May 22, 1962 A. N. GREENWOOD 3,036,180

CONTACT STRUCTURE FOR A VACUUM-TYPE CIRCUIT INTERRUPTER

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Fig. 2.

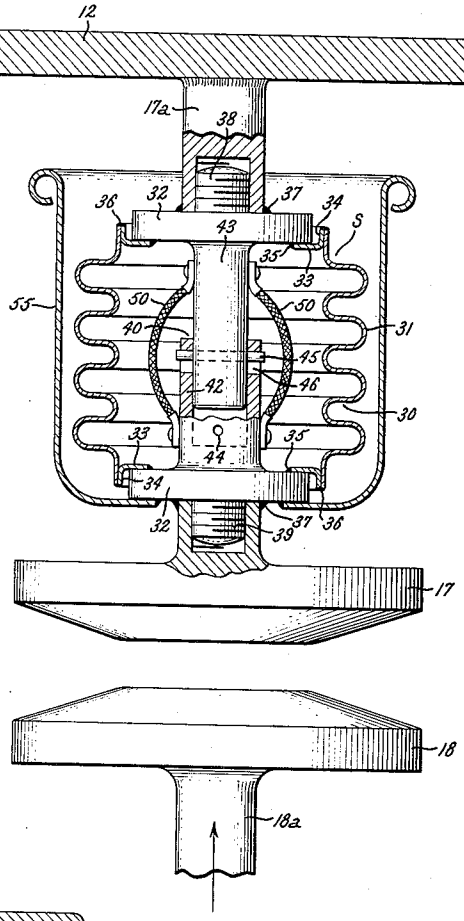


Fig. 1.

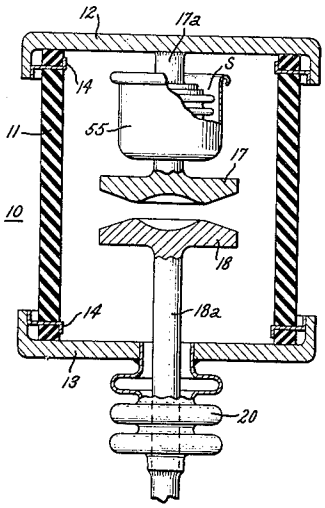
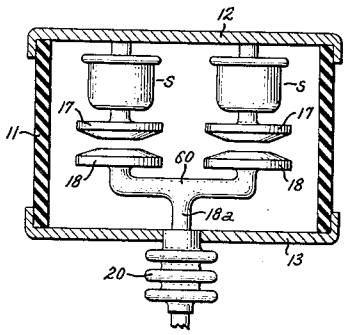


Fig. 3.



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CONTACT STRUCTURE FOR A VACUUM-TYPE CIRCUIT INTERRUPTER

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This invention relates to a vacuum-type circuit interrupter and, more particularly, to contact structure for such an interrupter.

The usual non-vacuum-type circuit interrupter comprises a pair of separable contacts, one of which is movable through an opening and closing stroke and the other of which is generally fixed. It is customary in such interrupters to provide the generally fixed contact with a limited degree of resilience so as to reduce the mechanical shocks occurring when the contacts are driven into engagement during closing and so as to reduce the tendency of the contacts to bounce upon being driven into closing engagement. In addition, this resilience enables a predetermined pressure to be maintained between the contacts when the interrupter is closed and also provides a wear allowance to accommodate erosion of the contacts.

The above advantages are equally desirable in a vacuum-type circuit interrupter but heretofore have been difficult to attain for several different reasons. One reason arises out of the fact that a vacuum-type circuit interrupter must be "baked out" before it can be relied upon for satisfactory performance. This bake-out procedure involves baking the interrupter at relatively high temperatures in order to remove any adsorbed gases from the internal surfaces of the interrupter so as to avoid subsequent impairment of the vacuum inside the interrupter when the interrupter is in service. The high temperatures accompanying the bake-out are such that the resilient properties of any conventional spring, e.g., a coil or leaf spring made of a conventional resilient material, located inside the interrupter would be seriously impaired, if not completely destroyed, by the bake-out. Thus, such a conventional spring cannot be relied upon for imparting the desired resilience to the fixed contacts.

