United States Patent

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[54] **VACUUM-TYPE CIRCUIT INTERRUPTER WITH HOLLOW CONTACTS**
6 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **200/144,** 200/166
[51] **Int. Cl.** **H01h 33/66**
[50] **Field of Search** 200/144.2, 166.8

[56] **References Cited**

UNITED STATES PATENTS

2,980,782	4/1961	Schneider	200/144(.2)
3,082,307	3/1963	Greenwood et al.	200/144(.2)
3,185,798	5/1965	Titus	200/144(.2)
3,250,880	5/1966	Jennings	200/144(.2)
3,261,954	7/1966	Yonkers	200/144(.2)
3,366,762	1/1968	Smith, Jr.	200/144(.2)

FOREIGN PATENTS

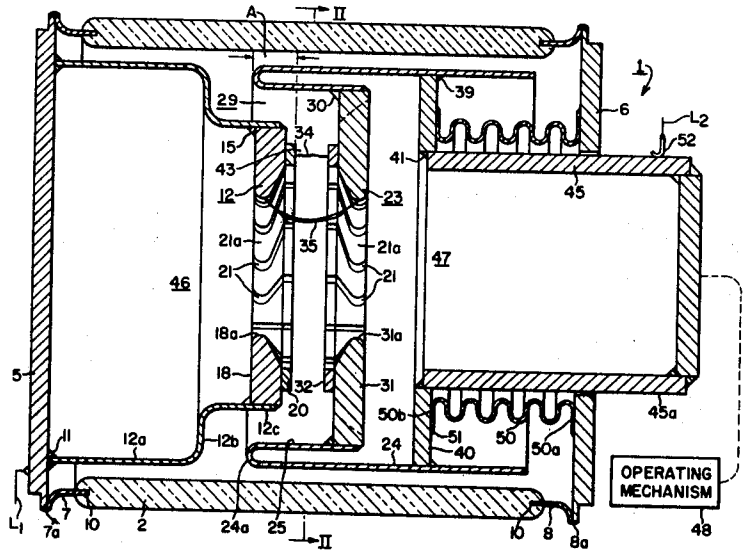
571,959	1/1958	Italy	200/144.2

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ABSTRACT: A vacuum-type circuit interrupter is provided having a pair of separable generally tubularly-shaped contacts disposed within an evacuated enclosure, and having confronting inner arcing-ring portions, with the arcing-ring portions being generally normal to the longitudinal axis of the interrupter. Preferably, the arcing-ring portions have laterally-disposed radial slots, which open into the inner periphery of the respective apertures provided by the arcing-ring portions.

Additionally, the disclosed vacuum-type circuit interrupter utilizes a nested construction, wherein one of the cooperable contacts has a reverse-bend portion to cause an overlapping relationship between the cooperable ring-shaped contacts.

Modifications include a ceramic condensing shield, insulating ribs disposed on the outer insulating casing, or a cylindrical metallic shield taken in conjunction with the aforesaid particularly-configured contact structure.



