# United States Patent [19]

**Emmerich et al.**

[11] **3,889,080**

[45] **June 10, 1975**

[54] **VACUUM INTERRUPTER SHIELD PROTECTOR**

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[52] **U.S. Cl.** .............................................. **200/144 B**
[51] **Int. Cl.** ............................................ **H01h 33/66**
[58] **Field of Search** ................................. 200/144 B

[56] **References Cited**

UNITED STATES PATENTS

3,185,799 5/1965 Greenwood et al. ............ 200/144 B
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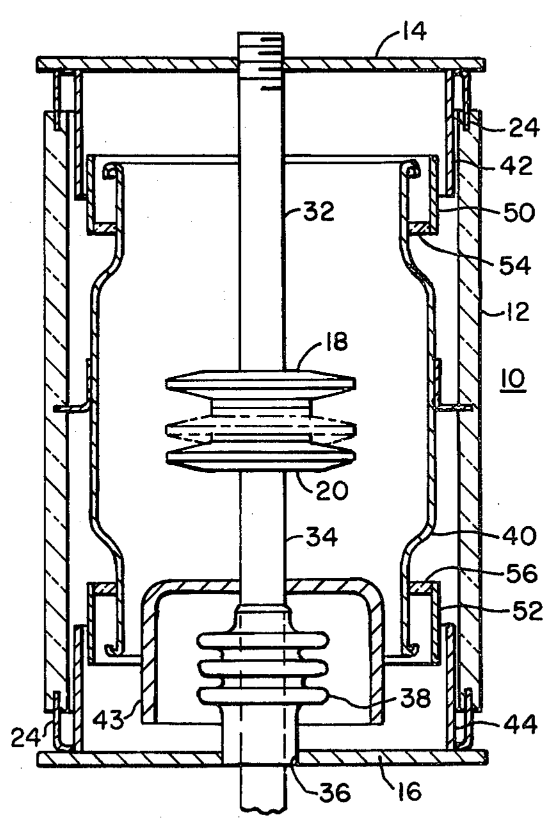
[57] **ABSTRACT**

A vacuum type circuit interrupter having a main arcing shield, surrounding the contacts, which is provided with arc inhibiting means preventing migration of the arc root along the external surface of the main arcing shield. In one embodiment of the invention an insulating coating is applied to the external surface of the main arcing shield to prevent arc movement. In another embodiment auxiliary end shields, which are supported from the main arcing shield, are disposed around the free ends of the main arcing shield preventing arc movement to the outer surface of the main arcing shield. Auxiliary end shields can either be directly attached to the main arcing shield or connected to the main arcing shield through insulating members. In another embodiment of the invention the main arcing shield, generally tubular shaped, has a circumferential groove formed around the main arcing shield near the end. This groove which can be either inwardly projecting or outwardly projecting with respect to the longitudinal axis of the vacuum interrupter limits migration of an arc from traveling along the outside surface of the main arcing shield. The various arc inhibiting means described can be used singly or in combination to restrict arc movement.

