion 32e of the second auxiliary sealing member 32.

Figure 12 shows a modification of the vacuum power 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 annular portion 30b and a second annular portion 30f of diameter smaller than that of the first annular portion 30b and formed integrally with the first annular portion by way of a flange portion 30a. The first annular 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 annular 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 annular

portion 32b, a flange portion 32a, and a second annular portion 32f formed integrally with the first annular portion 32b via a flange portion 32a, and is secured similarly to the first sealing means D.

5 Figures 13 through 15 show further modifications of the interrupter of Figure 11. In the interrupter of Figure 13, a first auxiliary sealing member D includes a flange portion 30a, a first annular portion 30b, a second flange 30g and a second annular portion 30f, all which are
10 formed integrally. The first annular 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 annular portion 30f, sandwiching therebetween a metallized portion 34, to form the first
15 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 similar to the first sealing means D.

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

annular auxiliary sealing member 32 and fixed to an end of the housing 10.

In the interrupter of Figure 15, a first auxiliary sealing member 30 has a flange 30a and a annular 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 annular portion 30b sandwiching therebetween a metalized 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 an annular portion 32b, and which is formed as described for the first sealing means D.

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

Figure 16 shows a fifth embodiment of the vacuum power interrupter according to the present invention. The vacuum power 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 annular portion 30b connected to the outer edge of the first flange 30a, a second flange 30g formed perpend-

iculary with respect to the first annular portion 30b, and a second annular portion 30c connected to the inner edge of the first flange 30a. An end of a metallic housing 10 is secured to the second flange 30g. An end of a ring-shaped projection 12b of an upper end plate 12 is secured to the first flange 30a 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 second flange 32f of the second auxiliary sealing member 32, and a ring-shaped projection 14b of a lower end plate 14 is secured to a first flange 32a, 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 annular 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 annular portion 32e of the second auxiliary sealing member 32 by means of spot welding.

Figure 17 shows a modification of the interrupter of Figure 16. The differences between the interrupter of Figure 17 and the interrupter of Figure 16

reside in the shape of an auxiliary sealing member for aiding the positioning of auxiliary shields for brazing. As is shown in Figure 17, a first auxiliary sealing member 30 has a ring-shaped flange 30a and a curved portion 30c curved inwards 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 of the curved portion 30c is secured to an end surface of a ring-shaped projection 12a 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 inwards 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 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 such 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 inwards and a second auxiliary shield 54 curved inwards. One end of the shield 52 is fixed to an inner surface of the curved portion 30c of the first auxiliary sealing member 30 by brazing or spot welding and the other end is brazed to the inner surface of the upper end plate 12. An end of the shield 54 is secured

to an inner surface of a lower end plate 14 by brazing, and an axial portion of the shield 54 is fastened to the curved portion 32c of the second sealing member 32 by brazing or spot welding.

5 In accordance with the vacuum power interrupter shown in Figures 16 and 17, mechanical stress due to the interrupting operation of the interrupter is relieved as well as the thermal stress due to brazing, and high reliability of sealing and high efficiency of the
10 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
15 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 embodiment of the vacuum power interrupter according to the present invention. In the vacuum power interrupter of Figure 18, auxiliary
20 sealing members are provided with at least one curved portion for absorbing the mechanical stress generated by activation of the interrupter or by thermal stress during brazing. One end of the auxiliary sealing member is
25 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, an annular 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 annular 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 annular portion 30b extending at right angles and the semi-circular curved portion 30h, the end of the housing 10, which is inserted into the annular 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. The second sealing means E comprises an end of the housing 10, a second auxiliary sealing member 34 having a ring-shaped flange portion 32a, an annular 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 annular portion 32b, and an end of a projection 14b

which is secured to an end of the annular 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 end 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 deformable by the thermal stress generated by the 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 annular 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 annular 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 annular 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 annular 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 annular portion 58c formed integrally with an outer edge of the first flange portion 58b, a second flange portion 58d extending outwards from the second annular portion 58c and having an outer diameter larger than that of the flange 10e of the housing 10 and a annular projection 58e projecting from the outer edge of the second flange portion 58d. The second annular portion 58c of the first auxiliary shield 58 is mounted on the housing 10 by inseting the second annular portion 58c into the flange 10e of the housing 10 and engaging the second flange portion 58d to 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 annular portion 62a having a smaller diameter than that of

the second main arc-shield 60 and coaxially located with the second main arc-shield 60, a flange portion 60b extending outwards from the first annular portion 60a and a second annular portion 60c formed integrally with the flange 60b. The second annular portion 60c is inserted into the annular portion 32c of the second auxiliary sealing member 32 and is secured to the annular 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 accordance with the vacuum power 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 interrupting operation 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 D 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.

5 The second auxiliary sealing member 32 of the second sealing means E has a flange portion 32a, a first annular 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
10 annular portion 32a 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.

15 Second supporting means G comprises a bellows 40, an upper end 40b of which is secured to a movable contact rod 20 and a 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
20 a fourth auxiliary sealing member 66. 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 is fixed on the
25 inner surface of the lower end plate 14 near the aperture 14a by brazing. In accordance with the vacuum power interrupter shown in Figure 19, the same advantages

as those of Figure 18 can be achieved.

Figure 20 shows a vacuum power interrupter employing 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 such that a flange portion 30a engages with the projection 12b formed near the center of the upper end plate by way of the metallized portion 34 and an annular portion 30b is fitted to the outer edge surface of the upper end plate 12. The annular 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 32b engages with the projection 14b of the lower end plate 14 by way of the metallized portion 34 and an annular portion 32a is fitted to the outer edge surface of the lower end plate 14. The annular portion 32a 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 accordance with the vacuum power interrupter shown in Figure 20, it is easy to provide

brazing material between each component of the interrupter and to perform the assembly, because the upper end plate 12 and the lower end plate 14 are aligned in the same direction.

