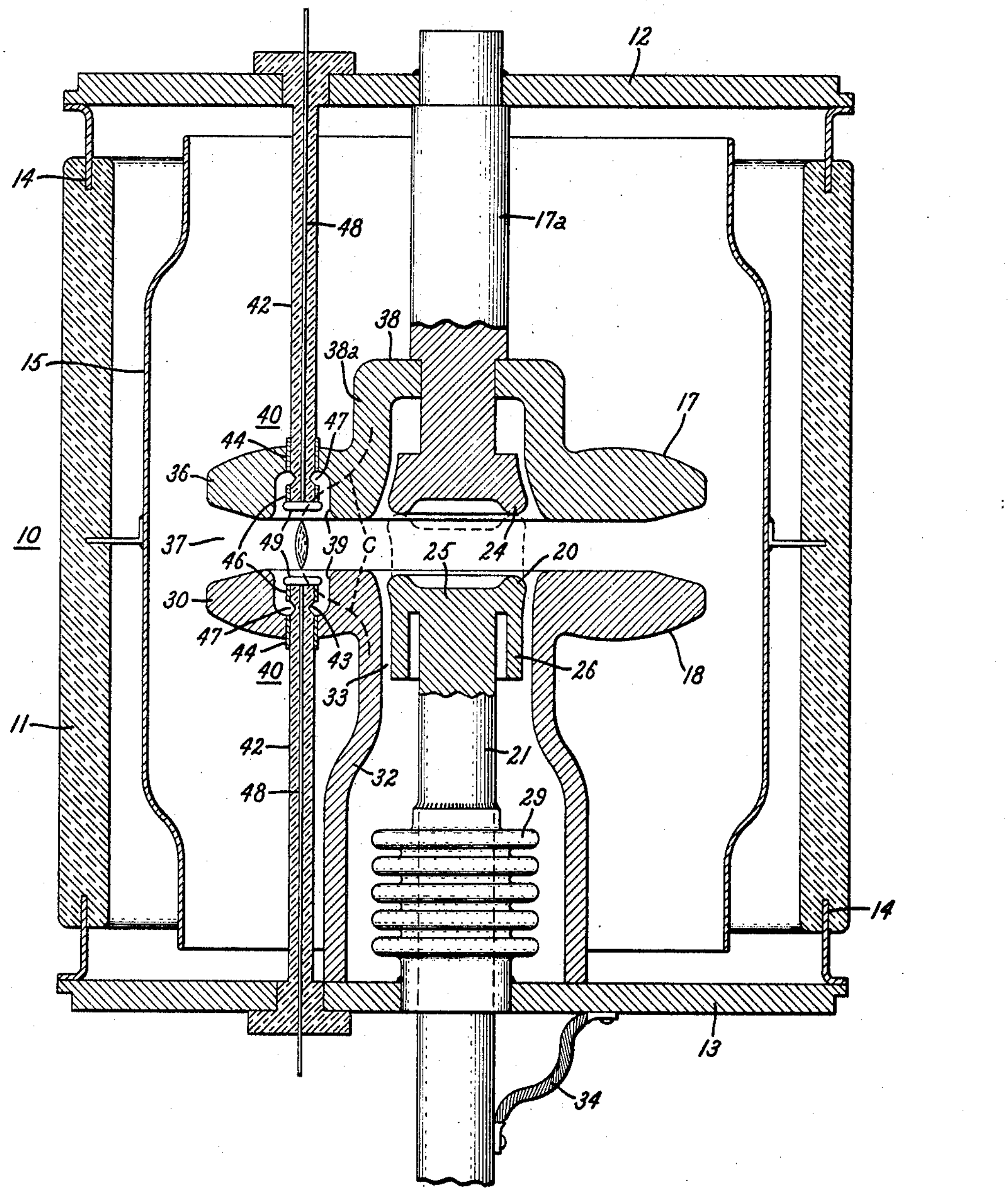
Jan. 13, 1970 D. R. KURTZ ET AL 3,489,873

TRIGGERED VACUUM TYPE CIRCUIT INTERRUPTER

Filed Nov. 6, 1967 2 Sheets-Sheet 1

Fig. 1.