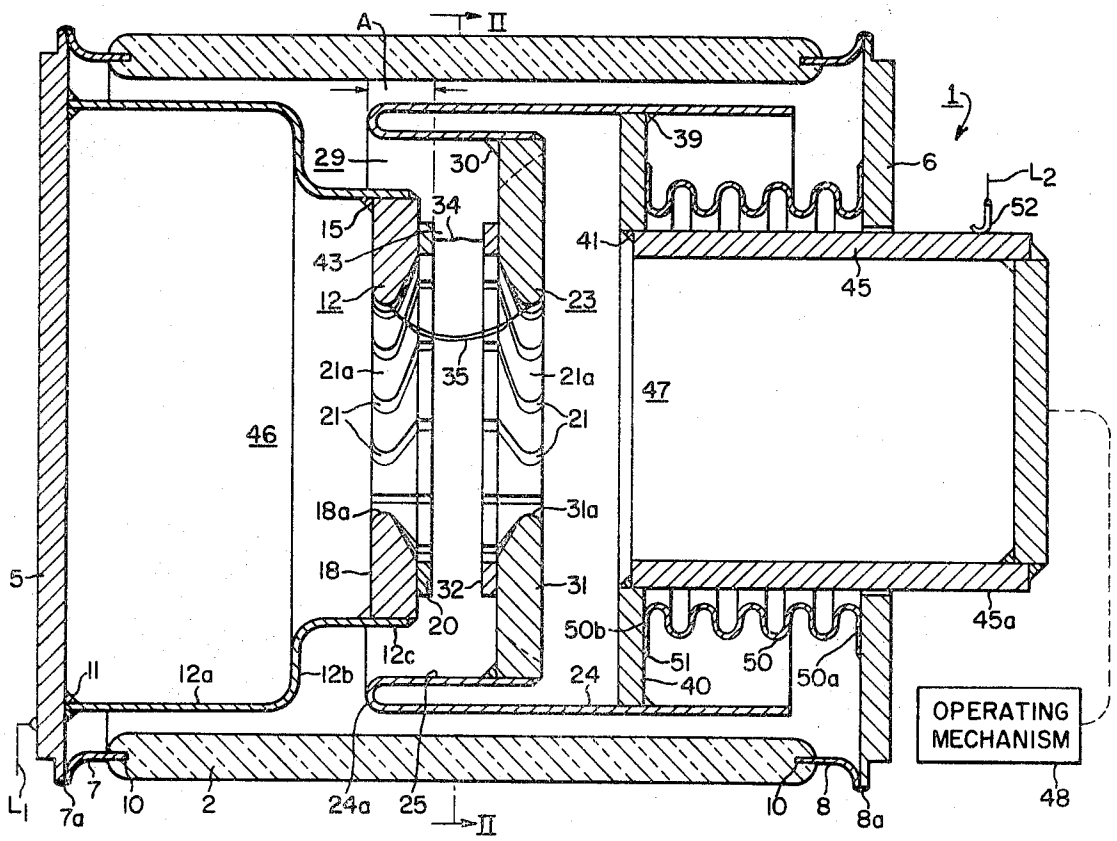


FIG. 1.

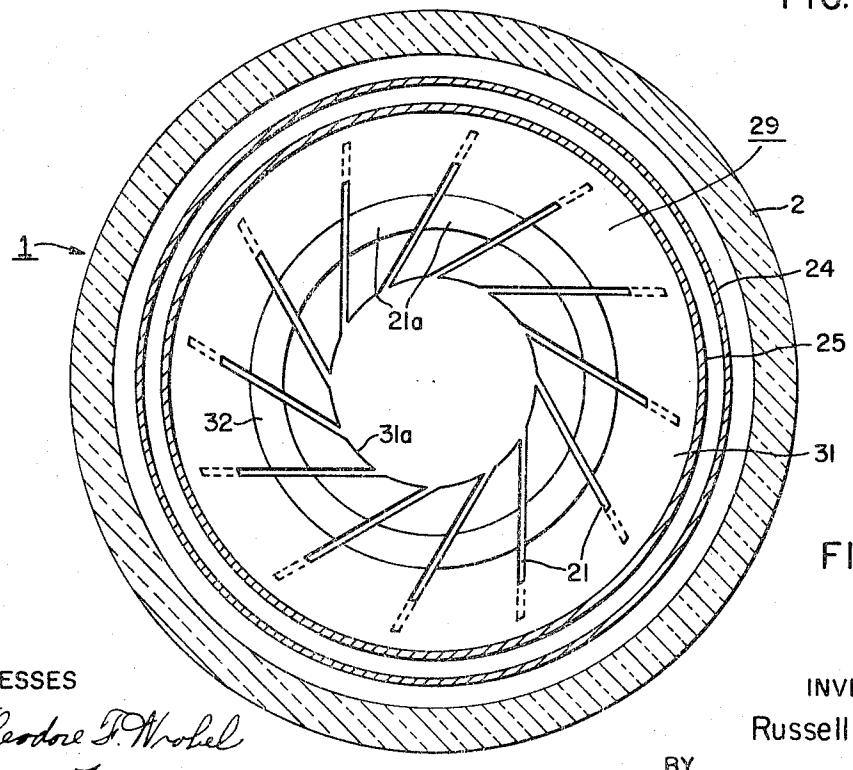


FIG. 2.