5 Figure 21 shows a seventh embodiment of a vacuum power interrupter according to the present invention. In accordance with the embodiment, a part of a shielding member C is made of a metallic material which is deformed by the thermal stress generated in cooling after brazing
10 and is employed in an auxiliary sealing member to aid sealing between the metallic material and the insulating material.

 In more detail, the shielding member C comprises a first main arc-shield 22 mounted on a stationary contact
15 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 deformed by the thermal stress in slow cooling after the brazing.
20 The first auxiliary shield 70 comprises an annular portion 70a and a flange portion 70b extending outwards from the annular 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
25 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
5 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.

According to the vacuum power interrupter of Figure 21, the number of elements of the interrupter is
10 reduced and thereby the constructual of the 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 deformed by the thermal stress in brazing and is employed as the auxiliary sealing member for aiding the
15 sealing the 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
20 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.

The vacuum power interrupters shown in Figures 5
25 to 21 are manufactured by the same method as that of the vacuum power interrupter shown in Figure 1 to 4.

While preferred embodiments of the invention have been shown and described, it will be apparent to those skilled in the art that modifications can be made without departing from the invention,
5 /the scope of which is defined in the appended claims. Accordingly, the foregoing embodiments are to be considered illustrative, rather than restricting of the invention and those modifications which come within the meaning and range
10 of equivalency of the claims are to be included herein.

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WHAT IS CLAIMED IS:

1. A vacuum power interrupter comprising in combination;

an envelope including a cylindrical housing made
5 of a metallic material, a disc-shaped upper end plate made
of an inorganic insulating material having an aperture in
the center portion thereof and a disc-shaped lower end
plate made of an inorganic insulating material having an
aperture in the center portion thereof;

10 an electrical contact member including a
stationary contact rod inserted into said envelope through
said aperture of the upper end plate, a stationary
electrical contact secured to said stationary contact rod,
a movable contact rod inserted into said envelope through
15 said apperture of the lower end plate and a movable
electrical contact secured to said movable contact, both of
the stationary contact rod and the movable contact rod are
made of Cu;

a shielding member for shielding inner surface of
20 said envelope;

a first sealing means for sealing hermetically
said upper end plate to said housing and including a first
auxiliary sealing member made of a plastic deformable
metallic material which is deformable by the thermal stress
25 and a metallized portion provided between said first
auxiliary sealing member and said upper end plate;

a second sealing member for sealing hermetically

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said lower end plate to said housing and including a second auxiliary sealing member made of a plastic deformable metallic material which is deformable by the thermal stress and a metallized portion provided between said second auxiliary sealing member and said lower end plate;

first supporting means for supporting and securing hermetically said stationary contact rod to said upper end plate including a metallized portion provided between said upper end plate and said stationary contact rod; and

hermetic seal means for sealing movably and hermetically said movable contact rod to said lower end plate including a bellows for securing said movable contact rod to said lower end plate and a metallized portion provided between said lower end plate and said bellows.

2. A vacuum power interrupter as claimed in claim 1, wherein said first sealing means comprises an end portion of said housing, said first auxiliary sealing member secured to said end portion of said housing and a peripheral edge portion of said upper end plate secured to said first auxiliary sealing member via the metallized portion.

3. A vacuum power interrupter as claimed in claim ^{1 or 2,} wherein said second sealing means comprises other end portion of said housing, said auxiliary sealing member

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. secured to said other end of the housing and a peripheral edge portion of said lower end plate secured to said second sealing member via the metallized portion.

5 4. A vacuum power interrrupter as claimed in any preceding
 /claim, wherein said first and second auxiliary sealing members of the first and second sealing means are made of Cu.

10 5. A vacuum power interrupter as claimed in ^{any of} /claims 1 to 3,
 /wherein said first and second auxiliary members of said first and second sealing means are made of Fe.

15 6. A vacuum power interrupter as claimed in claim 2, wherein said first sealing means comprises a stepped portion provided in an inner surface of one end portion of said housing, the first auxiliary sealing member having a ring-shaped flange portion and a ,tubular portion fitted into said stepped portion of said housing, and a ring-
20 shaped projection formed in an outer edge portion of said disc-shaped upper end plate and secured to said flange portion of said first auxiliary sealing member by means of the metallized portion.

25 7. A vacuum power interrupter as claimed in claim 3, wherein said second sealing means comprises a stepped portion provided in an inner surface of said other end

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portion of said housing, the second auxiliary sealing member having a ring-shaped flange and a tubular portion fitted into said stepped portion of the housing, and a ring-shaped projection formed in an outer edge portion of said lower end plate and secured to said flange portion of said second auxiliary sealing member by means of the metallized portion.

8. A vacuum power interrupter as claimed in ^{any preceding} claim, wherein said first supporting means for supporting hermetically said stationary contact rod to said end plate further comprises a third auxiliary sealing member made of a non-magnetic material which is deformable by the thermal stress in brazing.

15

9. A vacuum power interrupter as claimed in claim 8, wherein said third auxiliary sealing member is made of Cu.

10. A vacuum power interrupter as claimed in claim 8, wherein said third auxiliary sealing member of said first supporting means is made of Fe.

11. A power vacuum interrupter as claimed in ^{any preceding} claim, wherein said hermetic seal means comprises a bellows having an upper end secured to said movable contact rod a lower end inserted into and secured to said aperture of said lower end plate by means of the metallized portion.

25

8, 9 or 10,
12. A vacuum interrupter as claimed in claim 1,
wherein said third auxiliary sealing member of the first
supporting means comprises a tubular portion inserted into
and secured to the aperture of said upper end plate by the
5 metallized portion and a flange portion secured
hermetically to the upper end plate by means of the
metallized portion.

