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VACUUM-TYPE CIRCUIT INTERRUPTER

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Fig. 1.

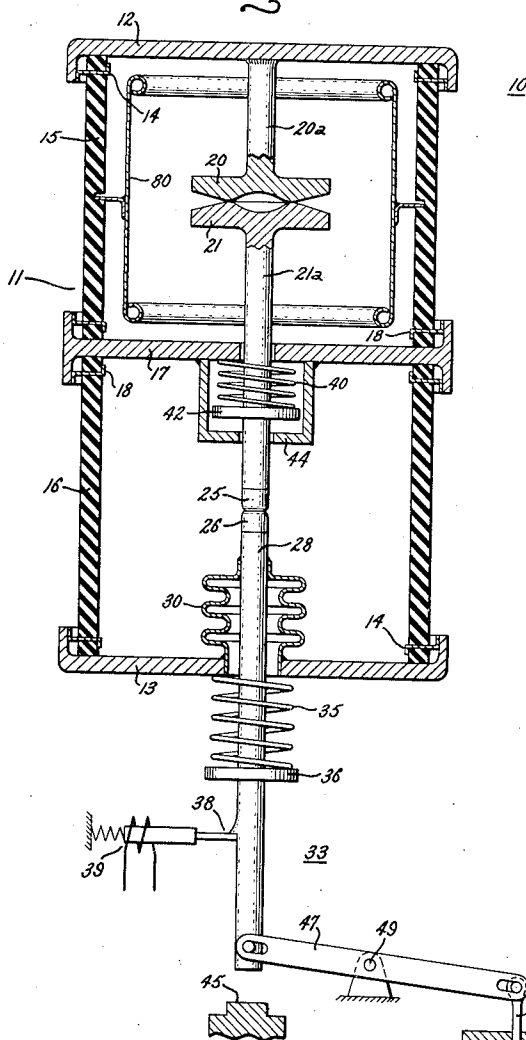
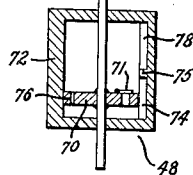
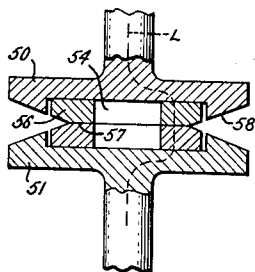


Fig. 2.



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VACUUM-TYPE CIRCUIT INTERRUPTER
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This invention relates to a vacuum-type circuit interrupter and, more particularly, to a vacuum-type circuit interrupter that is capable of successfully interrupting very high currents, has little tendency to chop during low current interruptions, and has a high withstand voltage rating.

The current-interrupting capacity of a vacuum-type circuit interrupter depends to a large extent upon the nature of the interrupter's contact materials. In this regard, interrupters with contacts made of copper or silver are capable of interrupting much larger amounts of current than interrupters having contacts of the highly refractory metals such as tungsten and molybdenum. For example, a pair of simple butt contacts of copper can interrupt at least two and a half times as much current as a pair of tungsten butt contacts under corresponding voltage conditions.

In addition to their poor current-interrupting capacity, the highly refractory metals exhibit rather poor performance from a current-chopping viewpoint. By current-chopping is meant the tendency during interruption to force the current to zero abruptly and prematurely before a natural current zero is reached. This abrupt change in current which accompanies chopping induces across any device in the circuit a voltage equal to $I_0 Z$, where I_0 is the chopping current in amperes and Z is the surge impedance of the device in ohms. The surge impedance for inductive devices is usually quite high, e.g., on the order of thousands of ohms and even higher, and thus the over-voltages that can be generated in an inductive circuit by relatively small chopping currents of only, say, ten amperes, are usually excessive. Under high current interrupting conditions, little or no chopping occurs. But under low current interruptions, e.g., less than fifty amperes, materials such as tungsten and molybdenum ordinarily have chopping levels substantially greater than ten amperes and, thus, are not generally usable in inductive circuits. Examples of contact materials superior from a chopping viewpoint and capable of consistently holding the maximum chopping level to a value of four amperes are tin, antimony, lead, zinc, bismuth, and suitable alloys thereof. Copper and silver have representative maximum chopping levels of about six or seven amperes and are therefore considerably better than tungsten and molybdenum from a chopping viewpoint. By "representative maximum" chopping level is meant the maximum current level to which chopping will consistently be held by contaminant-free contacts of the particular material in question under low current interrupting conditions.