**16 Claims, 5 Drawing Figures**



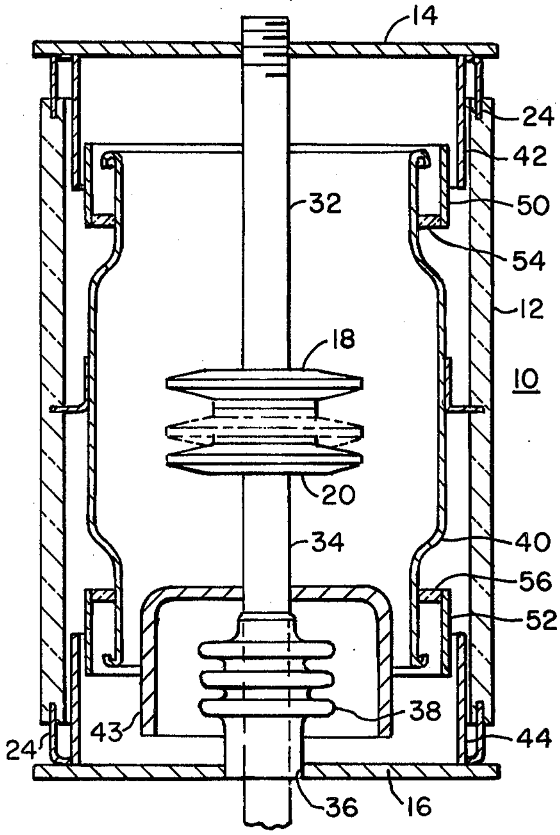



FIG. 1

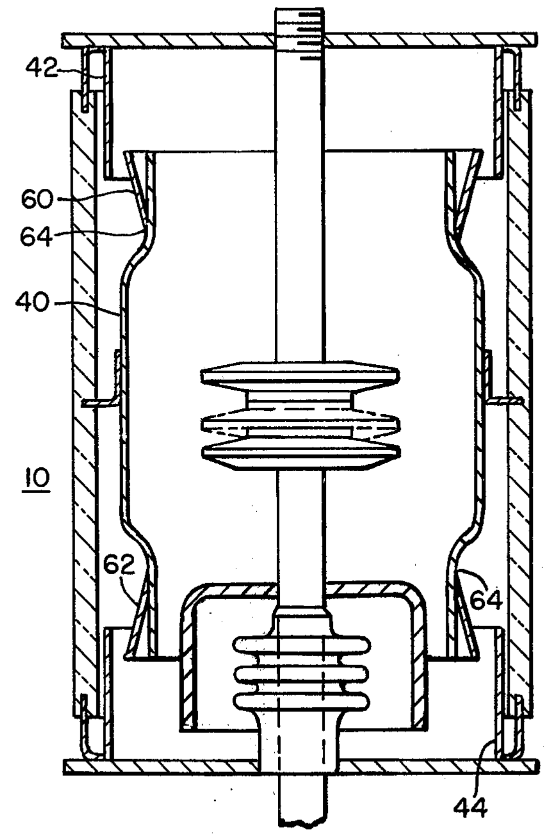



FIG. 2

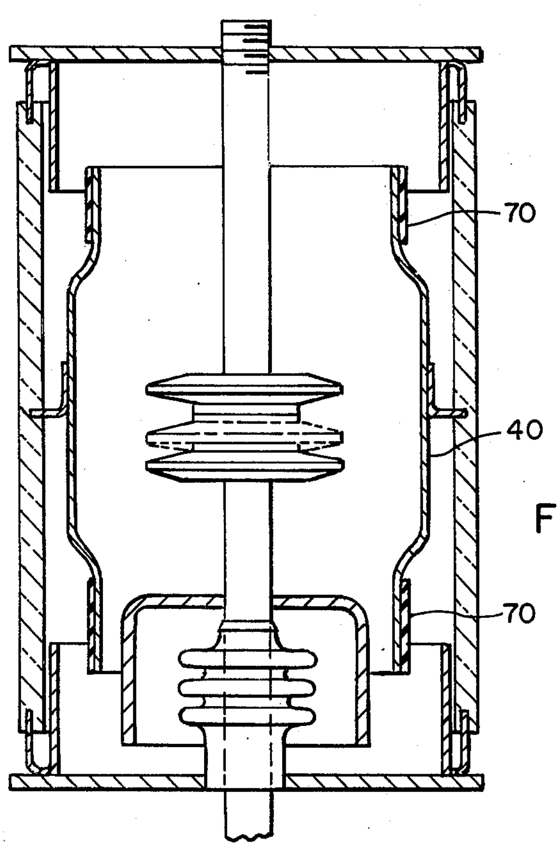



FIG. 3

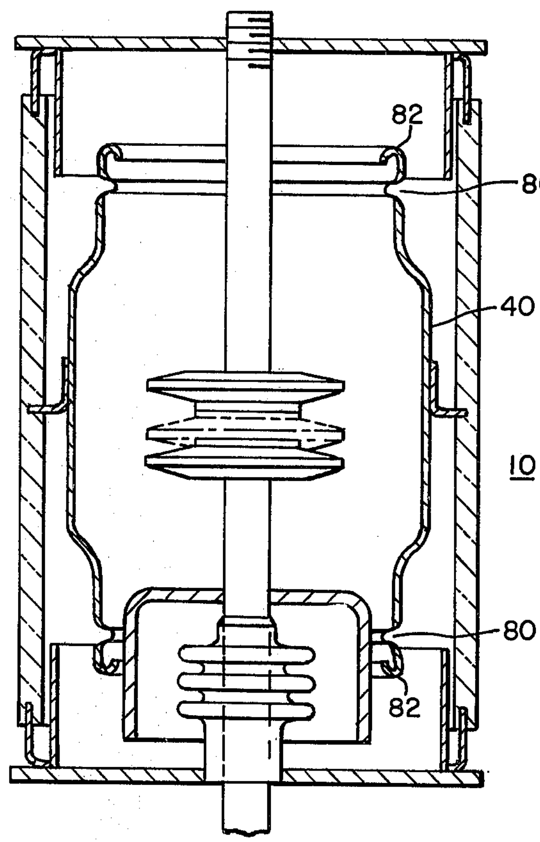



FIG. 4

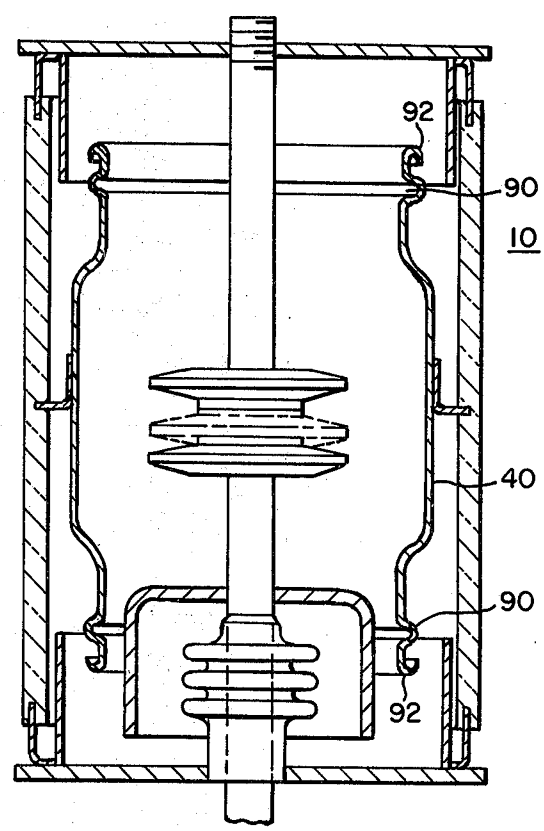



FIG. 5

# VACUUM INTERRUPTER SHIELD PROTECTOR

## BACKGROUND OF THE INVENTION

This invention relates to vacuum type circuit interrupters and more particularly to an improved construction of the main arcing shield. In the usual vacuum type circuit interrupter an envelope or housing fabricated from a suitable insulating material such as glass, ceramic or the like forms a vacuum chamber in which a pair of separable contacts or electrodes are disposed. In the closed position direct electrical connection exists between the contacts of the interrupter and a continuous current path is established through the interrupter. In the open circuit position the contacts are spaced apart forming an arcing gap and no current can flow therebetween. During operation current interruption is initiated by separating the contacts. When the contacts separate an arc is formed across the arcing gap. The arc vaporizes a portion of the metallic contact material and these particles become ionized to help sustain the arc through which current flows until a natural current zero is reached. After the current zero point has been reached, recovery voltage transients begin building up between the separated contacts. If the dielectric strength of the gap is sufficiently strong to withstand the recovery voltage transients, breakdown will not occur, the arc will not reignite and circuit interruption will be complete. If the internal insulating surfaces of the vacuum interrupter are not protected, the metallic vapors and particles formed during arcing will condense on the internal surfaces and form a metallic coating. After a number of interruptions a metallic coating will form a shorting path and cause the interrupter to fail. To protect the insulating surfaces of the vacuum interrupter it is customary to provide a main metallic shield located between the insulating surfaces and the arc formed during interruption. This main metallic shield is either fixed to one end cap of the interrupter or it is supported by the insulating wall as exemplified by U.S. Pat. No. 3,185,860. Most of the metallic vapor then condenses on the shielding surfaces before reaching the insulating surfaces of the vacuum interrupter. This shielding thus collects the particles and condenses the metallic vapor given off from the electrodes during arcing, protecting the insulating envelope or housing of the circuit interrupter.