INVENTORS:
DONALD R. KURTZ,
JOSEPH C. SOFIANEK

BY William Freedman
ATTORNEY

TRIGGERED VACUUM TYPE CIRCUIT INTERRUPTER

Filed Nov. 6, 1967 2 Sheets-Sheet 2

Fig. 2.

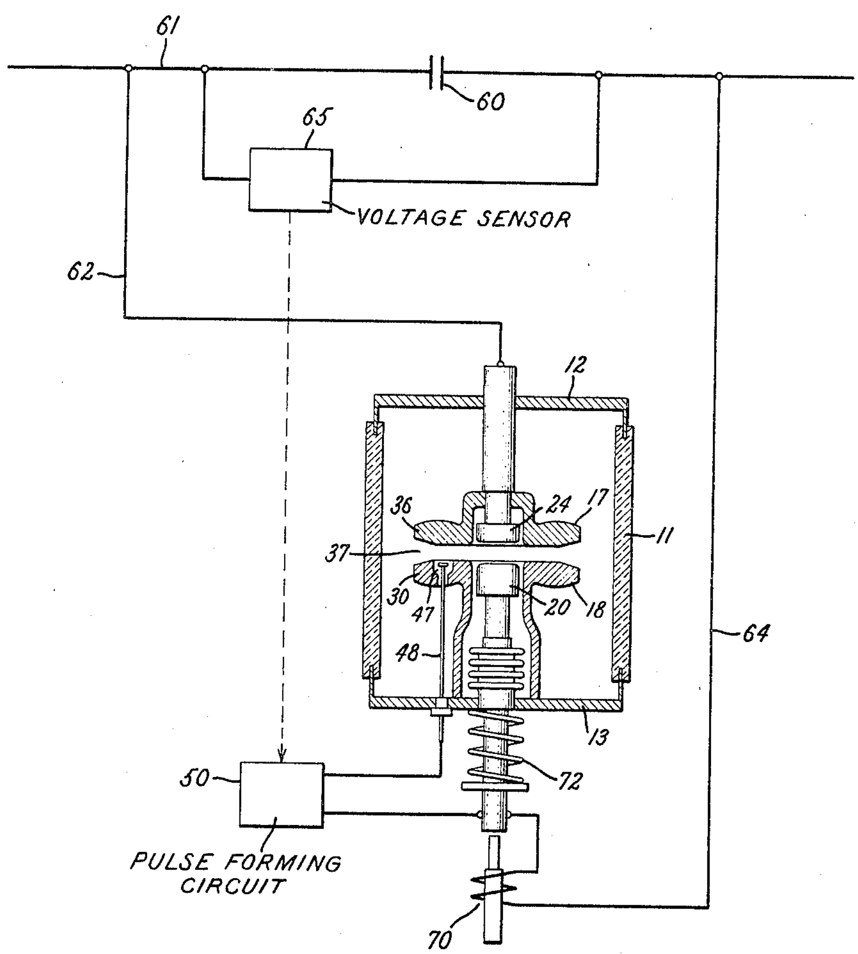
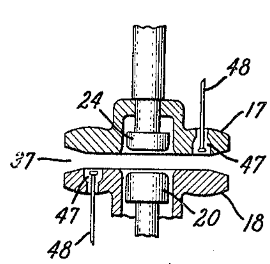


Fig. 3.



INVENTORS:
DONALD R. KURTZ,
JOSEPH C. SOFIANEK,
BY William Freedman
ATTORNEY

United States Patent Office

3,489,873
Patented Jan. 13, 1970

3,489,873
TRIGGERED VACUUM TYPE CIRCUIT INTERRUPTER

Donald R. Kurtz, Malvern, and Joseph C. Sofianek, Broomall, Pa., assignors to General Electric Company, a corporation of New York

Filed Nov. 6, 1967, Ser. No. 680,809
Int. Cl. H01h *9/30*
U.S. Cl. 200—144 10 Claims

ABSTRACT OF THE DISCLOSURE

A triggered vacuum interrupter comprising relatively movable contacts and spaced-apart, stationary annular arc-runners respectively surrounding the contacts with clearance. Triggering means is provided in one of the arc-runners in a position spaced radially outward from its associated contact for initiating an arc between the arc runners in a position spaced from the contacts, after which the contacts are driven into engagement.

This invention relates to a vacuum type circuit controller and, more particularly, a vacuum type circuit interrupter which includes triggering means for initiating an arc when the interrupter is in fully-open position.