8, 9 or 10,
13. A vacuum interrupter as claimed in claim 2,
10 wherein said third auxiliary sealing member of the first
supporting means comprises a first tubular portion secured
to a stationary contact rod, a ring-shaped flat portion
formed integrally with said first tubular portion and a
second tubular portion formed integrally with said flat
15 portion and secured to an inner surface of an upper end by
means of a metallized portion.

14. A vacuum interrupter as claimed in claim 2,
wherein said first sealing means comprises a stepped
20 portion provided in an outer surface of one end portion of
said housing, a tubular first auxiliary sealing member
secured to said stepped portion of said housing and an
outer circumferential surface of the upper end plate
secured to an inner surface of said first auxiliary sealing
25 member by means of a metallized portion.

15. A vacuum interrupter as claimed in claim 3,

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wherein said second sealing means comprises a stepped portion provided in an outer surface of other end portion of said housing, a tubular second auxiliary sealing member secured to stepped portion of said housing and an outer
5 circumferential surface of the lower end plate secured to an inner surface of said second auxiliary sealing member by means of the metallized portion.

16. A vacuum interrupter as claimed in ^{any preceding} claim,
10 wherein said shielding member comprises a first main arc-shield mounted on said stationary contact rod by means of a brazing material and a first auxiliary shield fixed to said first sealing member of said first sealing means, a second main arc-shield mounted on said movable contact rod, and a
15 second auxiliary shield secured to said second auxiliary sealing member of said second sealing means, each of said shield is made of non-magnetic metallic material including an austenite stainless steel.

20 17. A vacuum interrupter as claimed in claim 16, wherein said second auxiliary shield having a tubular portion secured to an inner surface of the lower end plate.

18. A vacuum interrupter as claimed in claim ^{16 or 17,}
25 wherein said second auxiliary shield having thermal stress releasing means for eliminating the thermal stress in brazing.

19. A vacuum interrupter as claimed in claim 18, wherein said thermal stress releasing means comprises a tapered portion provided in the tubular portion of said second auxiliary shield.

5

20. A vacuum interrupter as claimed in claim 18, wherein said thermal stress releasing means comprises an annular groove provided on the circumferential surface of the tubular portion of said second auxiliary shield.

10

21. A vacuum interrupter as claimed in claim 18, wherein said thermal stress releasing means comprises a plurality of axial slits provided along with the circumference of an open end portion of said tubular portion of the second auxiliary shield.

15

22. A vacuum interrupter as claimed in ^{any of 17 to 21,} claims ¹ wherein said first auxiliary shield is secured to an inner surface said upper end plate, and said second auxiliary shield is secured to an inner surface of said lower end plate.

20

23. A vacuum interrupter as claimed in claim 16, wherein each of said first and second auxiliary sealing members having a first flange portion secured to an end of the housing and a second flange portion, and each of said first and second auxiliary shields is secured to said

25

second flange portion.

24. A vacuum interrupter as claimed in ^{any of 1 to 5,} ~~claims~~ wherein each of said first and second auxiliary sealing
5 member comprises a first tubular portion secured to an inner surface of one end of said housing and a second tubular portion secured to an outer circumferential surface of an end plate.

10 25. A vacuum interrupter as claimed in claim 24, wherein each of said first and second auxiliary sealing members further housing a second flange portion secured to an end of said housing.

15 26. A vacuum interrupter as claimed ^{in claims} ~~2 and 3,~~ wherein each of said first and second auxiliary sealing members having a first tubular portion secured to a circumferential surface of an end plate and a flange portion of which an end portion is secured to a stepped portion provided in an
20 outer circumferential surface of an end portion of said housing.

27. A vacuum interrupter as claimed in ~~claims~~ 2 and 3, wherein each of said first and second auxiliary sealing
25 members has a first flange portion secured to an end of a ring-shaped projection, a first tubular portion formed integrally with said first flange portion and a second

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flange portion formed integrally with said first tubular portion and secured to an end of said housing.

28. A vacuum interrupter as claimed in claim 2,
5 wherein said first auxiliary sealing member comprises a tubular portion secured to an outer circumferential surface of said housing, a flange portion inwardly extending from said tubular portion and a stress absorbing portion curled inwardly from said flange portion and secured to an upper
10 end surface of an upper end plate.

29. A vacuum interrupter as claimed in claim 3,
wherein said second auxiliary sealing member comprises a flange portion a tubular portion having a smaller diameter
15 than that of said flange portion formed integrally with said flange portion by way of a curled portion and secured to a ring-shaped projection of a lower end plate.

30. A vacuum interrupter as claimed in ^{any preceding} claim,
20 wherein said hermetic seal means including a bellows of which one end is secured to said stationary contact rod and of which other end portion is inserted into an aperture of said lower end plate and a fourth auxiliary sealing member which is deformable by the thermal stress generated in
25 cooling after brazing.

31. A vacuum interrupter as claimed in claim 29,

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· further comprising a shielding member having an approximately disc-shaped shield having an inner curved portion and having a smaller diameter than that of the housing, said shield is mounted on an end portion.

5

wherein

32. A vacuum interrupter as claimed in claim 1, said envelope includes an upper end plate having a projection provided on an outer surface of the upper end plate and a lower end plate having a projection provided on an inner surface of the lower end plate.

10

33. A vacuum interrupter as claimed in claim 1, wherein said shielding member comprising a shield made of a metal which is deformable by the thermal stress generated in cooling after the brazing.

15

34. A vacuum interrupter as claimed in claim 33, further comprising a first auxiliary sealing member including a portion of said shield and a second auxiliary sealing member including a portion of said shield.