During operation it is desirable that any arc generated during interruption should be confined to the electrode or contact and not come into contact with the metal shielding. Due to the confined space in the vacuum interrupter there is a possibility, however, that the arc will strike the shielding. The main function of the central arcing shield in the vacuum interrupter is to prevent metallic vapors from settling on the surface of the insulating envelope. However, it has been found that cathode spots formed during arcing to the shield can travel along a shield surface, surmount the edge and form a discharge on the outside of the main metallic shield, depositing a conducting layer of metal vapor on the internal surface of the insulating envelope. Past experience has shown that cathode spot traces on the outside of the central floating shield are found regularly in interrupters having a single floating shield. If the arc formed during interruption contacts this shielding it is desirable that the arc which does occur be confined to the inside of the main arcing shield surface facing away from the insulating envelope. If cathode spots travel to the outside of the main shield and these surfaces face the insulating surface of the vacuum interrupter, metal vapors sputtered from the cathode spots will be deposited on the insulating envelope and eventual interrupter failure will result.

## SUMMARY OF THE INVENTION

A vacuum type circuit interrupter comprising an insulating envelope generally tubular in shape, two metallic end caps mounted on opposite ends of the insulating envelope in sealing relationship, a stationary contact assembly, a movable contact assembly with the contact movable along the longitudinal axis of the insulating envelope into and out of engagement of the stationary contact, and a main shield having a general tubular shape and being constructed to confine any arc formed during circuit interruption to the inside of the shielding surface facing away from the insulating envelope. Pressure within the insulating envelope under normal conditions is lower than $10^{-4}$ Torr to assure that the mean free path for electron travel will be long with respect to the potential breakdown distance within the envelope.

In one embodiment of the invention auxiliary shields which are supported from the main arcing shield by an annular insulating member are provided surrounding the free ends of the main arcing shield. This construction can simulates three floating shields as exemplified by U.S. Pat. No. 3,792,214 to R. E. Voshall which has been found to be very effective in containing cathode spots within the main arcing shield.

In another embodiment auxiliary shields which are electrically connected and supported from the main arcing shield are provided surrounding the ends of the main arcing shield. The auxiliary shields can extend past the end of the arcing shield, be even with the end of the arcing shield, or be recessed from the end of the arcing shield. Such auxiliary shields will catch the vapor from the cathode spots which have traveled to the outside of the main shield. By field shaping these auxiliary shields may also prevent cathode spots from moving to the outside of the main arcing shield.

In another embodiment a portion of the outside surface of the main arcing shield is coated with an insulating material. Insulating material extends to the outside end of the main arcing shield. The insulating material can be applied in a band around the outside surface of the end of the main arcing shield only. Due to heat dissipation and ease of application a thin insulating coating is superior to a thick insulating member surrounding a portion of the main arcing shield. This insulating coating would preclude a migration of cathode spots to the outside of the main arcing shield as they will only burn on electrically conducting surfaces.

In another embodiment of the invention circumferential grooves are formed around the main arcing shield near the ends. That is, the ends of the main arcing shield are contoured to form a groove which will inhibit arc movement. The groove formed near the end of the main arcing shield can either face toward the longitudinal axis of the vacuum interrupter or away from the longitudinal axis of the vacuum interrupter. Experience with grooves on electrodes has shown them to be very effective in confining the cathode spots to a desired region of the electrode surface.

## BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention reference may be had to the preferred embodiment exemplary of the invention shown in the accompanying drawings in which:

FIG. 1 is a sectional view of a vacuum circuit interrupter comprising a main arcing shield illustrating one embodiment of the present invention;

FIG. 2 is a sectional view of a vacuum interrupter similar to FIG. 1, but with the auxiliary end shields electrically connected to the main arcing shield;

FIG. 3 is a sectional view of a vacuum interrupter having a main arcing shield utilizing another embodiment of the present invention;

FIG. 4 is a sectional view of a vacuum interrupter having a main arcing shield utilizing another embodiment of the invention; and