WITNESSES

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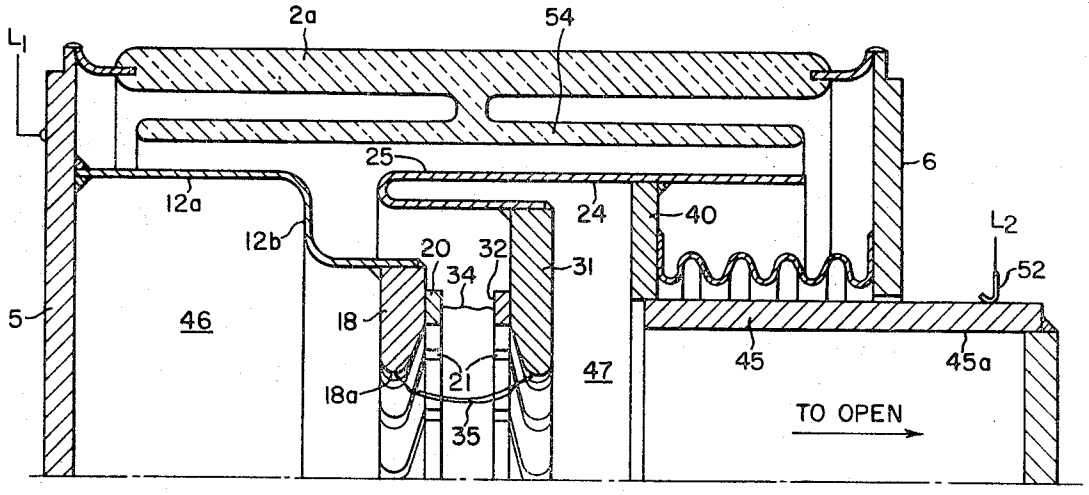
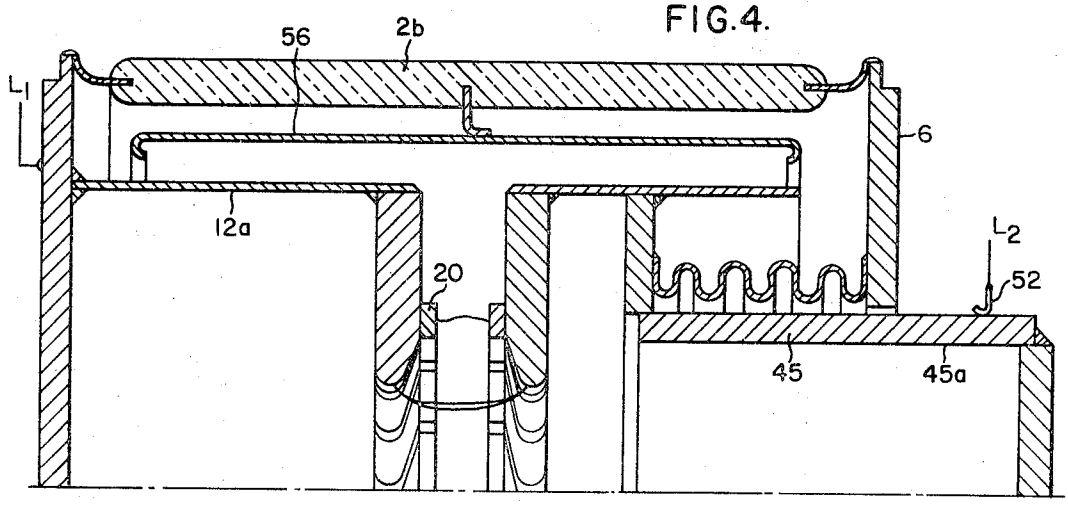


FIG.3.

FIG.4.



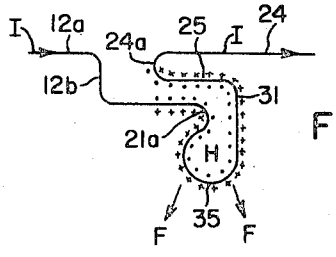


FIG.1A.

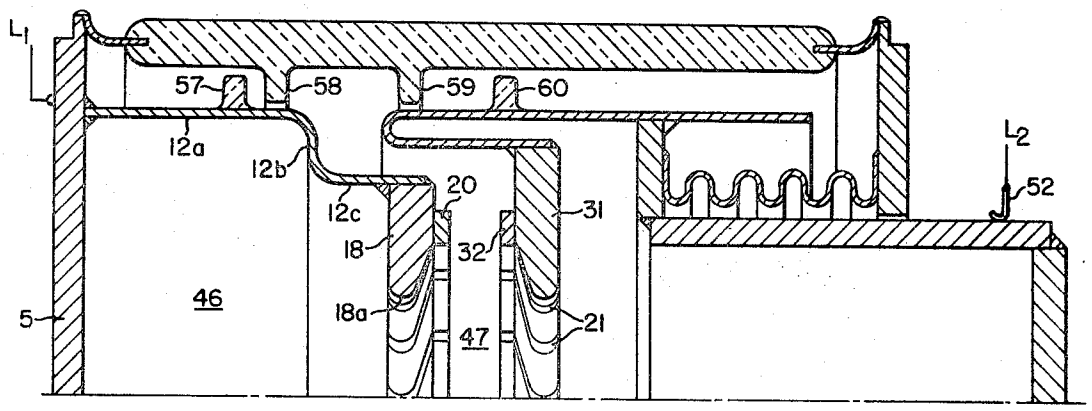

L1
57
58
59
60
12a
12b
12c
20
31
18
32
46
18a
47
21
5
L2
52

FIG.5.