A disadvantage involved in using most of the metals that have superior current-chopping characteristics and high current-interrupting capacities is that the withstand, or breakdown, voltage between spaced contacts of these materials is not as high as might be desired, particularly if the interrupter is so designed that the gap between the fully-open contacts is quite short. With regard to this withstand voltage, it is not unusual for industry standards to require that an interrupter have an impulse withstand rating of six or seven times the R.M.S. value of the normal circuit voltage and a low frequency withstand rating of more than three times this R.M.S. value. For example, industry standards require that the impulse withstand rating of a 14.4 kv. interrupter be at least 110 kv. and that the low frequency withstand rating be at least

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50 kv. By its "impulse withstand rating" is meant its ability to withstand a sharply rising voltage pulse of standard wave form having a peak value corresponding to the impulse withstand rating. The low frequency withstand rating is determined by the R.M.S. value of the 60 cycle voltage that the interrupter can withstand.

It is therefore an object of my invention to provide a vacuum-type interrupter which is capable of successfully interrupting higher values of current than can be interrupted with corresponding interrupters having their contacts made of highly refractory materials and yet is capable of withstanding voltages higher than those that can be withstood by comparable prior interrupters having their contacts formed of materials suitable for high current interruptions.

Another object is to provide an interrupter which has little tendency to chop during low current interruptions and yet is capable of withstanding voltages much higher than those that can be withstood by interrupters having all their contacts formed of materials that are superior from a chopping viewpoint.

Another object is to provide for increased voltage-withstand ability in an interrupter that has its interrupting contacts formed of materials that are superior from both a high current-interrupting capacity viewpoint and a chopping viewpoint.

Still another object is to construct the interrupter in such a manner that it has this high voltage-withstand ability across its contacts from a time commencing at an exceptionally short interval after interruption.

In carrying out my invention in one form, I provide evacuated housing means and a first set of separable contacts disposed within the housing means. Also disposed within the housing means, I provide a second set of separable contacts that is connected in series with the first set of contacts and is mechanically isolated from any arcing products generated at said first set of contacts. Means is provided for separating the two sets of contacts in sequential relationship during an opening operation, with parting of the second set being delayed until from one to three electrical cycles after said first set parts. The first set of contacts has arcing regions formed at least in part of a conductive material having a lower maximum representative current-chopping level than the material of the second set, and the material of said second set has a higher voltage-withstand ability than the material of said first set. In addition, the material of said first set on which high current arcs are interrupted has a higher current-interrupting capacity than the material of said second set.

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

FIG. 1 is a cross-sectional view through a vacuum-type circuit interrupter embodying one form of my invention.

FIG. 2 shows a modified form of contact structure for use in the interrupter of FIG. 1.

Referring now to FIG. 1, there is shown a highly-evacuated envelope 10 comprising a cylindrical casing 11 and a pair of metallic end caps 12 and 13 closing off the ends on the casing 11. Suitable seals 14 are provided between the end caps and the casing to render the envelope vacuum-tight. The casing 11 is shown as comprising a pair of aligned cylinders 15 and 16 of suitable insulating material and a transverse metallic plate 17 disposed between the adjacent ends of the insulating cylinders 15 and 16. Suitable seals 18 are disposed between the ends of the insulating cylinders and the plate 17 in order to prevent leakage in this region. Pressure within the envelope 10 under static conditions is preferably below 10^{-4} mm. of mercury.

Located within the envelope 10 above the transverse

plate 17 is a pair of separable disc-shaped contacts 20 and 21 shown in their engaged or closed position. The upper contact 20 is a stationary contact suitably secured to a conductive rod 20a, which at its upper end is united to the upper end cap 12. The lower contact 21 is a movable contact conductively joined to a conductive intermediate rod 21a which is slidably mounted in a suitable guide opening in the transverse plate 17 so as to be capable of limited motion in a vertical direction.