In U.S. Patent 3,319,121—Lee, assigned to the assignee of the present invention, there is disclosed a vacuum type circuit interrupter that comprises relatively movable contacts and triggering means for initiating an arc between the contacts when they are in a spaced-apart fully open position. After the arc is initiated, the contacts are driven together to extinguish the arc and provide a solid metallic path through the interrupter for carrying the current previously carried by the arc. This is the type of closing duty that our triggered vacuum interrupter must be capable of handling.

This type of closing duty differs significantly from that imposed on the conventional vacuum type interrupter. In the conventional interrupter, closing is initiated prior to any arcing between the contacts; and any arcing that does occur during closing is initiated only when the gap is very short, for example, just prior to the contacts' engaging or during any contact-bouncing that occurs immediately following initial engagement. As a result, the arcing duration is very short, and there is little chance that the contacts of a well-designed interrupter will be damaged by the closing. But in our interrupter, arcing persists over a much longer period, occurring during the entire closing operation, and this increases the chance for impairment of the contacts.

An object of our invention is to reduce the chance for impairment of the contacts of such a triggered vacuum interrupter during a closing operation.

In carrying out our invention in one form, we provide a first contact and a second contact movable into and out of engagement therewith. A first annular arc runner surrounds the first contact and is electrically connected thereto. A second annular arc runner surrounds the second contact and is electrically connected thereto but is physically spaced therefrom by a clearance space surrounding the second contact. The annular arc runners are mounted in generally-aligned, spaced-apart relationship with a primary arcing gap therebetween. Mounted in one of the arc runners in a position located radially outward from its associated contact is means including a trigger gap for injecting a concentration of charged conduction carriers into the primary gap in response to a predetermined signal being applied across the trigger gap, thereby causing an arc to be established between the arc runners across the primary gap. After the arc is established between the arc runners, the second contact is driven into engagement with the first contact.

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

FIG. 1 is a sectional view through a triggered vacuum interrupter embodying one form of our invention.

FIG. 2 is a schematic diagram showing an application of our triggered vacuum interrupter.

FIG. 3 illustrates a modified form of the invention.

Referring now to FIG. 1, there is shown a vacuum-type circuit controller or interrupter comprising a highly evacuated sealed envelope **10**. This envelope **10** comprises a cylindrical casing **11** of insulating material and a pair of metallic end caps **12** and **13** at opposite ends of the casing **11**. Suitable seals **14** are provided between the end caps and the casing **11** to provide a vacuum-tight joint between these parts. The normal pressure within the envelope is lower than 10^{-4} mm. of mercury, so that a reasonable assurance is had that the mean free path for all electrons will be longer than the potential breakdown paths in the interrupter.

The internal insulating surfaces of the casing **11** are protected from the condensation of arc-generated metallic vapors thereon by means of a tubular metallic shield **15** suitably supported on the casing **11** and preferably isolated from both end caps **12** and **13**. This shield acts in a known manner to intercept arc-generated metallic vapors before they can reach the casing **11**.

Located within the envelope **10** is a pair of electrodes **17** and **18** shown in solid lines in FIG. 1 in their fully open position. The upper electrode **17** is a stationary electrode suitably attached to a conductive rod **17*a***, which at its upper end is united to the upper end cap **12**. The lower electrode **18** is referred to hereinafter as the movable electrode although only a portion of this lower electrode is movable. The movable portion of the lower electrode is a centrally-disposed part **20** referred to hereinafter as a movable contact. This contact **20** is suitably attached to a conductive operating rod **21**, which is suitably mounted for vertical movement along the axis of the rod **21**. In the dotted lines of FIG. 1, the movable contact **20** is shown in its uppermost position engaging a stationary contact **24** constituting a part of the stationary electrode **17**. When the contacts **20** and **24** are in this engaged position, the interrupter is closed and current can flow therethrough via the conductive rod **17*a***, stationary contact **24**, movable contact **20**, and conductive rod **21**. Downward movement of the rod **21** separates the movable contact **20** from the stationary contact **24** and thereby opens the interrupter. The position of the parts when the interrupter is fully open is depicted with solid lines in FIG. 1, where the movable contact **24** has been withdrawn from the stationary contact through its full downward opening stroke. During a closing operation, soon to be described, the movable contact **20** is driven upwardly from its solid line position of FIG. 1 to its dotted line position to reengage the contacts **20** and **24**. The operating rod **21** projects through an opening in lower end cap **13**, and a flexible metallic bellows **29** provides a seal about the rod **21** to allow for vertical motion of the rod without impairing the vacuum inside the envelope **10**. As shown in FIG. 1, the bellows **29** is secured in sealed relationship at its respective opposite ends to the operating rod **21** and the lower end cap **13**.