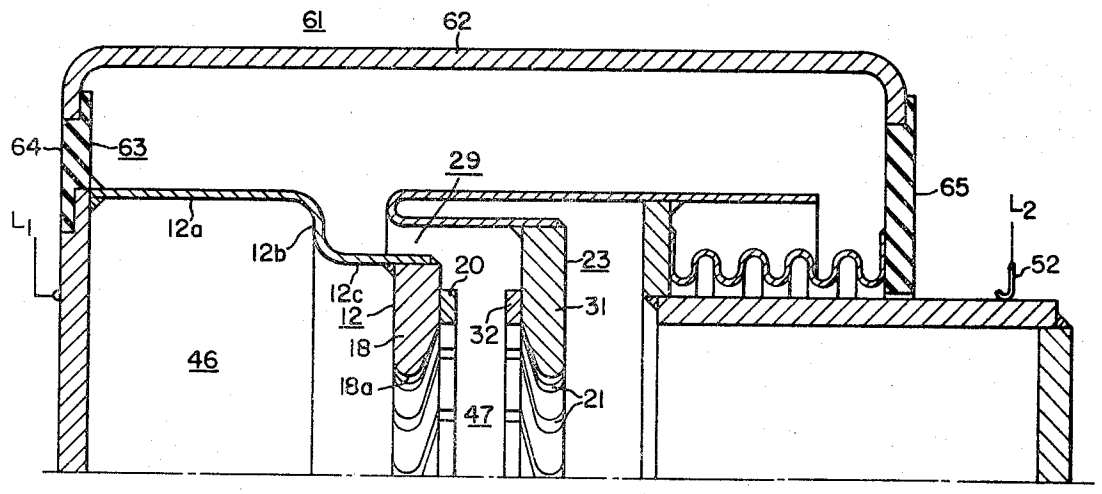

61
62
64
63
29
65
L1
12a
12b
20
23
12c
12
31
32
18
46
18a
47
21
L2
52

FIG.6.

VACUUM-TYPE CIRCUIT INTERRUPTER WITH HOLLOW CONTACTS

VACUUM-TYPE CIRCUIT INTERRUPTER WITH HOLLOW CONTACTS

This invention relates, generally, to vacuum-type circuit interrupters and, more particularly, to vacuum-type circuit interrupters having means for minimizing the condensation of vaporized metal during arcing on the surrounding insulating envelope defining the evacuated enclosure.

As well known by those skilled in the art, in the vacuum circuit-interrupter field, it has heretofore been necessary to utilize elaborate condensing shielding structure to prevent the deposition of metallic vapor emitted during arcing upon the surrounding envelope, which customarily is of insulating material, such as glass or ceramic. Accordingly, it is a general object of the present invention to provide an improved vacuum-type circuit interrupter in which such condensing shielding structure may be completely eliminated by a novel configuration of the separable contact structure, so that the magnetic interaction between the established arc and adjacent magnetic fields is such as to force the arc through apertures provided in generally hollow separable contacts to result thereby in the condensation action taking place interiorly of the separable contacts, and not ejected into the surrounding external region adjacent the circumferentially-extending insulating envelope.

Still a further object of the present invention is to provide an improved vacuum-type circuit interrupter capable of carrying relatively heavy currents, and adapted for the interruption of the same with a minimum of condensing vapors being emitted.

Still a further object of the present invention is the provision of an improved vacuum-type circuit interrupter having generally nested hollow contacts, so that the path of current flow during the opening operation is such as to set up a magnetic field to drive the established arc interiorly within the hollow cooperable separable electrode, or contact structure.

Still a further object of the present invention is the provision of an improved vacuum-type circuit interrupter in which generally nested hollow contacts are provided, in combination with means for inducing a circumferential direction of arc movement during the arcing operation.

As well known by those skilled in the art, when an alternating current is interrupted by separating the contacts in a vacuum circuit interrupter, a metallic vapor arc forms, and continues to burn until the first current-zero occurs in the alternating-current waveform. At this instant, the arc ceases, the metallic vapor deionizes, cools and condenses, and the gap presents a region of dielectric strength capable of withstanding a high recovery voltage. Most of the metallic vapor is redeposited on the contacts and is available for subsequent arcing. The remainder, although lost to the contact surfaces, collects on a shield situated so as to preserve the insulation of the switch envelope. The arcing period does not exceed one-half cycle and the arc voltage is low; the energy of the vacuum arc is, therefore, not as great as that of arcs in air break switches, and the contacts consequently suffer less damage. It is, accordingly, still a further object of the present invention to provide improved separable contact structure of generally cylindrical, or tubular configuration, in which the arc is directed to move radially inwardly into the two cavities provided by the generally tubular separable contact structure. Such a construction has considerable advantage and may be used with a minimum of shielding.