Connected in series circuit relationship with the upper pair of contacts 20, 21 is a second pair of contacts 25, 26 located within the envelope 10 below the transverse plate 17. The upper contact 25 of this pair is carried by the lower end of the conductive intermediate rod 21a and is conductively joined thereto. The lower contact 26 is conductively joined to a conductive operating rod 28 which is suitably mounted for vertical movement. The operating rod 28 projects through an opening in the lower end cap 13, and a flexible metallic bellows 30 provides a seal about the rod 28 to allow for vertical movement of the rod without impairing the vacuum inside the envelope 10. As shown in FIG. 1, the bellows is sealingly secured at its respective opposite ends to the operating rod 28 and the lower end cap 13.

Coupled to the lower end of the operating rod 28 I provide suitable switch-opening means which is shown in schematic form at 33. This opening means 33 comprises a compression-type opening spring 35 disposed between the lower end cap 13 and a shoulder 36 on the operating rod 28 and also a latch schematically shown at 38 holding both sets of contacts closed against the bias of the opening spring 35. When the latch 38 is released, as by suitable electromagnetic means 39, the spring 35 quickly expands to drive the operating rod 28 in a downward switch-opening direction. The speed of this switch-opening movement is controlled by suitable speed-governing means such as a liquid-filled dashpot 48 having its usual piston 70 coupled to the operating rod 28 through a lever 47 pivoted on a stationary pivot 49. The operation and purpose of this dashpot will soon be explained in greater detail.

For producing separation of the upper contacts 20 and 21 in response to this downward switch-opening motion of the operating rod 28, a suitable compression spring 40 is disposed between the transverse plate 17 and a shoulder 42 integral with the intermediate rod 21a. When the operating rod 28 moves downward, this compression spring 40 drives the intermediate rod 21a downwardly in follow-up relationship to the operating rod 28, thereby separating the upper contacts 20 and 21 but maintaining the lower contacts 25, 26 engaged until the shoulder 42 encounters a suitable stop 44 carried by the transverse plate 17. Engagement between the stop 44 and the shoulder 42 terminates the opening stroke of contact 21 and also enables continued downward movement of the operating rod to separate the lower contact 26 from its mating contact 25. For reasons which will soon be explained, the stop 44 is so positioned that the contacts 25 and 26 do not part until about one electrical cycle after the upper contacts 20 and 21 first part. When the lower contact 26 has separated a predetermined distance from its mating contact 25, downward movement of the operating rod 28 is terminated by a suitable stop schematically indicated at 45, and the opening operation is thus completed.

Closing of the interrupter is effected by returning the operating rod 28 from its lower fully-open position to its upper closed position of FIG. 1 by closing force applied in a suitable manner (not shown) to the actuating lever 47. Such upward motion of the operating rod 28 first produces engagement between the lower contacts 25 and 26 and then drives the contact 21 upwardly into engagement with the contact 20 while compressing the spring 40. When the contacts 20 and 21 have engaged, the latch 38 becomes operative to hold the parts of the interrupter in the fully-closed position of FIG. 1. During closing mo-

tion of the operating rod 28, the dashpot piston 70 is driven downwardly from a position at the top of its cylinder to the position shown in FIG. 1. Such movement can take place without significant retardation from the liquid above the piston 70 because of a large check valve 71 provided in the piston 70 to allow liquid to flow freely from the lower to the upper surface of the piston during downward movement thereof. Thus, the dashpot 48 does not interfere with closing at the desired speed.

The disc-shaped contacts 20 and 21 are formed of a material having a high current-interrupting capacity, such as copper or silver. By employing such materials, my interrupter is capable of interrupting far greater amounts of current than could be interrupted with identical contacts formed of highly refractory materials such as molybdenum or tungsten, which are presently the more commonly used vacuum-switch contact materials. As an illustration of the superior current-interrupting capacity of these materials, I have found that a pair of copper butt contacts can interrupt at least two and a half times as much current as corresponding tungsten contacts under corresponding voltage conditions.

Copper, silver, and other non-refractory metals are also far superior to the highly refractory metals from a current-chopping viewpoint. For example, under low current interrupting conditions, e.g., less than 50 amperes, copper and silver have maximum representative current chopping levels of only about six or seven amperes, whereas tungsten and molybdenum have chopping levels far over ten amperes and sometimes even as high as 40 amperes.