20

25

[illegible]

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FIG. 4

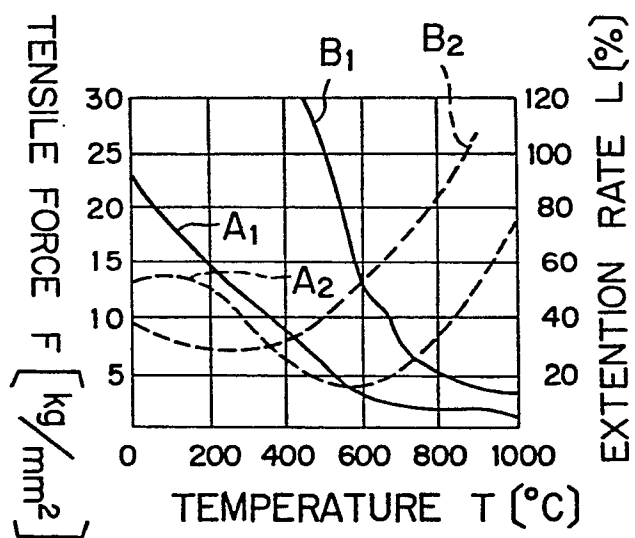


FIG. 5

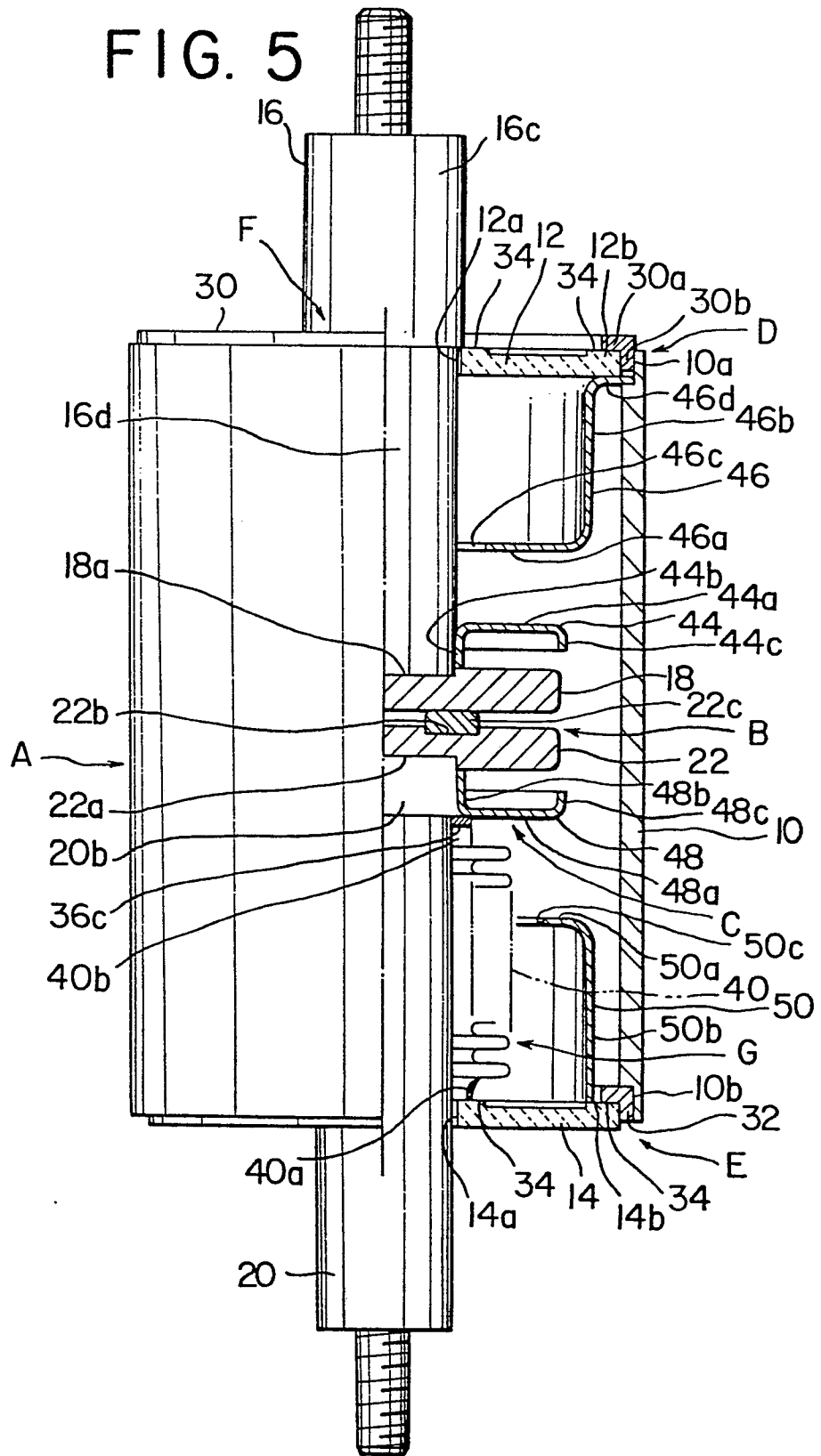