Another reason that it has been difficult to attain the above-noted advantages of a resilient mounting is that such mountings customarily involve a certain degree of relative motion between the resiliently-mounted contact and its support, and such relative motion involves a certain amount of friction. Friction in a vacuum can be an extremely troublesome problem because the coefficient of friction between most clean metals in a vacuum is very high. This, of course, can produce galling or virtual welding together of the two surfaces that are intended to slide relative to each other, with the end result being complete impairment of the resilient mounting.

One approach that has been made toward overcoming these problems involves mounting the springs and bearings for the resiliently-mounted contact outside of the vacuum envelope. This results in an elaborate and costly design which it is desirable to avoid if possible.

Thus, an object of my invention is to provide for one of the contacts of a vacuum-type circuit interrupter a resilient mounting which utilizes a spring device located inside the vacuum envelope.

Another object is to construct the internally located resilient mounting in such a manner that its spring properties are not impaired by the usual bake-out of the interrupter.

Still another object is to construct the internally-located resilient mounting in such a manner that sliding motion between its parts can take place without undue frictional

interference resulting from the presence of the vacuum inside the interrupter.

In carrying out my invention in one form, I provide within the usual vacuum chamber of the interrupter a pair of separable contacts. On suitable supporting structure within the vacuum chamber, I resiliently mount one of the contacts by means of a sealed gas-filled capsule having flexible metallic walls which permit compression of the gas within the capsule. The capsule is disposed between the supporting structure and the contact in such a manner that the gas within the capsule is compressed by closing motion of the other contact after initial contact-engagement occurs. The compressed gas provides a force acting in a direction to resist contact-separation. Inasmuch as a gaseous medium is relied upon for the spring properties of the resilient mounting and inasmuch as the spring properties of such gaseous medium are not permanently affected by the temporary temperature rises accompanying bake-out, it will be apparent that the spring properties of my resilient mounting will be retained unimpaired despite any bake-out to which the interrupter is subjected.

In accordance with another feature of my invention, I guide the movable contact during its motion by suitable guide means. This guide means has its bearing surfaces located within the gas-filled capsule, instead of in the vacuum, thus eliminating any undue frictional interference that would result if the sliding surfaces were located in the vacuum.

For a better understanding of my invention reference may be had to the following description taken in conjunction with the accompanying drawing, wherein:

FIG. 1 is a side elevational view partly in section showing a vacuum-type interrupter embodying one form of my invention.

FIG. 2 is an enlarged sectional view of one part of the interrupter shown in FIG. 1.

FIG. 3 is a schematic showing of a slightly modified form of my invention.

Referring now to FIG. 1, there is shown a highly evacuated envelope **10** comprising a casing **11** of suitable insulating material and a pair of metallic end caps **12** and **13** closing off the ends of the casing. Suitable seals **14** are provided between the end caps and the casing to render the envelope **10** vacuum-tight.

Located within the envelope **10** is a pair of separable disc-shaped contacts **17** and **18** shown in their disengaged or open-circuit position. The upper contact **17** is a generally fixed contact mounted on a stationary conductive rod **17***a*, which at its upper end is united to the upper end cap **12**. The mounting between the upper contact **17** and the conductive rod **17***a* is constituted by a spring device S embodying one form of the present invention, as will be described in greater detail hereinafter. The lower contact **18** is a movable contact joined to a conductive operating rod **18***a* which is suitably mounted for vertical movement. The operating rod **18***a* projects through an opening in the lower end cap **13**, and a flexible metallic bellows **20** provides a seal about the rod **18***a* to allow for vertical movement of the rod without impairing the vacuum inside the envelope **10**. As shown in FIG. 1, the bellows **20** is secured by suitable seals at its respective opposite ends to the operating rod **18***a* and the end cap **13**.

Coupled to the lower end of the operating rod **18***a*, there is provided suitable actuating means (not shown) which is capable of driving the contact **18** upwardly into engagement with the contact **17** so as to close the interrupter and which is also capable of returning the contact **18** downwardly to its illustrated position so as to open the interrupter. These circuit-controlling operations, particularly as they involve the resilient mounting S, will soon be explained in greater detail.