Still a further object of the present invention is the provision of improved separable contact structure of generally tubular, or cylindrical configuration utilized in a vacuum-type circuit interrupter, in which the configuration of the separable contact structure is such that a nested, or overlapping of the separable contact structure results to thereby prevent the radial outward transmission of metallic vapor particles during the interruption of the arc, which action would otherwise adversely affect the dielectric properties of the surrounding insulating envelope.

Still a further object of the present invention is the provision of an improved separable contact structure for a vacuum-type circuit interrupter in which a pair of tubular, or cylindrical separable contacts are provided with suitable slots provided in the facing portions thereof, to magnetically direct the established arc inwardly toward the cavities provided by said separable contacts, with preferably a rotative action being secured.

Still a further object of the present invention is the provision of slotted tubular separable contacts for a vacuum-type circuit interrupter in which inward movement of the established arc is thereby secured.

According to a preferred embodiment of the invention, there is provided separable contact structure including a nested pair of tubular contacts having apertures provided therethrough, with means for magnetically directing the established arc inwardly through the two apertures provided by the two separable contacts. Such action is obtained by providing a reverse bend in one of the separable contacts so that the reverse-bend portion thereof circumferentially surrounds an inwardly extending portion of the cooperable contact. By such a nested construction, radial outward travel of metallic vapor during arcing is prevented from contacting the outer insulating envelope.

Additional embodiments of the invention include partial shielding arrangements in which due to the inward magnetic travel of the arc, a minimum of metallic vapor is emitted.

Further objects and advantages will readily become apparent upon reading the following specification, taken in conjunction with the drawings, in which:

FIG. 1 is a vertical sectional view taken through a vacuum-type circuit interrupter incorporating the principles of the present invention, and the contact structure being shown in the open-circuit position;

FIG. 1A is a diagrammatic view illustrating the principles of arc movement;

FIG. 2 is a sectional view taken substantially along the line II–II of FIG. 1;

FIG. 3 is a fragmentary vertical sectional view taken through a modified-type of construction, the contact structure being illustrated in the open-circuit position;

FIG. 4 is a fragmentary vertical sectional view taken through a further modified-type of construction, again the contact structure being illustrated in the open-circuit position;

FIG. 5 is a fragmentary vertical sectional view taken through a further form of the invention, again the contact structure being illustrated in the open-circuit position; and,

FIG. 6 shows a further modified-type construction in which a metallic outer envelope is utilized, the contact structure being illustrated in the open-circuit position.

Referring to the drawings, and more particularly to FIG. 1 thereof, the reference numeral 1 generally designates a vacuum-type circuit interrupter. As shown in FIG. 1, the circuit interrupter 1 comprises an outer evacuated envelope 2 of glass, or other suitable insulating material, and a pair of metallic end plates 5, 6 disposed at opposite ends of the casing 2, and joined thereto by means of suitable flange rings 7, 8. The flange rings 7, 8 may be suitably secured, as by brazing connections 7*a*, 8*a* to the end plates 5, 6. In addition, the inner opposed ends of the flange rings 7, 8 may be suitably secured to the opposed outer ends of the ceramic casing 2 by suitable vacuum-type seals 10.

Fixedly secured, as by a brazed connection 11, to the end plate 5 is a stationary contact structure, generally designated by the reference numeral 12, and comprising a hollow stationary contact having a tubular portion 12*a*, a radially-inwardly extending portion 12*b*, and an outwardly axially-extending portion 12*c*. Fixedly secured, as by a brazing connection 15, to the inner open end of the tubular contact 12 is an apertured slotted arcing ring 18 having secured thereto, adjacent the inward side thereof, a contact ring 20. The annular arcing rings 18, 20 preferably have slots 21 provided therein to induce a circumferential travel of the established arc around the inner periphery 18*a* of the stationary contact structure 12.