FIG. 6

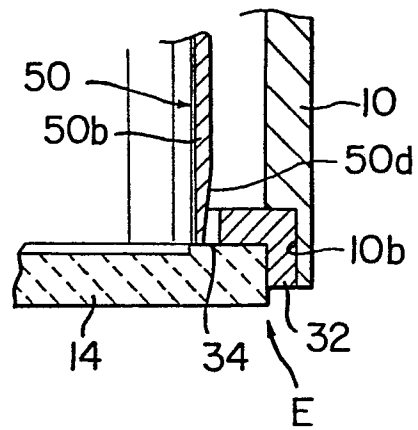


FIG. 7

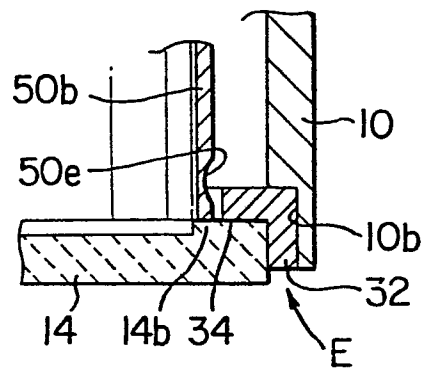


FIG. 8

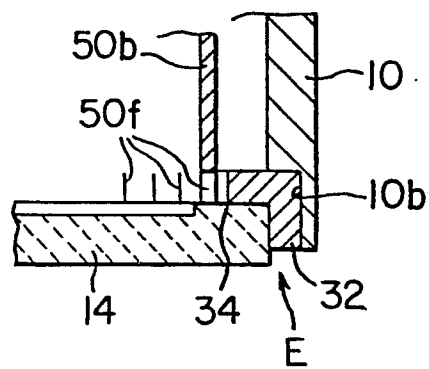


FIG. 9