FIG. 5 is a sectional view of a vacuum interrupter similar to FIG. 4, but with outward projecting circumferential grooves near the ends of the main arcing shield.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings there is shown a vacuum type circuit interrupter **10**. The vacuum circuit interrupter **10** comprises a highly evacuated tubular envelope **12** formed from glass or suitable ceramic material and a pair of metallic end caps **14** and **16** closing off the end of the insulating envelope **12**. Suitable seal means **24** are provided between the end caps **14** and **16** and the insulating envelope **12** to render the inside of the insulating envelope **12** vacuum tight. The pressure within the insulating envelope **12** under normal conditions is lower than $10^{-4}$ Torr to insure that the mean free path for electrons will be longer than the potential breakdown path within the envelope **12**. Located within the insulating envelope **12** are a pair of relatively movable electrodes or contacts **18** and **20**. When the contacts **18** and **20** are separated there is formed an arcing gap there-between. The upper contact **18** is a stationary contact secured to a conducting rod **32** by suitable means such as welding or brazing. The conducting rod **32** is rigidly joined to the stationary end cap **14** by suitable means such as welding or brazing. The lower contact **20** is a movable contact and is joined to a conductive operating rod **34**. The operating rod **34** is suitably mounted for movement along the longitudinal axis of the insulating envelope **12**. The operating rod **34** projects through an opening **36** through bellows end cap **16** as shown. A metal bellows **38** is secured in sealing relationship at its respective opposite ends to the operating rods **34** and to the bellows end cap **16**. Flexible metallic bellows **38** provides a seal about the operating rod **34** to allow for movement of the operating rod **34** without impairing the vacuum within the insulating envelope **12**.

Coupled to the lower end of the operating rod **34** is a suitable actuating means (not shown) provided for driving the movable contact **20** upward into engagement with the stationary contact **18** so to close the interrupter **10**. The actuating means is also capable of returning the movable contact **20** to its open circuit position during circuit interruption.

When the contacts **18** and **20** are separated during circuit interruption an arc is formed in the arcing gap



between the contacts. The arc which is formed between contacts **18** and **20** vaporizes some of the contact material. These vapors and particles are dispersed from the arcing gap toward the insulating envelope **12**. The internal insulating surfaces of the insulating envelope **12** are protected from the condensation of the arc generated metallic vapors and paticles by means of a tubular main metallic arcing shield **40**. Shield **40** acts to intercept and to condense arc generated metallic vapors and particles before they can reach the insulating envelope **12**. To further reduce the chances for vapor or particles reaching the insulating envelope **12** by bypassing the shield **40** end cap shields **42** and **44** are provided facing the main arcing shield **40**. A cup shaped shield **43** is attached to the movable operating rod **34** and partially surrounds the flexible metallic bellows **38** to prevent the bellows **38** from being bombarded by arc generated metallic vapors or particles. The speed with which the vapors generated during arcing are removed determines the steady state operating conditions during arcing and also the recovery capability of the unit. If the vapor is not quickly removed, high voltage transients may cause the arc to reignite after it has been extinguished resulting in failure of the interrupter **10**. This embodiment is explained for a floating main shield **40**, however it is to be understood that main shield **40** could be electrically connected to end cap **14, 16** and/or mechanically supported from end cap **14, 16**.

During circuit interruption the movable contact **20** separates from the stationary contact **18** and an arc develops across the arcing gap. The arc that is formed vaporizes some of the material from the contacts **18** and **20** and the resulting metallic vapor and particles are ejected radially outward from the arcing gap, in a straight line. At times during circuit interruption the arc can contact the main arcing shield **40**. When this results it is desirable that the arc be contained to the inner facing surface of the main shield **40**. That is, it is desirable that no portion of the arc can proceed to the outside surfaces of the shield **40** which are exposed to the insulating housing **12**.

Referring now to FIG. **1** there is shown auxiliary shields **50, 52** attached to the main arcing shield **40** to prevent arcs formed during circuit interruption from migrating to the outside of the shield **40**. Shields **50** and **52** are connected to annular insulating members **54** and **56** which are attached to the main shield **40**. This construction permits auxiliary shield **50** and **52** to be physically supported from main shield **40** while being electrically insulated therefrom. Auxiliary shields **50** and **52** surround the ends of the main arcing shield **40** and project within the end cap shields **42** and **44**. Shields **50** and **52** can be of any desired circular shape. Shields **50** and **52** function to simulate a three floating shield construction as shown in U.S. Pat. No. 3,792,214.