Cooperable with the stationary contact structure **12**, and separable therefrom, during the opening operation, is a movable contact structure, generally designated by the reference numeral **23**, and comprising a tubular metallic member **24** having the inner end thereof **24***a* provided with a reverse bend **25**, the inner end of which has fixedly secured thereto, as by brazed connection **30**, an annular movable arcing ring **31**, which has a movable annular contact ring **32** fixedly secured thereto. As was the case with the annular rings **18, 20**, the two contiguously-mounted arcing rings **31, 32** have slanted radial slots **21** provided therein to magnetically induce circumferential rotative travel of the initially-established arc **34** during the opening operation of the vacuum interrupting device **1**. Reference may be made to the sectional view of FIG. **2** in this connection.

With further reference to FIG. **1** of the drawings, it will be observed that the axially-extending tubular portion **24** of the movable contact structure **23** has brazed thereto, as at **39**, an actuating ring **40**, the inner end of which is brazed, as at **41**, to a tubular operating member **45**. The tubular operating member **45** may be actuated by any suitable mechanism, diagrammatically represented by the reference numeral **48**.

To accommodate reciprocal movement of the operating member **45** without loss of the vacuum within envelope **2**, a bellows **50** is provided, as well understood by those skilled in the art. One end of the bellows **50***a* is secured to the end metallic plate **6**, and the other or inner extremity **50***b* of the bellows **50** is secured to the annular actuating ring **40** as by the brazed connection **51**.

From the foregoing, it will be apparent that inward closing movement of the movable contact structure **23**, as provided by actuation of the operating mechanism **48**, will cause contacting engagement between the annular slotted contact rings **20, 32** to provide a current flow through the circuit interrupter **1**. In more detail, in the closed-circuit position of the device (not shown), the current flow passes from line connection L_1 to metallic end plate **5**. tubular portion **12***a* of stationary contact structure **12**, through the arcing ring **18** and contact ring **20** to the movable arc-resisting ring **32** of the movable contact structure **23**. The circuit then extends through the annular arcing ring **31**, through the reverse bend **25**, through the axially-extending portion **24** of movable contact structure **23**, through the movable supporting ring **40** to the metallic operating member **45**. The other line connection L_2 is connected, as shown, by a suitable sliding connection **52** to the external projecting portion **45***a* of the movable operating member **45**.

During the opening operation the operating mechanism **48** functions to cause rightward opening travel of the movable contact structure **23**, as viewed in FIG. **1**, establishing an arc **34** between the arcing rings **20, 32** of arc-resisting material. Due to the travel of current flow through the reverse bend portion **25** of the movable contact structure **23**, the initially-established arc **34** will be magnetically forced inwardly to the position **35**, and rotated around the annular arcing rings **18, 31** because of the provision of the slots **21**. Arc extinction soon occurs.

FIG. **1A** is a diagrammatic view indicating the interaction between the magnetic field H and the arc current I because of the particular contact configuration of the separated contacts **12, 23** of FIG. **1**. It will be observed that the current path along the axial portion **12***a*, the radial inward portion **12***b* and one of the contact segments **21***a* is such as to create a magnetic field in a direction coming out of the plane of the paper in FIG. **1A**, and indicated by the customary arrow points. The crosses indicate, in the conventional manner, the direction of the magnetic field on the outside of the current loop **35**. As well known by those skilled in the art, the interaction between the magnetic field H and the current flow I is such as to bow, or loop the arc **35** outwardly so that it will contact the next adjacent contact projection **21***a* and, in similar manner, keep jumping from contact segment **21***a* to contact segment **21***a* around the peripheries **18***a*, **31***a* of the separated contact structure **12, 23**. As a result, rotative or circulating movement of the arc **35** is obtained around the apertures **18***a*, **31***a*. Rapid rotative movement of the arc column **35** is thus achieved with a consequent diminution of arc erosion upon the separated arcing rings **18, 31**. The foregoing is an attempt to roughly theoretically explain the magnetic interaction between the field H and the arcing current I to clarify the arc rotative action.

In a vacuum-type interrupter it is customary to provide vapor-condensing shielding to condense the metallic vapors generated by arcing. Such condensation by the shielding not only protects the insulation of the interrupter envelope from being coated, and thus impaired by the metallic particles contained in the emitted vapors, but also reduces the chances that such vapors will induce a breakdown across an electrically-stressed region of the interrupter.

In accordance with the invention, there is provided the nested contact or electrode structure **12, 23** in such a manner that it is capable of itself as serving as the primary vapor-condensing shielding structure of the vacuum interrupter **1**. In more detail, it will be noted that the arcing gap **43** is virtually surrounded by the two nested cup-shaped contacts **12, 23**, and thus most of the metallic vapors generated by arcing are intercepted by, and condensed on the internal walls of the two cup-shaped electrodes or contacts **12, 23**. As shown in FIG. **1**, the tubular separable contact structure defines first and second condensation cavities **46, 47**, on the inner walls of which vaporized metallic particles may be condensed.