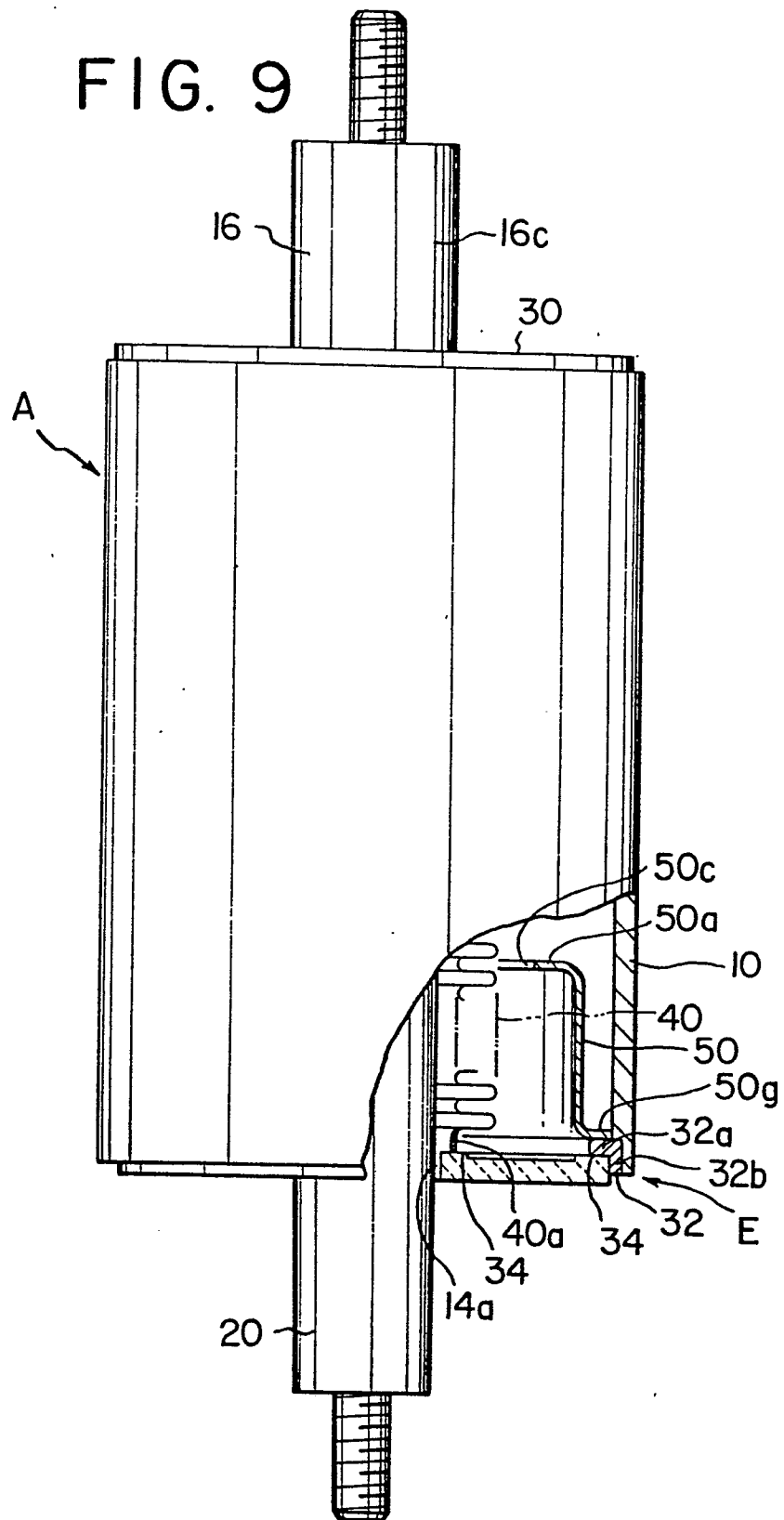


FIG. 10

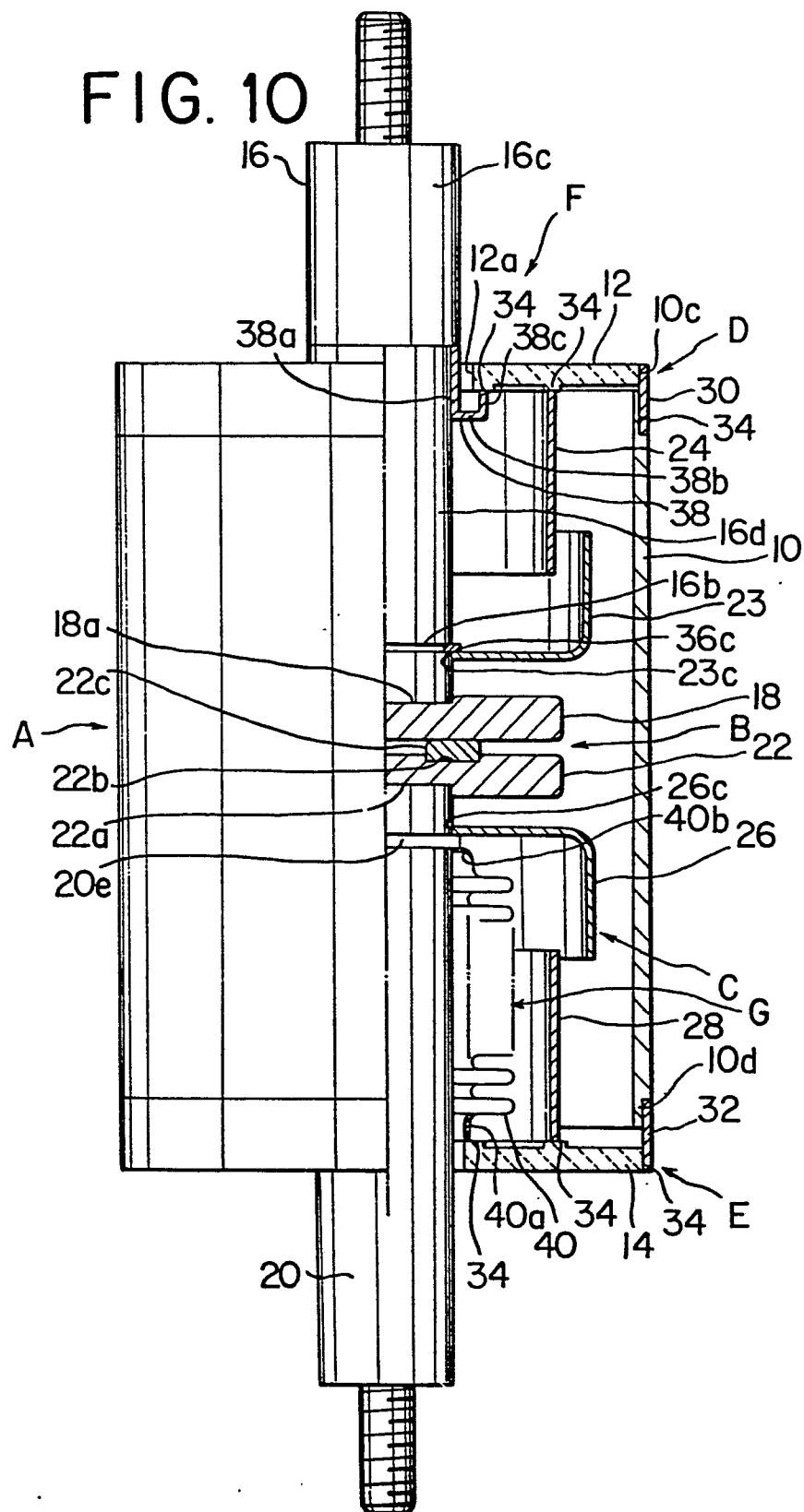


FIG. 11

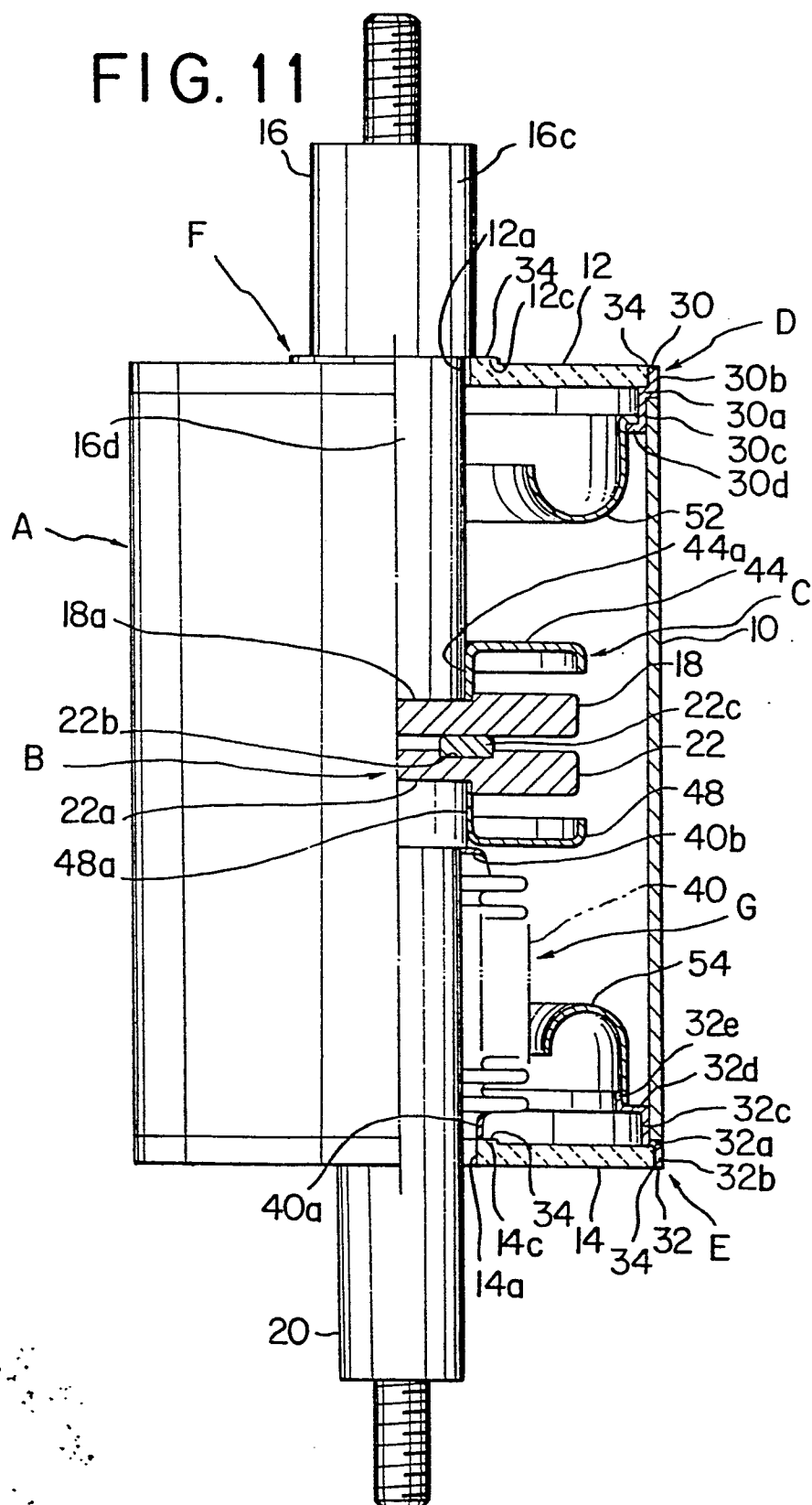


FIG. 12

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