Referring now to FIG. **2** there is shown a vacuum interrupter **10** with the main arcing shield **40** having metallic end shields **60** and **62** directly connected thereto. End shields **60** and **62** are electrically and mechanically connected to main shield **40**. Shields **60** and **62** are shown schematically like the frustum of a right circular cone with the smaller diameter portion attached to the main arcing shield **40** at point **64**. The larger diameter portions of shields **60** and **62** project beyond the ends of the main arcing shield **40** within the confines of end cap shields **42** and **44**. Auxiliary shields **60** and **62** surround the ends of the main arcing shield **40**. The auxiliary shields **60** and **62** protect the inner surface of the insulating envelope **12** if the cathode spots should migrate to the outside surface of main shield **40** between shield **60** or **62.**

Referring now to FIG. **3** there is shown another embodiment of the invention. The main shield **40** has an external insulating coating **70** applied to the outer surface. Insulating coating **70** projects to the ends of main shield **40** and surrounds at least the end portions of main shield **40.** The insulating material can be spray coated on the outer surface of main arcing shield **40.** This insulating coating **70** precludes a migration of cathode spots to the outer surface of shield **40.** A thin insulating coating bonded to the main shield is superior to an external insulating member attached to the shield, due to heat transfer properties and simplicity of application.

Referring now to FIGS. **4** and **5** there is shown a vacuum interrupter **10** wherein the main arcing shield **40** is constructed with a circumferential groove positioned near each end to prevent migration of an arc to the outside surface. In the embodiment shown in FIG. **4** the grooves **80** are disposed so that the depressed portion projects towards the longitudinal axis of vacuum interrupter **10.** The end of main shield **40** also includes a lip portion **82** which projects towards the longitudinal axis of vacuum interrupter **10.** Because of the circumferential groove **80,** cathode spots formed during circuit interruption will not travel to the outside of main arcing shield **40.**

FIG. **5** shows a vacuum interrupter **10** having a main arcing shield **40** with circumferential grooves **90** formed near the ends thereof. The depressed portion of circumferential groove **90** projects away from the longitudinal axis of the vacuum interrupter **10.** The ends of the main arcing shield **40** have a lip portion **92** which projects away from the longitudinal axis of the vacuum interrupter **10.** Circumferential grooves **90** prevent cathode spots from migrating to the outside of the main arcing shield **40.**

The main arcing shields **40** as described in this disclosure have the advantage of preventing cathod spots from migrating to the outside of the shield **40.** Therefore the possibility of depositing metal vapor on the inside walls of the insulating envelope **12** or causing other damage to the insulation is minimized. It is to be noted that the arcing control means described can be used singly or in combination to prevent an arc formed during circuit interruption from migrating to a position where metal vapors or particles can be deposited on the inside surface of insulating envelope **12.** It is understood that if the main arcing shield extends to one of the end caps, the arcing control means described refer to the free end of the shield. It is to be further understood that the various arc control means can be used singly or in combination to provide the desired arc control.

What is claimed is:

**1.** A vacuum type circuit interrupter comprising:

a tubular insulating envelope being sealed and evacuated;

a first end cap sealing one end of said tubular insulating envelope;

a second end cap sealing the other end of said tubular insulating envelope;

a stationary contact supported from said first end cap within said tubular insulating envelope;



a movable contact disposed within said insulating envelope being relatively movable with respect to said stationary contact between a closed position in engagement with said stationary contact and an open position separated from said stationary contact to form an arcing gap there-between;

a main shield generally tubular shaped partially surrounding said first contact and said second contact and being alinged with the longitudinal axis of said tubular insulating envelope; and,

said main shield being metallic and including a layer of insulating material surrounding and on at least the outside ends of said main shield.

**2.** A vacuum type structure interrupter as claimed in claim **1** including:

a first end cap shield being generally tubular shaped and connected to said first end cap and surrounding one end of said main shield; and,

a second end cap shield having a generally tubular shape and being connected to said second end cap and partially surrounding the other end of said main shield.

**3.** A vacuum type circuit interrupter as claimed in claim **1** wherein:

said main arcing shield is supported from said insulating envelope to be electrically isolated from said first end cap and said second end cap.

**4.** A vacuum type circuit interrupter as claimed in claim **1** wherein said main arcing shield is supported from said first end cap.

**5.** A vacuum type circuit interrupter comprising:

a tubular insulating envelope being sealed and highly evacuated;

a first end cap sealing one end of said tubular insulating envelope;

a second end cap sealing the other end of said tubular insulating envelope;

a stationary contact disposed within said insulating envelope and being relatively movable with respect to said stationary contact between a closed position in engagement with said stationary contact and an open position separated from said stationary contact to form an arcing gap therebetween;

a main arcing shield having a generally tubular shape partially surrounding said stationary contact and said movable contact and being aligned with the longitudinal axis of said tubular insulating envelope;

a first auxiliary shield being metallic and having a generally circular cross-sectional area connected to said main arcing shield near one end and surrounding and extending toward that end of said main arcing shield;

a second auxiliary shield being metallic and having a generally circular cross-sectional area and connected to said main shield near the end opposite said first auxiliary shield and surrounding and extending toward the opposite end of said main arcing shield.