Each of the disclosed contacts **17**, **18** is of a disc shape and is preferably constructed as shown and claimed in application Serial No. 730,413—Schneider, filed April 23, 1958, now Patent No. 2,949,520, granted August 17, 1960, and assigned to the assignee of the present invention. It is to be understood, however, that any suitable form of contact structure can be used with the contact mounting arrangement of my invention.

The contact-mounting arrangements will now be described in greater detail, with particular reference being had to FIG. 2. Referring now to FIG. 2, it will be seen that the spring device S comprises a sealed capsule **30** formed from a flexible bellows **31** of tubular form and a pair of end structures **32**, **33** closing off the bellows **31** at its longitudinally opposite ends. Each of these end structures comprises an end plate **32** to the inner side of which is brazed a sheet metal ring **33** terminating in an axially extending flange **34** to which the end of the tubular bellows **31** is welded. The brazed joint **35** between the end plate **32** and the ring **33** and the welded joint **36** between the ring **33** and the bellows **31** each form gas-tight seals for isolating the inside volume of the capsule from the surrounding volume.

The capsule **30** is filled with gas at a predetermined pressure and this gas is relied upon for the spring properties of the contact mounting arrangement S, as will soon be apparent. The opening for filling the capsule **30** with gas is not shown, but it is to be understood that this opening is permanently sealed off after the capsule has been filled.

The upper end plate **32** is secured to the stationary conductive rod **17***a* by suitable fastening means such as a threaded stud **38** integral with the end plate **32** and threaded into a suitably tapped hole in the rod **17***a*. The lower end plate **32** of the capsule **30** is secured to the contact **17** preferably by means of a threaded stud **39** integral with the lower end plate **32** and threaded into a suitably tapped hole in a centrally disposed boss provided on the contact **17**.

When the lower contact **18** is driven upwardly during a contact-closing stroke, it encounters the generally fixed contact **17** near the end of its closing stroke and then travels a short distance further in an upward direction until the closing stroke is completed. This continued upward movement of the contact **18** after initial contact-engagement forces the contact **17** upwardly, thereby decreasing the volume of the capsule **30** and thus compressing the gas within the capsule **30**. As the gas is compressed, it, of course, acts in the same general manner as a spring, thus cushioning the shock of the closing impact and exerting a progressively increasing downward force tending to preclude contact bounce. The downward force exerted by the compressed gas also maintains a predetermined desired pressure between the contacts when they are engaged and serves the additional purpose of compensating for any contact erosion. Upward motion of the contacts **17** and **18** is terminated when the lower contact **18** reaches the end of its closing stroke, and thereafter the two contacts are held in this terminal position by suitable restraining means such as a latch (not shown) constituting a part of the operating mechanism. The terminal point for the opening stroke is governed by the construction of the operating mechanism.

For guiding the generally fixed contact **17** during its above described upward motion, guide means **40** is provided internally of the gas-filled capsule **30**. The guide means **40** comprises a guide sleeve **42** integral with the lower end cap **32** and extending upwardly therefrom and a guide rod **43** integral with the upper end cap and extending downwardly therefrom. The guide rod **43** is slidably received in telescoping relationship within the guide sleeve **42**, and these two parts constitute a slide bearing which serves to guide the movable contact **17** along a substantially straight line path as it moves upward under the influence of closing forces applied through the movable contact **18**. A small hole **44** provided in the guide sleeve **42** near its lower end precludes gas from being trapped within the guide sleeve during such upward movement.

For providing a stop during contact-opening movement, the guide rod **42** is provided with a transversely extending pin **45** that is loosely received within a slot **46** formed in the guide sleeve **42**. The slot **46** is of sufficient length to insure that the pin **45** does not interfere with a closing operation, but during an opening operation the pin **45**, upon engaging the upper end of slot **46**, serves to limit the downward travel of the movable contact **17**.

For example, when the hold-closed latch (not shown) is released and the movable contact **18** moves downwardly under the influence of its opening spring (not shown), the compressed gas within the capsule **30** forces the generally fixed contact **17** to follow along in follow-up relationship to the movable contact **18**. This follow-up motion continues until the pin **45** reaches the upper end of the slot **46**, at which time the fixed contact **17** is blocked from further downward motion, thereby permitting the movable contact **18** to separate from the fixed contact **17** and, thus, to establish the desired circuit-interrupting arc between the two contacts **17** and **18**.