FIG. 13

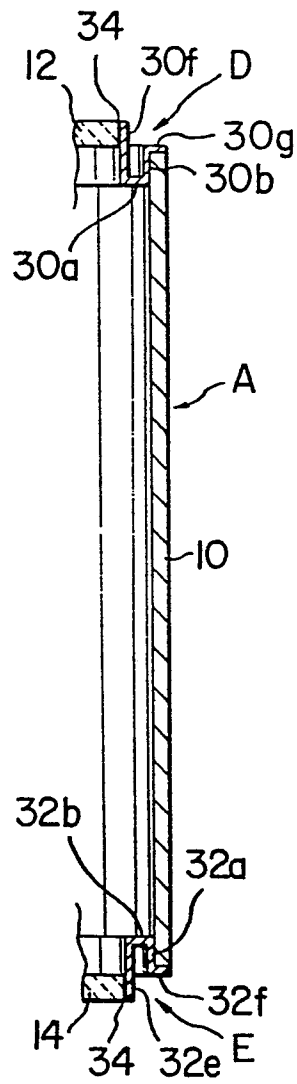


FIG. 14

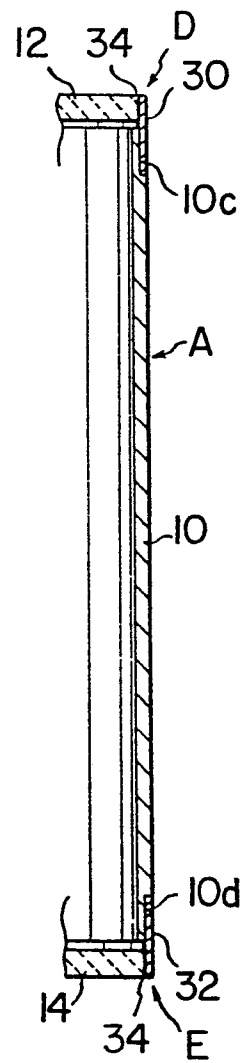


FIG. 15

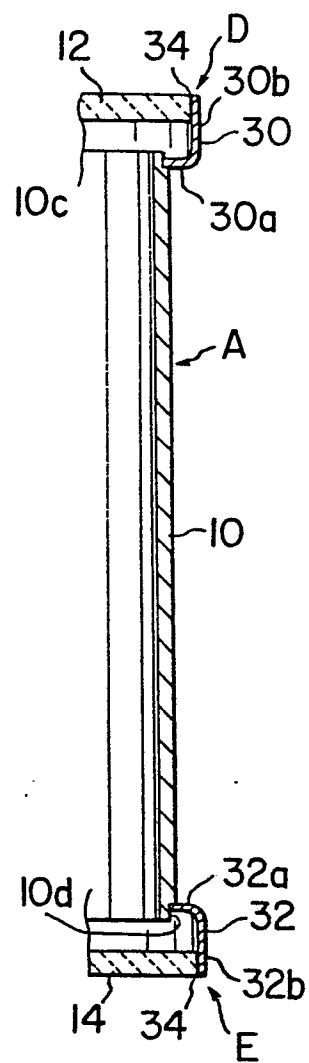