**6.** A vacuum type circuit interrupter as claimed in claim **5** wherein said first auxiliary shield and said second auxiliary shield are shaped like frustums of a right circular cone with the inner diameter of the smaller diameter portion of the cone joined to said main arcing shield.

**7.** A vacuum type circuit interrupter as claimed in claim **5** wherein said first auxiliary shield and said second auxiliary shield extend past the end of said main arcing shield to which they are attached.

**8.** A vacuum type circuit interrupter as claimed in claim **7** including:

a first end cap shield, having a generally tubular shape, extending from said first end cap and surrounding the free end of said first end shield; and,

a second end cap shield, having a tubular shape, extending from said second end cap and surrounding the free end of said second end shield.

**9.** A vacuum type circuit interrupter as claimed in claim **5** including:

a first annular insulating member connected at the inner diameter to the main arcing shield and connected at the outer diameter to said first auxiliary shield supporting said first auxiliary shield from one end of main arcing shield; and,

a second annular insulating member connected at the inner diameter to the other end of said main arcing shield and connected at the outer diameter to said second auxiliary shield supporting said second auxiliary shield from said main arcing shield.

**10.** A vacuum type circuit interrupter as claimed in claim **9** wherein:

said first auxiliary shield and said second auxiliary shield are metallic members having a circular tubular shape; and including,

a first end cap shield having a circular tubular shape attached at one end to said first end cap and extending therefrom to surround the free end of said first auxiliary shield;

a second end cap shield having a circular tubular shape attached at one end to said second end cap extending therefrom to surround the free end of said second auxiliary shield.

**11.** A vacuum type circuit interrupter comprising:

a tubular insulating envelope being sealed and evacuated;

a stationary contact disposed in said insulating envelope;

a movable contact disposed within said insulating envelope and being relatively movable with respect to said stationary contact between a closed position in engagement with said stationary contact and an open position separated from said stationary contact to form an arcing gap there-between;

a main arcing shield having a generally tubular shape partially surrounding said stationary contact and said movable contact and being aligned with the longitudinal axis of said tubular insulating envelope; and,

said main arcing shield having a groove formed towards each free end thereof to limit arc movement.

**12.** A vacuum type circuit interrupter as claimed in claim **11** wherein:

the depressed portions of each of said grooves extends away from the longitudinal axis of said vacuum interrupter; and,

the free end of said main arcing shield have a generally lip shaped portion extending away from the longitudinal axis of said vacuum interrupter.

**13.** A vacuum interrupter as claimed in claim **12** including a first end cap shield extending from one end of said vacuum interrupter around one end of said main arcing shield; and,

a second end cap shield extending from the other end of said vacuum interrupter around the other end of said main arcing shield.

**14.** A vacuum interrupter as claimed in claim **11** wherein:

the depressed portion of each of the grooves extend toward the longitudinal axis of said vacuum interrupter; and,

the free ends of said main arcing shield have a lip shaped portion extending toward the longitudinal axis of said vacuum interrupter.

**15.** A vacuum interrupter as claimed in claim **13** including:

a first end cap shield extending from one end of said vacuum interrupter around one end of said main arcing shield; and,

a second end cap shield extending from the other end of said vacuum interrupter around the other end of said main arcing shield.

**16.** A vacuum type circuit interrupter comprising:

a tubular insulating envelope being sealed and evacuated;

a stationary contact disposed within said vacuum interrupter;

a movable contact disposed within said insulating envelope and being relatively movable with respect to said stationary contact between a closed position in engagement with said stationary contact and an open position separated from said stationary contact to form an arcing gap there-between;

a main shield having a generally tubular shape partially surrounding said first contact and said second contact and being aligned with the longitudinal axis of said tubular insulating envelope; and,

arc inhibiting means attached to and extending from said main shield in proximity to the free end of said main shield for preventing any arc formed during circuit interruption from migrating to the outside surface of the main shield facing the inner walls of said tubular insulating envelope.

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