A disadvantage involved in using most of the metals that have superior current chopping characteristics and high current interrupting capacities is that the withstand voltage between spaced-apart contacts of these materials is not as high as might be desired. This is particularly the case if the gap between the fully-open contacts is very short. To enable such materials to be used for my contacts 20 and 21 even though there might be a very short gap between the contacts 20 and 21, I rely upon a second gap, series-connected with respect to the first inter-contact gap, and established between contacts made from one or more materials having very high withstand-voltage characteristics, such as tungsten or molybdenum. This second gap is the gap that is established between the lower set of contacts 25 and 26 following interruption of the circuit at the gap between the contacts 20 and 21. The stop 44 of my interrupter is so positioned that this second gap is not established until the usual arc at the first gap is extinguished. This arc ordinarily will be extinguished at the first current zero following its initiation (i.e., within one-half cycle), but in certain cases, such as in the interruption of asymmetrical currents, it might persist for as much as a full cycle. Thus, to insure that the gap between the contacts 25 and 26 is established only after the arc in the first gap is extinguished, I delay separation of the contacts 25, 26 until at least one cycle after the first set of contacts 20, 21 part. Separation should occur as soon as possible after expiration of this one cycle period, and in a preferred embodiment of my invention, I initiate separation of the contacts 25, 26 between one and two cycles after the upper contacts 20 and 21 first part.

This delay in separation of the lower contacts 25, 26 is effected by reliance upon the dashpot 48. This dashpot 48 is shown as comprising a piston 70 that is suitably coupled to the lever 47 through a piston rod 73 and is slidably mounted for reciprocation in a dashpot cylinder 72. A first large groove 74 in the internal wall of the lower portion of cylinder 72 allows the piston to move rapidly upward during initial contact-opening movement of the movable interrupting contact 20 without significant retardation from the liquid in the dashpot. After the desired length of gap is established between the interrupting contacts 20 and 21, the dashpot piston 70 enters a portion 75 of the cylinder 72 that is ungrooved. In this un-

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grooved region, the cylinder wall blocks free flow of liquid about the periphery of the piston 70, and as a result, continued upward movement of the piston 70 is retarded until the piston 70 passes beyond the ungrooved portion of the cylinder. During this interval the upward speed of the dashpot piston 70 is controlled by the rate at which liquid can be forced through a small metering passage 76 in the dashpot piston 70. Once the ungrooved portion 75 of the cylinder is passed, upward movement of the piston at high speed is resumed by reason of a second large groove 78 in the upper portion of the internal cylinder wall that allows liquid to flow freely around the dashpot piston.

The stop 44 for the intermediate contact structure 21, 21a is so arranged that it blocks further downward movement of the contact 21 after the high speed upward movement of the dashpot piston 70 has been resumed, thus allowing the contacts 25 and 26 to separate at high speed. The ungrooved portion 75 of the cylinder 72 is so positioned that retardation of the dashpot piston 70 and, hence, the contact 21 does not occur until after the desired gap length is established between the contacts 20 and 21. Moreover, the ungrooved portion of the cylinder 72 is of such a length that it delays separation of the contacts 25 and 26 until between one and two electrical cycles have elapsed after the interrupting contacts 20 and 21 first part. As was pointed out hereinabove, this delay provides a reasonable assurance that the arc between contacts 20 and 21 is extinguished before the lower contacts 25 and 26 part.

The reason that I delay separation of the contacts 25 and 26 until after there is reasonable assurance that the arc between the contacts 20 and 21 is extinguished is to avoid any arcing between the contacts 25 and 26. In this regard, if these contacts are made of a highly refractory material such as tungsten or molybdenum, then any arcing therebetween during low current interruptions would produce excessive current-chopping. Since no arcing takes place between these refractory contacts 25 and 26, then separation thereof can produce no chopping.

The reason that I prefer to separate the contacts 25 and 26 within two, or in some cases three, cycles after the contacts 20 and 21 part is to avoid any delay in attaining the tremendously-increased dielectric strength resulting from the establishment of the series-connected refractory gap between contacts 25 and 26. In this particular regard, it sometimes happens that an interrupter is subjected to a series of closely successive high voltage impulses, e.g., as a result of multiple lightning strokes. Should one of these impulses be applied to my interrupter even two cycles following interruption, it would be much less likely to cause a breakdown across the interrupter's contacts in view of the presence of the extremely high dielectric strength gap that would then have been established between the refractory contacts 25 and 26.