As was pointed out hereinabove, friction can be an extremely troublesome problem in a vacuum interrupter because the coefficient of friction between most clean metals is very high in a vacuum. This leads to galling and welding between the two surfaces that are intended to constitute the bearing. I have overcome this problem in my contact-mounting arrangements by locating the guide means (**40**) for the movable contact inside the gas-filled capsule **30** instead of in the vacuum chamber. As a result, the guide means is not subject to the galling and welding problems that would have been present had the guide means been located in the high vacuum of the vacuum chamber.

For transferring current between the conductive rod **17***a* and the contact **17**, I provide flexible conductive braids **50** also located within the capsule **30**. Each of these braids has its upper end connected electrically and mechanically to the guide rod **43** and its lower end connected electrically and mechanically to the guide sleeve **42**, thus providing an electrical connection which bridges the guide means **40**. Locating the braids **50** inside the capsule **30**, instead of in the vacuum chamber, is highly advantageous for a number of reasons. First of all, the necessity for freeing the braids of adsorbed gases is eliminated. This can be a formidable problem in view of the fact that a braid is made up of a large number of strands each having a surface which must be freed of adsorbed gases and, at the same time, is difficult to free of adsorbed gases. Secondly, flexing of the braids involves a certain amount of friction between the strands of the braid, and the vacuum would tend to accentuate this friction due to the high coefficient of friction prevailing between clean metal surfaces in a high vacuum. The resulting high friction would shorten the useful life of a braid in comparison to its life in most gases such as air.

It will be apparent that my capsule **30** is a self-contained sub-assembly that can be easily assembled apart from the interrupter and then readily incorporated into the interrupter. Starting with the end caps **32** having the rings **34** brazed thereto, the sub-assembly is assembled simply by placing the guide rod **43** of the upper end structure **32** inside the guide sleeve **42** of the lower end cap structure **32**, pressing the transverse pin **45** in place, attaching the braids **50**, and then slipping the bellows **31** over the two end structures **32** and welding it into position. Thereafter, the capsule is filled to the desired pressure with a suitable gas and then sealed.

This sub-assembly can then be incorporated into the vacuum interrupter simply by screwing the stud **34** into the tapped opening of the rod **17***a* and screwing the disc-shaped contact **17** onto the lower stud **36**. When so

assembled, the upper end cap **32** abuts against the lower surface of the rod **17***a* thereby providing for current tansfer between the rod **17***a* and the end cap **32**. Correspondingly, the lower end cap **32** abuts against the upper surface of the boss on the contact **17**, thereby providing for current transfer to the contact **17** from the lower end cap **32**. Suitable brazed joints such as shown at **37** are preferably provided between the rod **17***a* and the end cap **32** and between the contact **17** and the lower end cap **32** to prevent loosening of the threads **38** and **39**, thereby maintaining the desired electrical engagement between the end caps **32** and the adjacent surfaces of the interrupter.

As was pointed out hereinabove, a vacuum switch must be baked-out at high temperatures before it can be relied upon for satisfactory performance. The temperatures involved in the usual bake-out operation are so high that any conventional metallic spring or spring constructed of organic material disposed in the vacuum envelope would have its resilient properties impaired or even destroyed by the bake-out. In contrast to conventional metallic springs or springs of organic material, the contact-mounting arrangement of my invention can be subjected to bake-out temperatures of any desired level, within practical limits, without in any way impairing the spring properties of my assembly. I am relying upon the gas within my capsule for providing the desired spring properties, and it will be apparent, of course, that the properties of this gas will not be significantly affected by the bake-out. Once the interrupter returns to normal temperatures after bake-out, the gas within the capsule will have substantially the same spring properties as it had before bake-out. Any resilience present in the bellows may be destroyed by the bake-out, but this is no significant disadvantage inasmuch as I rely upon the gas within the capsule and not upon the bellows itself for providing the desired resilience. It is to be understood that the spring gradient of my resilient capsule **30** can be preregulated by selection of a suitable initial pressure for the gas within the bellows.