FIG. 16

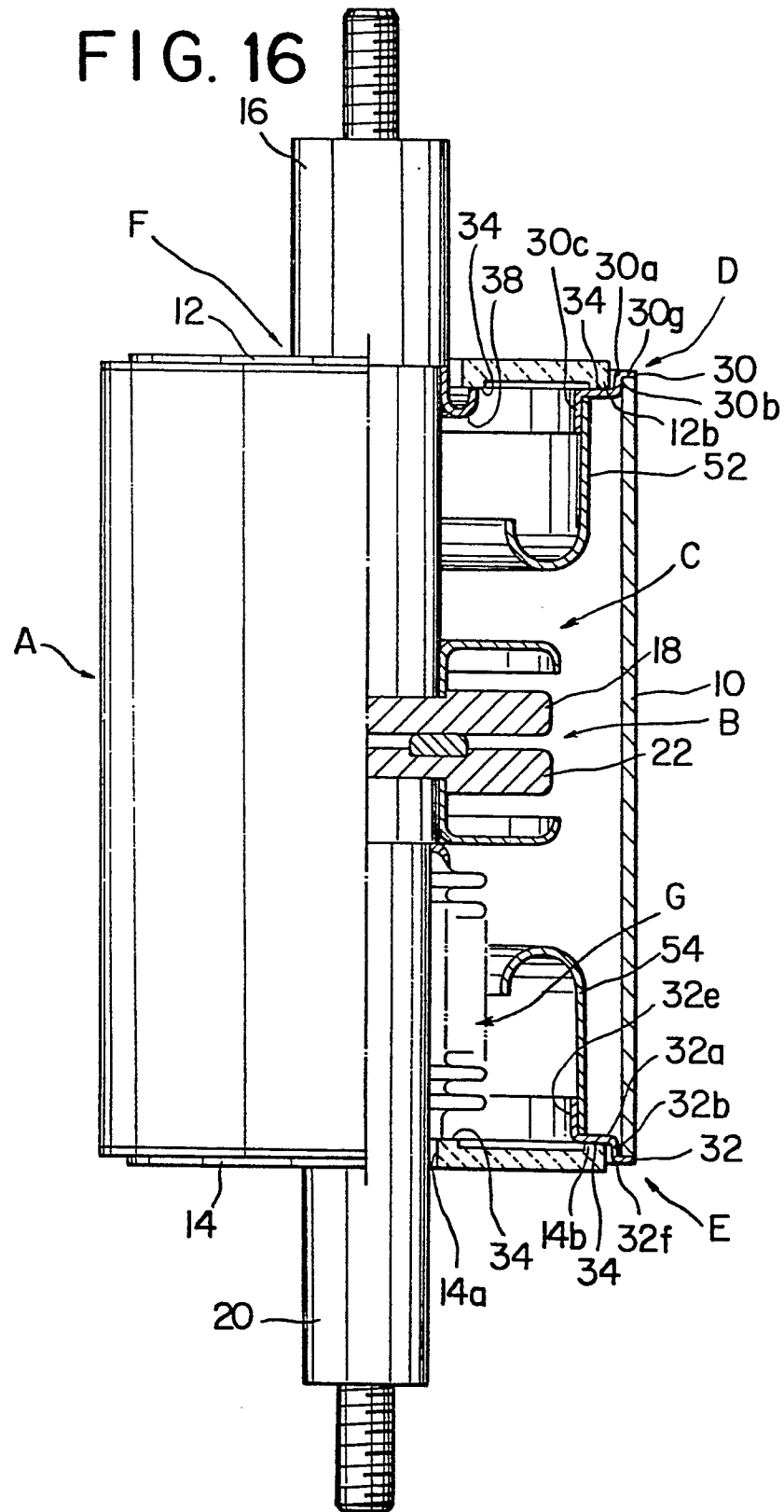
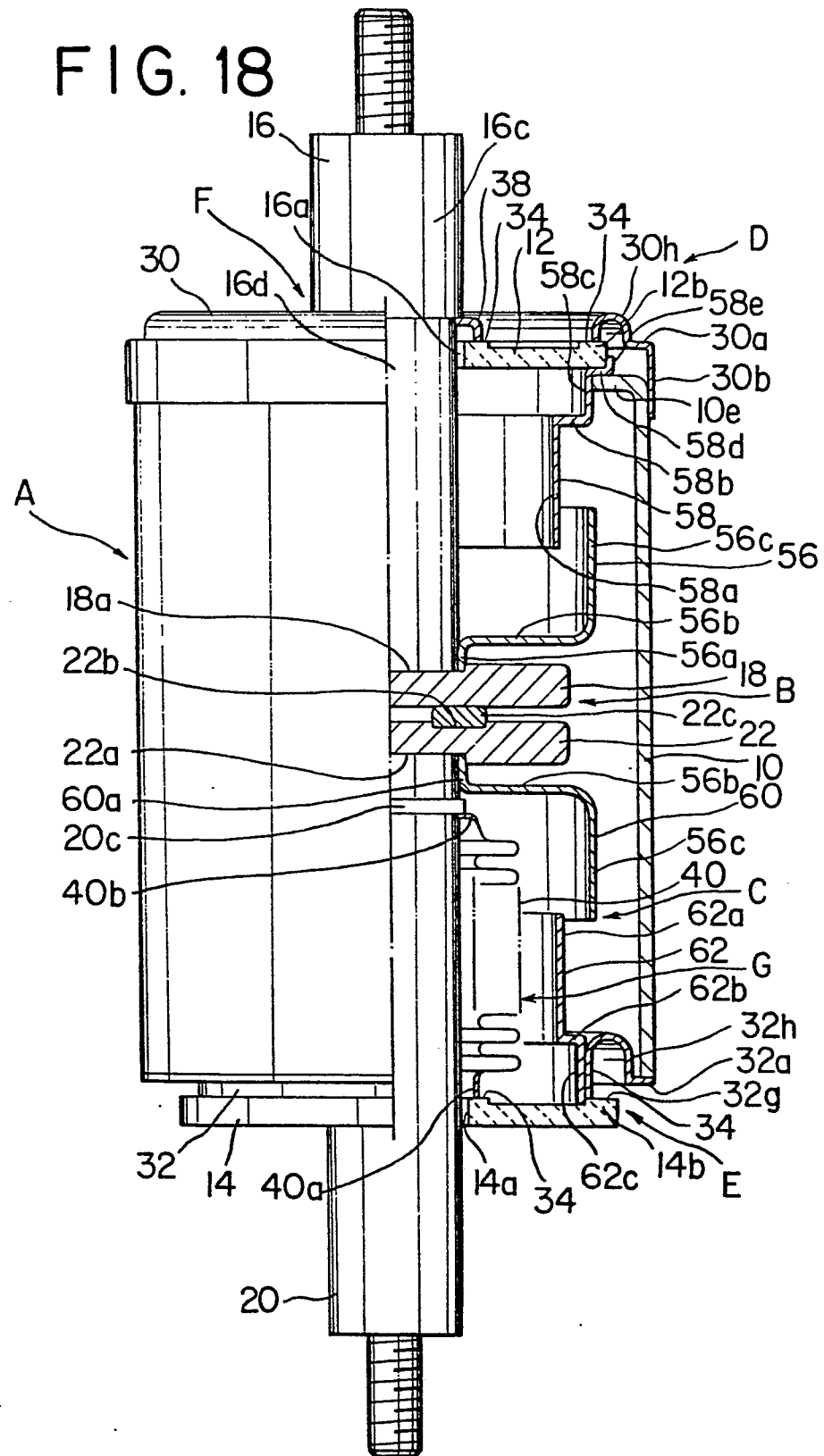


FIG. 18



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FIG. 21