The amount of current a vacuum-type interrupter can interrupt is directly dependent upon the efficiency with which the metallic vapors are condensed. The cup-shaped contacts **12, 23** are exceptionally efficient vapor condensers because they are of a relatively thick-walled construction. This relatively large wall thickness helps the cup-shaped contacts **12, 23** to remain cool and this, in turn, improves the vapor-condensing abilities of the inner walls **12***a*, **12***b*, **12***c* and **25**. Another factor that contributes to the efficiency of the cup-shaped contacts as vapor condensing shields is their previously provided high degree of freedom from sorbed gases and other gas-producing contaminants. Thus, despite bombardment of the cup-shaped contacts by the hot arcing vapors, there is little likelihood that any permanent gases will be released, or otherwise derived from the electrodes when they are acting in their shielding capacity.

Another factor that contributes to the high current interrupting capacity of the illustrated interrupter is the fact that a large percentage of the arcing vapors are forced into regions of low electric field strength. In this respect, the skirts **12***a*, **25** of the cup-shaped electrodes **12, 23** are made relatively long so that there are relatively large regions adjacent the inner surface of the cup-shaped electrodes that are only weakly stressed by the electric fields. By forcing most of the arcing vapors into these regions of low electric stress, the chances that they will trigger a dielectric breakdown after interruption at the first current zero is materially reduced.

Another important feature of the shielding in a vacuum interrupter is to prevent the arcing vapors from reaching the insulation of the interrupter so as to prevent the vapors from condensing on the insulation, and thus impairing it. The nested cup-shaped electrodes **12, 23** are interposed between the arcing region **43** of the interrupter **1** and its insulation **2**, and thus are capable of providing a substantial amount of protection for the insulation, such as the outer insulating envelope **2**. This also provides an additional third condensing chamber **29**.

As mentioned previously, when the moving contact **23** is moved to the right, as viewed in FIG. **1**, an arc **34** is established, and by the magnetic effect of the current path is driven into the apertures **18***a*, **31***a* in the separable contacts **18, 31** and may occupy a path indicated by the looped line **35**. For higher currents, where investigation has shown that a vacuum arc tends to be a number of small arcs in parallel, the magnetic pinch effect will tend to squeeze these arcs together in the center of the apertures **18***a*, **31***a*, will help to keep them located, and will assist in interruption. The metallic vapors

from the arc 35 will, as mentioned, be condensed on the walls 12*a*, 25 of the cavities 46, 47. It has been shown that the metallic particles, which comprise the arc, move in straight lines from the arc to the nearest solid surface. The nesting configuration of the tubes 12*c*, 25 intercept the particles, which are directed radially outwardly so that they do not condense on the glass tube or envelope 2 and impair its insulating properties.

The slots 21 in the arcing members 18, 31 are such as to cause the arc terminals to migrate or rotate around the apertures 18*a*, 31*a*. They are shown as simple cuts 21, but may take a spiral form, if desired. These slots 21 have another advantage besides producing arc rotation in that they provide a certain degree of flexibility and produce multiple contact points.

The advantages of the described construction utilizing the invention are numerous: (1) no metallic condensing shield is required and its cost is eliminated. Furthermore, a metallic condensing shield is also a radiation shield, and since there is no convective cooling in a vacuum, the heat in the contacts must be conducted through the terminals. With the described construction, the contacts 12, 23 can radiate their heat through the glass tube. (2) much more massive contacts are accommodated in a given volume, permitting thereby higher continuous current rating. (3) much better conductivity is afforded for a given quantity of material arranged in tubular configuration, than for the same amount of material formed into a solid rod. Also the radiating surface area for the tube is much larger.

It is a common conception that arcs tend to expand outwardly. However, circuit breakers with tubular contacts, where the arcing is confined to the space within the contacts are practical. U.S. Pat. application filed Sept. 1, 1966, Ser. No. 576,740 may be referred to in this connection.

While it is felt that a primary advantage of the described construction is the elimination of the shield, which has been a necessity of previous vacuum-type circuit interrupters, it is also believed that other features of the invention are sufficiently important to be used with modified structure employing shielding. Therefore, three possible modified arrangements are shown in FIGS. 3—6.

FIG. 3 shows a glass shield 54 which is practical since high-temperature metallic particles will not bombard it. It provides shielding for any possible escape of vaporized metallic particles from the nested contacts.

In FIG. 4 a conventional metallic shield 56 is shown. When a metallic shield 56 is used, it is not necessary to provide nesting of the tubular contact members.