It is desirable to protect the bellows **31** from the effects of any arc established between the contacts **17** and **18**. For this purpose I provide a cup-shaped metallic shield **55** surrounding the bellows. This cup-shaped shield, which is shown brazed to the lower end plate **32**, is preferably incorporated into the spring sub-assembly before the sub-assembly is incorporated into the interrupter.

Although air, argon, nitrogen, and numerous other gases are suitable for use as fillers for the capsule, there is one gas which is exceptionally well-suited for this purpose. This gas is helium. One characteristic of helium that renders it highly advantageous for use in this application is that helium, being a monatomic gas, has a relatively high gamma coefficient, i.e., a relatively high ratio of specific heat at constant pressure to specific heat at constant volume, as compared to the gamma coefficient of polyatomic gases. For example, the gamma coefficient for a monatomic gas such as helium is 1.67 as compared to 1.4 for diatomic gases. This relatively high gamma coefficient renders helium exceptionally advantageous as a filler for my capsule inasmuch as a given decrease in volume of the capsule produces a relatively large increase in the pressure of the gas within the capsule. Thus, by using helium, a higher spring gradient can be obtained than with polyatomic gases, and this is especially advantageous where the available motion of the generally-fixed contact is small.

Another characteristic of helium that renders it highly advantageous for use in this application is its high thermal conductivity. Because of such high thermal conductivity, the helium can be relied upon to facilitate heat transfer from the contact structure **17** to the upper end cap **12** via a path extending from the lower end of the capsule **30** to the upper end. In addition, the helium because of its high thermal conductivity helps to cool the parts within the bellows and to transfer heat from such parts to the upper end cap **32** at a relatively high rate in comparison to that available with most other gases. The combination of these two properties renders helium, or a gaseous mixture containing helium exceptionally well-suited for use as a filler for my capsule **30**.

Any suitable lubricant, such as graphite, which is capable of withstanding the usual high bake-out temperatures without decomposition can be used for the guide bearing **40**. Because such lubricant is located within a gaseous atmosphere instead of in the vacuum, there is no danger of any loose particles therefrom contaminating the vacuum and interfering with circuit interruption.

Although not shown, it is to be understood that a suitable vapor-condensing shield is provided between the arcing gap and the insulating housing **11** to protect the surfaces thereof from the deposition of arc-liberated metallic particles thereon. For a detailed example of such a shield, reference may be had to application S.N. 630,247, Crouch, now Patent No. 2,892,911, assigned to the assignee of the present invention.

One type of interrupter in which my resilient mounting can be used to particular advantage is an interrupter including a plurality of breaks connected either in series or parallel. An interrupter of this type having parallel-connected breaks is shown schematically in FIG. 3, where each of the generally stationary contacts **17** is shown mounted by means of a resilient mounting S corresponding to the mounting S of FIGS. 1 and 2. Any desired number of such breakers with corresponding stationary contact arrangements can, of course, be utilized inside a suitable envelope. Utilizing my spring mountings S contributes to a much simpler overall construction than could be attained if the stationary contacts were resiliently mounted by means of springs individual to each stationary contact located outside the envelope. Such an external spring arrangement would require a separate bellows of the type shown at **20** for each stationary contact, and this would involve numerous complications. In the arrangement of FIG. 3, the movable contacts **18** are mounted on a common reciprocable support **60** for moving them jointly either into or out of engagement with the contacts **17** through the movable operating rod **18***a*. The resilient mountings S serve the various functions described hereinabove in connection with FIGS. 1 and 2 and also serve to maintain the desired contact pressures in spite of uneven contact-wear or erosion.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects and I, therefore, intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A vacuum-type circuit interrupter comprising means defining a vacuum chamber, a pair of separable contacts disposed within said chamber, means for moving one of said contacts into and out of engagement with the other of said contacts comprising a movable contact actuating member connected to said one contact and disposed at least partially within said vacuum chamber, supporting structure for said other contact disposed within said vacuum chamber, means within said vacuum chamber for resiliently mounting said other contact on said supporting structure comprising a sealed gas-filled capsule having flexible metallic walls permitting compression of the gas within said capsule, said capsule being disposed between said supporting structure and said other contact in such a manner that the gas within said capsule is compressed by closing motion of said one contact after initial engagement with said other contact, said compressed gas providing a force acting in a direction to hold said contacts in engagement, the surfaces of said interrupter that are ex-

posed to the vacuum within said vacuum chamber being substantially free of adsorbed gases.