Timing the opening of contacts 25 and 26 in such a manner that there is no arcing therebetween is an important factor in rendering my interrupter capable of successfully meeting very high withstand-voltage requirements even after an extensive number of operations. In this regard, an important determinant of the amount of voltage that can be withstood between a pair of spaced electrodes in a vacuum is the roughness of the surface of the electrodes; such roughness tending to lower the withstand-voltage. Arcing tends to roughen the electrode surfaces, and thus by preventing or at least minimizing any arcing across the contacts 25, 26, I am able to prevent any substantial impairment of the dielectric strength by roughening due to arcing.

The property of a metal that appears to be most predominant in determining the voltage at which a breakdown between electrodes of such metal will occur is its modulus of elasticity in tension, i.e., Young's modulus. The highly refractory metals such as tungsten and molybdenum have very high values of Young's modulus, e.g.,

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about 60×10^6 p.s.i. for tungsten and about 50×10^6 p.s.i. for molybdenum. For iron and most steels, which are less refractory metals than tungsten and molybdenum, the Young's modulus is about 29×10^6 p.s.i. Nickel, which has about the same melting point as iron, has about the same Young's modulus as iron. Copper, which has a lower melting point than iron and nickel, has a Young's modulus of about 16×10^6 p.s.i. Aluminum, which has a lower melting point than copper, has a Young's modulus of about 10×10^6 p.s.i. Static and impulse breakdown tests run with electrodes of these materials in a vacuum have shown that the breakdown voltage is highest for the metals with the highest Young's moduli, is lowest for the metals with the lowest Young's moduli, and is in an intermediate range for the metals having intermediate values of Young's modulus. Considering these particular metals only, there is also a correlation between breakdown voltage and the melting point of the metals in that the more refractory are these metals, the higher is their breakdown voltage. This correlation between melting point and breakdown voltage is not as exact as the correlation between Young's modulus and breakdown voltage and is subject to some exceptions but can be used as a rough guide in selecting electrode materials for parts such as 25, 26 of my interrupter.

In the hereinabove description of the disc contacts 20 and 21 each contact has been referred to as being of a single metal, such as, for example, copper or silver. It is to be understood, however, that the present invention is not limited to an arrangement where contacts such as 20 and 21 are of a single metal. It is equally applicable to an arrangement where each of the contacts is constructed from components made of differing metals. FIG. 2 illustrates a cooperating pair of such contacts designated 50 and 51. These contacts 50 and 51 correspond to contacts described and claimed in application Serial No. 769,215, Lee and Schneider, filed October 23, 1958, and assigned to the assignee of the present invention, and their details form no part of the present invention. The contacts will, however, be briefly described to facilitate an understanding of the present invention. Each of these contacts 50 and 51 comprises a disc provided with a centrally located recess 54 in its surface that faces the other contact. Surrounding this recess 54 is an annular ring 56 integrally united with the remainder of the contact by suitable brazed joint. Part of the exposed surface of the ring 56 serves as a contact making area 57 and the remainder as an arc-running surface. The exposed surface 58 of the remainder of the disc also serves as an arc-running surface. When the contacts 50 and 51 are separated, an arc is initiated on the contact-making surfaces 57, and its terminals are then driven radially outward toward the outer periphery of the disc-contact by the magnetic forces resulting from the loop-shape configuration of the current path L. These magnetic forces are insufficient to drive low current arcs off the rings 56, and thus, such arcs are interrupted on the rings 56. For higher current arcs, the magnetic forces are higher and such arcs are therefore driven off the rings 56 and on to the surfaces 58 where they are extinguished near the outer peripheries of the discs 50 and 51.

The rings 56 are formed from a high vapor pressure, low thermal conductivity material that is capable of consistently holding the vacuum chopping level to a very low value, for example, no higher than four amperes. Examples of metals capable of holding the current chopping level to such a value are bismuth, antimony, indium tin, and suitable alloys thereof. Thus, interrupting low currents on the rings 56 results in the chopping currents being held to no higher than four amperes. The outer arc-running surfaces 58 of the disc contacts are formed of a metal such as copper or silver more suited to high current interruptions. Although these metals have higher chopping levels than four amperes when interrupting low currents, this is not objectionable since all low current arcs

are interrupted on the rings 56. The high current arcs that are interrupted on the arc-running surfaces produce no significant chopping because of their high current content.