The movable electrode **18** comprises a stationary arc runner **30** in the form of an annular disc surrounding the movable contact **20**. This stationary arc runner **30** is mounted on the lower end cap **13** by means of a tubular conductor **32** that is secured at its opposite ends to the end cap **13** and the arc runner **30**. The joint between the tubular contact **32** and annular arc runner **30** is located at the inner periphery of the annular arc runner for reasons which will soon be explained in more detail. There is a relatively large clearance space **33** between the movable contact **20** and the annular arc runner **30** about the entire outer periphery of the movable contact **20** so as to permit free vertical movement of the movable contact within the annular arc runner **30**, as will soon appear more clearly. The movable contact **20** and the annular arc runner **30** are electrically connected together by means of a flexible braid **34** located outside of the evacuated envelope **10**.

The stationary electrode **17** also includes an annular arc runner surrounding its centrally-disposed contact portion **24**. This annular arc runner, which is designated **36**, is generally aligned with the other arc runner **30** and is spaced therefrom to provide a primary arcing gap **37** of annular configuration between the opposed faces of the arc runners. Preferably, the annular arc runner **36** is supported on the conductive rod **17***a* by means of a radially-extending integrally-formed body portion **38** that is suitably brazed at its inner periphery to the rod **17***a*. This body portion **38** has a tubular portion **38***a* that is joined to the arc runner **36** at the inner periphery of the arc runner.

In a preferred form of our invention, the movable contact **20** is of the general configuration shown and claimed in U.S. Patents 3,210,505—Porter and 3,185,799—Greenwood et al., assigned to the assignee of the present invention. As such, the contact **20** is of a cup-shaped configuration and comprises a base **25** and a tubular wall **26** that extends from the base **25** in a direction away from the location of the stationary contact **24**. When contact **20** is in its dotted-line closed position, engagement is made with the stationary contact **24** along an annular surface near the outer periphery of the contacts. As explained in the aforesaid Porter patent, the cup-shaped configuration of the movable contact **20** provides a magnetic force for driving arcs initiated on the contacts radially off the contacts. Even when the inter-contact gap is short, the tubular wall **26** provides an immediately-available conductive path along which the lower terminal of the arc can run into proximity with the lower arc runner **30** and transfer thereto.

The illustrated vacuum interrupter is a triggered vacuum interrupter and includes trigger means for initiating an arc across the primary gap **37** at a predetermined instant when the interrupter is in its fully-open position of FIG. 1. This trigger means comprises a trigger electrode assembly **40** associated with each arc runner. Each of these trigger electrode assemblies **40** can be of a conventional design, such as is shown and claimed in U.S. Patent 3,087,092—Lafferty, assigned to the assignee of the present invention. These trigger electrode assemblies are identical, and therefore only one will be described. The trigger electrode assembly associated with arc runner **30** comprises a cylindrical ceramic rod **42** extending through the end cap **13** in sealed relationship thereto and fitting into an opening in the arc runner **30**. At the upper end of the ceramic rod **42** are two thin layers **44** and **46** of metal bonded to its external surface in spaced-apart relationship. These two layers of metal constitute the electrodes of the trigger gap **47**. They are separated by a V-shaped groove **43** that extends about the circumference of the ceramic rod and has its walls defined by the ceramic material itself. One of the trigger electrodes **44** is electrically connected to arc runner **30** and the other **46** is normally electrically isolated from the arc runner **30**. The electrodes **44** and **46** can be of titanium impregnated with hydrogen.