FIG. 5 shows an alternate construction using glass or ceramic rings.

The aforesaid description of various modifications of the invention are given for the purpose of illustration, and can be varied over a wide range by a person skilled in the art. For instance, the member 23, shown as the moving contact, can be made the stationary contact, and cooperable contact 12 made to move. The degree of nesting A (FIG. 1) can be varied, as desired, and the location of the contact break changed to suit. Also the member shown as a glass cylinder 2 can be metallic, as illustrated in FIG. 6, and insulation provided around the incoming leads.

With particular attention being directed to the modified type of vacuum circuit interrupter illustrated in FIG. 6, and generally designated by the reference numeral 61, it will be observed that an outer metallic envelope, or casing 62 is provided. Suitable insulating means 63, such as insulating rings 64, 75, prevent a bypassing of the current around the separable contact structures 12, 23. The modified interrupting construction 61 thus enables the use of an outer metallic envelope 62 to prevent any vaporized metallic particles which will escape around the nested construction, and might otherwise adversely affect the insulating properties of the device. As a result, FIG. 6 shows how the broad principles of the nested contact construction may be applied to a variant type of vacuum circuit interrupter, where application reasons might possibly dictate the use of a metallic envelope 62 rather than a glass or ceramic envelope 2, as illustrated in FIG. 1.

From the foregoing, it will be apparent that there are many advantages to be derived from the use of the present invention. First, the usual condensing shield is eliminated by the contact configuration, which does not allow metallic particles to vaporize and condense on insulating surfaces. Secondly, the cost of the device 1 is reduces, not only by the elimination of the usual shield itself, but by additionally eliminating the mounting means for the shield, which is generally required As is obvious, only a simple single outer envelope is required in the arrangement of FIG. 1.

An additional advantage of the invention is that the elimination of the usual condensing shield results in better space utilization within the envelope 2. Also, it is a fact known to those skilled in the art that a given quantity of conducting metal formed into a tube will carry appreciably more current within a specified temperature rise than the same quantity of metal formed into a solid rod of the same length. The present invention takes full advantage of this principle.

In a vacuum-type circuit interrupter, there is no heat loss by convection, and all of the heat generated in the contacts must be either radiated or conducted outside of the envelope and dissipated. Interposing a metallic shield between the contacts and the outer envelope is a very efficient barrier to radiation, leaving only cooling by conduction. In the present invention, it will be observed that heat will radiate from the contacts through the glass envelope 2 of the interrupter in the same manner as heat from the filament of an infrared lamp radiates through the lens. The heat dissipation from the contacts would be considerable.

A very important feature of the invention is the use of hollow contact members including magnetic means to confine the arcing within the cavities 46, 47 in the contacts, and with, or without nesting, to prevent metallic vapors from diffusing outwardly.

Although there have been illustrated and described specific structures, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made therein by those skilled in the art, without departing from the spirit and scope of the invention.

I claim:

I claim:

1. A vacuum-type circuit interrupter including means defining an evacuated envelope having a casing wall, a first tubular contact defining a first interior enclosed condensing chamber therein and having an inner annular contact area disposed at one end thereof in a plane normal to the longitudinal axis of the interrupter, a second tubular contact defining a second interior enclosed condensing chamber therein and having an inner annular contact area disposed at one end thereof in a plane normal to the longitudinal axis of the interrupter, at least one of said tubular contacts being movable relative to the other contact so that the two annular contact areas make separable contacting engagement, one of said tubular contacts having a reverse-bend portion overlapping the other contact in the closed-contact position, the other cooperable tubular contact having accommodation for said reverse-bend portion by having a radially-inwardly-extending portion and a longitudinally-extending portion to cooperatively define a third condensing chamber, said first and second tubular contacts being axially alined and the third condensing chamber preventing metallic deposition on the interior casing wall of the envelope during arcing, and the reverse-bend portion creating a magnetic field during arcing to force the established arc through the annular contact areas and into the first and second condensing chambers.

2. The vacuum-type circuit interrupter of claim 1, wherein the contact areas have radial slots therein to provide a rotative motion of the established arc.

3. The combination according to claim 1, wherein the casing wall has a plurality of radially inwardly-extending ribs to inhibit longitudinal travel of ionized products of decomposition.

4. The combination according to claim 1, wherein the casing wall largely comprises a metallic cylinder having annular insulating means connecting it to one of the contacts.

5. The combination according to claim 1, wherein the casing wall has a substantially H-shaped configuration.

6. The combination according to claim 2, wherein the casing wall has a substantially H-shaped configuration and is of a ceramic material.