The high vapor pressure, low thermal conductivity metals of which I prefer to form the rings 56 generally have rather poor voltage-withstand ability in comparison to the copper, silver, or other high current interrupting capacity material which I prefer to use for the remainder of the disc contacts. Thus, any breakdown across the separated contacts 50 and 51 would be most likely to initiate from the rings 56 rather than from the remainder of the contacts. When the contacts 50 and 51 are used in the interrupter of FIG. 1, very substantial improvements in the voltage withstand ability of the interrupter can be realized even if the secondary contacts 25 and 26 are constructed of copper, iron, or nickel. Still greater improvements can, of course, be realized if the contacts 25 and 26 are constructed of highly refractory materials such as tungsten or molybdenum.

Application Serial No. 750,784—Lee et al., filed July 24, 1958, now Patent No. 2,975,256 issued March 14, 1961 and assigned to the assignee of the present invention, sets forth certain criteria which can be utilized for selecting an appropriate material for the annulus 56. For example, it is pointed out in the Lee et al. application that the chopping-current level can consistently be held to no more than four amperes if the material of the arcing region (1) has a low chemical affinity for oxygen in comparison to that of aluminum, magnesium, and calcium (2) is free of sorbed gases and contaminants, and (3) comprises a metal having a vapor pressure at least equal to that of tin at temperatures exceeding 2000° K. and a thermal conductivity less than that of copper and silver if the metal is one having characteristic vapor pressures generally equalling or lower than those of silver for given temperatures.

It is unnecessary that the material be composed entirely of a metal meeting the above requirements. An alloy or mixture containing such a metal is adequate providing the metal is present in sufficient proportions and is distributed sufficiently uniformly to consistently hold the current-chopping level to the acceptable maximum value, which in the assumed case is four amperes.

If the maximum permissible chopping level is lower than four amperes and is as low as say, two amperes, then acceptable chopping performance can be obtained by utilizing for the arcing region a material which meets all of the above-requirements and which in addition contains as its high vapor pressure metal constituent a metal having characteristic vapor pressures at least as great as those of lead. If this high vapor pressure metal is combined or alloyed with some other metal, the high vapor pressure metal should be present in sufficient proportions to consistently hold the current-chopping level to the acceptable maximum value, which in this assumed case is two amperes.

Preferably the disc-shaped contacts of FIGS. 1 and 2 are provided with slots (not shown) of a generally spiral configuration extending from their outer peripheries inward. A slotted construction of this nature is shown and claimed in application Serial No. 730,413—Schneider, filed April 23, 1958, now Patent No. 2,949,520 issued Aug. 16, 1960 and assigned to the assignee of the present invention. When an arc is driven onto an arc-running surface slotted in the above-described manner, the presence of the slots results in the establishment of circumferentially acting magnetic forces. These circumferentially acting forces drive the arc in a circumferential direction about the periphery of the discs, and this facilitates extinguishing the arc.

It is to be understood that, in constructing the disclosed vacuum interrupter, the various parts inside the vacuum envelope should be freed of sorbed gases and other contaminants sufficiently to avoid harmful impair-

ment of the vacuum by any such gases or contaminants during operation of the interrupter. Conventional vacuum processing techniques can be used for attaining this desired result.

For protecting the insulation of a vacuum-type circuit interrupter from becoming coated by metallic particles liberated from the contacts by arcing, it is customary to provide a vapor-condensed shield between the arcing gap of the interrupter and the protected insulated surfaces. Such a shield is shown in the interrupter of FIG. 1 at 80. This shield comprises a metallic tube surrounding the arcing gap and electrically isolated from both contacts. The tube 80 is suitably supported on the upper cylinder 15.

The transverse plate 17 excludes arc-generated metallic vapors from the lower chamber and thus the high dielectric strength of the lower chamber is not impaired by any such vapors or by the condensation of any such vapors on the parts of the lower chamber. In some cases, it might also be desirable to provide the lower chamber with a shield corresponding to that of the upper shield so as to protect the insulation of the lower chamber from any arc which might possibly be established therein. If such a shield is used, it should preferably be formed of a transparent insulating material that would permit the position of the contacts 25, 26 to be observed from outside the interrupter, assuming that the tube 16 is also transparent.