As explained in the aforesaid Lafferty patent, a relatively low voltage pulse applied between trigger electrodes **44** and **46** will initiate a discharge across the trigger gap **47**. This discharge will evolve hydrogen from the trigger electrodes. This hydrogen will be immediately ionized by the arc and the ionized hydrogen will be rapidly propagated, or injected, into the primary gap **37**. This drastically reduces the dielectric strength of the primary gap **37** and causes it to break down in response to the voltage then prevailing between the arc runners **36** and **30**. The ionized particles that are injected into the gap are referred to hereinafter as charged conduction carriers. It will be noted that the trigger assembly is located in a recess **39** formed in the active surface of the arc runner. The arc across the primary gap is typically initiated immediately adjacent the periphery of this recess **39**.

For applying a voltage across the trigger gap, a conductive lead **48** is provided extending through a passageway in the ceramic rod **42**. At its inner end, this lead **48** is brazed to a metallic cap **49** which is in electrical contact with trigger electrode **46** and is hermetically sealed to the inner end of the ceramic rod. A suitable pulse forming circuit, such as indicated at **50** in FIG. 2, is connected between the lower conductive lead **48** and the conductive rod **21** for applying a voltage pulse between these parts and hence across the trigger gap **47** at a predetermined instant.

FIG. 2 is a schematic diagram showing our interrupter applied to protect against overvoltages in the manner disclosed and claimed in the aforesaid Lee patent. The apparatus being protected is a series capacitor **60** connected in a power line **61**, and the interrupter is connected thereacross by means of conductors **62** and **64**. When the voltage across the protected apparatus **60** reaches a predetermined level, a voltage sensor **65** turns on the pulse-forming circuit **50**, which responds by applying a voltage pulse to the trigger gap **47**. This immediately sparks over the trigger gap and thus produces an arc across the primary gap **37** of the interrupter. The arc establishes a low resistance path around the protected apparatus **60** through the interrupter and conductors **62** and **64**, thus reducing the voltage across **60**. To limit the period over which current flows through this arc in the low resistance path, the contacts of the interrupter are driven into engagement immediately following establishment of the arc. This is done by means of a solenoid **70** connected in the low resistance path. Solenoid **70** drives the operating rod **21** upwardly against a bias-open spring **72**, thereby causing the contacts **20** and **24** to engage. This extinguishes the arc and causes the continuing current to flow through the solid metallic path extending through the contacts. When the current through the contacts falls below a predetermined level, the solenoid drops out and the spring **72** reopens the contacts. On opening, the circuit controller can operate in the same manner as a conventional vacuum interrupter, drawing an arc between the contacts **20, 24** and forcing the arc radially outward, where it is extinguished at an early current zero.

As pointed out in the introductory portion of this specification, the above-described type of closing duty is more likely to impair the contacts of the interrupter than the duty associated with a typical circuit-interrupter closing operation. This is the case because in the present type of closing duty, arcing persists for a much longer period and is thus more likely to erode and overheat the contacts and to produce stronger welds between the contacts when they engage. We are able to overcome this problem by initiating our arc on the arc runners **30, 36** and not on the contacts **20, 24** themselves. In addition, after the arc is initiated, we force it radially outward away from the contacts **20, 24** thus preventing it in most cases from reaching the contacts. Thus, the contacts, when driven into engagement, have not had a long history of arcing just prior to closing impact and are thus able to withstand closing duty with less chance of impairment.

The trigger means **43–47** typically causes the arc across the main gap to be initiated immediately adjacent the mouth of the recess **39**, as was pointed out hereinabove. When the arc is in this position, there is a radially-outwardly acting magnetic force that drives the arc radially outward away from the contacts **20, 24**. This radially-outward magnetic force results from the fact that current flowing to the arc through each arc runner enters the arc runner at its radially inner periphery and thus forms a loop-shaped path of radially-outwardly bowing configuration, as indicated by the dotted line C in FIG. 1. The magnetic effect of current flowing through a path of this configuration acts, in a known manner, to expand the loop and drive the arc radially outward. Current is forced to enter the arc runner at its radially inner periphery because the tubular conductor **32** or **38***a*, as the case may be, through which all this current flows is joined to the arc runner at its inner periphery.

A factor that further reduces the chance for an arc developing between the contacts **20, 24** after initial establishment of an arc between the arc runners **30, 36** is that the arc voltage of the arc between the arc runners is quite low, and there is thus little voltage available to initiate an arc between the contacts **20, 24** while an arc is burning between the arc runners. This low arc voltage is a characteristic of a vacuum arc, and for currents as high as several thousand amperes, arc voltages of only 30 volts or less will typically be developed between copper electrodes. At much higher currents, the arc voltage typically will still be quite low, e.g., under 100 volts.