2. A vacuum-type circuit interrupter comprising means defining a vacuum chamber, a pair of separable contacts disposed within said chamber and arranged for relative movement into and out of engagement with each other, supporting structure for one of said contacts disposed within said chamber, means within said chamber for resiliently mounting said one contact on said supporting structure comprising a sealed gas-filled capsule having flexible metallic walls permitting compression of the gas within said capsule, said capsule being disposed between said supporting structure and said one contact in such a manner that said gas is compressed by contact-closing motion of said contacts after initial contact-engagement is established and acting thereafter to resist contact separation, the surfaces of said interrupter that are exposed to the vacuum within said vacuum chamber being substantially free of adsorbed gases.

3. The vacuum-type circuit interrupter of claim 2 in combination with guide means for guiding said one contact during movement thereof while said two contacts are engaged, said guide means including surfaces slidable on each other and located within said gas-filled capsule.

4. The vacuum-type circuit interrupter of claim 2 in combination with flexible conductive braid electrically interconnecting said one contact and said supporting structure and disposed within said gas-filled capsule.

5. The vacuum-type circuit interrupter of claim 2 in combination with guide means for guiding said one contact during movement thereof, said guide means including surfaces slidable on each other and located within said gas-filled capsule, and flexible conductive braid electrically interconnecting said one contact and said supporting structure and disposed within said gas-filled capsule.

6. The interrupter of claim 2 in which the gas within said capsule comprises a monatomic gas having a high thermal conductivity in comparison to air.

7. The interrupter of claim 2 in which the gas within said capsule comprises helium.

8. The interrupter of claim 2 in which said capsule is a self-contained assembly filled with gas to a predetermined pressure and sealed prior to its incorporation into said interrupter.

9. A vacuum-type circuit interrupter comprising means defining a vacuum chamber, a pair of separable contacts disposed within said chamber and arranged for relative movement into and out of engagement with each other, supporting structure for one of said contacts disposed within said chamber, means within said chamber for resiliently mounting said one contact on said supporting structure comprising a sealed gas-filled capsule; said capsule comprising a tubular metallic bellows providing flexible walls for permitting compression of the gas within said capsule and a pair of end structures disposed at longitudinally-opposite ends of said bellows and joined in sealed relationship to said bellows; means for causing the gas within said capsule to be compressed by contact-closing motion occurring after initial contact-engagement is established comprising fastening means for securing one of the capsule end structures to said supporting structure and the other of said capsule end structures to said one contact, said compressed gas acting during contact-engagement to resist contact-separation, the surfaces of said interrupter that are exposed to the vacuum within said vacuum chamber being substantially free of adsorbed gases.

10. A vacuum-type circuit interrupter comprising means defining a vacuum chamber, a pair of separable contacts disposed within said chamber and arranged for relative movement into and out of engagement with each other, supporting structure on which one of said contacts is resiliently mounted for relative movement with respect to said supporting structure, a sealed gas-filled capsule having flexible metallic walls disposed within said chamber, guide means located within said capsule for frictionally guiding said one contact during movement thereof relative to said supporting structure, the walls of said capsule flexing during movement of said one contact relative to said supporting structure, the surfaces of said interrupter that are exposed to the vacuum within said vacuum chamber being substantially free of adsorbed gases.

11. The vacuum-type circuit interrupter of claim 10 in combination with flexible conductive braid electrically interconnecting said one contact and said supporting structure and disposed within said gas-filled capsule.

12. In the vacuum type circuit interrupter of claim 2, an additional pair of separable contacts disposed within said chamber, and means for resiliently mounting one contact of said additional pair comprising a second sealed gas-filled capsule disposed within said chamber and having flexible metallic walls permitting compression of the gas therewithin, said second capsule being so disposed that said gas is compressed by contact-closing motion of said additional contacts after initial contact-engagement is established and acting thereafter to resist contact-separation.

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