In the disclosed embodiment of my invention, the two sets of contacts are shown in a single evacuated envelope. It is to be understood, however, that the present invention can equally well be embodied in an interrupter wherein each set of contacts is in a separate evacuated envelope. In this regard, the disclosed interrupter could be so modified simply by placing a suitable bellows about the intermediate rod 21a and using the transverse plate 17 to effect complete isolation between the chambers on opposite sides of the bellows.

While I have shown and described particular embodiments 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 for interrupting alternating current comprising highly-evacuated housing means, a first set of separable contacts disposed within said housing means, a second set of separable contacts disposed within said housing means, means for mechanically isolating said second set of contacts from products generated by arcing across said first set, means for connecting said first and second sets of contacts in series-circuit relationship, means for separating said sets of contacts in sequential relationship during an opening operation, means effective during an opening operation for delaying parting of said second set until circuit interruption is normally completed at said first set and until the expiration of at least substantially one cycle of said alternating current after said first set parts, the contacts of said first set having arcing regions formed at least in part of a conductive material having a lower maximum representative chopping current than the material of said second set of contacts, the material of said second set of contacts having a higher voltage-withstand ability than said material of said first set.

2. The interrupter of claim 1 in which the material of said second set of contacts has a higher Young's modulus than that of said material of said first set.

3. A vacuum-type circuit interrupter for interrupting alternating current comprising highly-evacuated housing means, a first set of separable contacts disposed within said housing means, a second set of separable contacts

disposed within said housing means, means for mechanically isolating said second set of contacts from products generated by arcing across said first set, means for connecting said first and second sets of contacts in series-circuit relationship, means for separating said sets of contacts in sequential relationship during an opening operation, means effective during an opening operation for delaying parting of said second set until circuit interruption is normally completed at said first set and until the expiration of at least substantially one cycle of said alternating current after said first set parts, the contacts of said first set having arcing regions formed of a material having a higher current interrupting capacity than the material of said second set of contacts, the material of said second set of contacts having a higher voltage-withstand ability than said material of said first set of contacts.

4. The interrupter of claim 3 in which the material of said second set of contacts has a higher Young's modulus than that of said material of said first set.

5. The vacuum-type circuit interrupter of claim 3 in which the contacts of said first set have arcing regions formed at least in part of a conductive material having a lower maximum representative current-chopping level than the material of said second set of contacts.

6. A vacuum-type circuit interrupter for interrupting alternating current comprising highly-evacuated housing means, a first set of separable contacts disposed within said housing means, a second set of separable contacts disposed within said housing means, means for mechanically isolating said second set of contacts from products generated by arcing across said first set, means for connecting said first and second sets of contacts in series-circuit relationship, means for separating said sets of contacts in sequential relationship during an opening operation, said second set parting after circuit interruption is completed at said first set and during a time interval extending from substantially one to three cycles of said

alternating current after said first set parts, the contacts of said first set having arcing regions formed of a material having a higher current-interrupting capacity than the material of said second set of contacts, the material of said second set of contacts having a higher voltage-withstand ability than said material of said first set of contacts.

7. The vacuum-type circuit interrupter of claim 6 in which the contacts of said first set have arcing regions formed at least in part of a conductive material having a lower maximum representative current-chopping level than the material of said second set of contacts.

8. A vacuum-type circuit interrupter for interrupting alternating current comprising highly-evacuated housing means, a first set of separable contacts disposed within said housing means, a second set of separable contacts disposed within said housing means, means for mechanically isolating said second set of contacts from products generated by arcing across said first set, means for connecting said first and second sets of contacts in series-circuit relationship, means for separating said sets of contacts in sequential relationship during an opening operation, said second set parting after circuit interruption is completed at said first set and during a time interval extending from substantially one to three electrical cycles of said alternating current after said first set parts, the contacts of at least said first set being formed of a material having a higher current-interrupting capacity than tungsten and molybdenum.

9. The vacuum interrupter of claim 1 in which said second set of contacts parts within three cycles of said alternating current after said first set parts.

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