If, for some unusual reason, the arc established by operation of the trigger means **40** should be initiated between the contacts **20, 24** instead of between the arc runners **30, 36** as desired, our interrupter can still provide substantial protection against damage to the contacts. This protection is derived from the bell-shaped configuration of the movable contact, which, as noted above, provides a magnetic force for arc transfer to the arc-runner and an always-available arc-transfer surface on the exterior of the tubular portion **26** along which the arc can run and transfer to the arc runner **30**. This prompt arc transfer reduces the chance that such an arc will persist on the contact surfaces for a long period prior to closing impact.

In a vacuum interrupter, the arc across the primary gap **37** will be extinguished at each current zero; but in the illustrated arrangement the trigger gap will reinitiate it if a pulse is thereafter received from the pulse-forming circuit **50**. In the embodiment of FIG. 2, the pulse-forming circuit **50** will continue to supply pulses to the trigger gap after each current zero if the over-voltage condition persists. Each time the arc across the main gap is reinitiated, it behaves in substantially the same manner as described hereinabove.

The ability of the interrupter to handle high currents without damage can be improved by providing arc-rotating slots in the outer periphery of the arc runners; and such slots, though not shown in the drawing, are preferably provided. Reference may be had to U.S. Patent 3,211,866—Crouch et al., assigned to the assignee of the present invention, for a more detailed showing of such slots. There slots cause the arc to move in a circumferentially-extending path as it approaches the outer periphery of the arc runners.

In the schematic showing of FIG. 2, only a single trigger gap **47** is shown; but as will be apparent from FIG. 1, a trigger gap may be provided for each of the two main electrodes. These two trigger gaps may be sparked over substantially simultaneously each time the primary gap **37** is to be arced over; or the trigger gap associate only with the main electrode that happens to be the cathode at a particular instant can be sparked to arc-over the primary gap **37**. The presence of two trigger gaps operated in either of these manners provides greater assurance that operation of the trigger gap will consistently produce arc cover of the primary gap **37**.

Although FIG. 1 shows the two trigger gaps **47** as being disposed in substantially aligned relationship, we prefer to angularly offset these trigger gaps with respect to each other. Preferably, shown in FIG. 3, one trigger gap is disposed in a location in its associated arc-runner diametrically-opposed relative to the location of the other trigger gap. This widely offset relationship of the trigger gaps lessens the chance that an arc initiated by one trigger gap will have access to and will damage the trigger gap in the opposite electrode. The arc initiated by one trigger gap is free to move radially outward without passing near the other circumferentially-offset trigger gap. This offset relationship of the trigger gaps is beneficial in protecting the trigger gaps even in a fixed electrode triggered vacuum gap, such as shown, for example, in application S.N. 569,944—Gallagher, filed Aug. 3, 1966, and assigned to the assignee of the present invention.

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

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

1. A triggerable vacuum-type circuit controller comprising:

(a) a first contact and a second contact movable into and out of engagement with said first contact,

(b) a first annular arc-runner surrounding said first contact and electrically connected thereto,

(c) a second annular arc-runner surrounding said second contact, electrically connected thereto and physically spaced therefrom by a clearance space surrounding said second contact,

(d) means for mounting said annular arc-runners in generally-aligned spaced-apart relation with a primary arcing gap therebetween,

(e) a high evacuated envelope in which said contacts, arc runners, and gap are located,

(f) means including a trigger gap mounted in one of said arc-runners in a position located radially outwardly from its associated contact for injecting a concentration of charged conduction carriers into said primary gap in response to a predetermined signal being applied cross said trigger gap, thereby causing an arc to be established between said arc runners across said primary gap,

(g) and means for driving said second contact into engagement with said first contact when said arc is established between said arc runners.

2. The circuit controller of claim **1** in combination with means for forcing the net current flowing through said arc runners to the location at which substantially all arcs are initiated therebetween by operation of said trigger gap to follow a radially-outwardly bowing path in the region of said arc, whereby a radially-outward magnetic force is developed on said arc to keep it off said contacts during a closing operation.

3. The circuit controller of claim **1** in combination with means for carrying current to or from an arc on said annular arc runners compising conducting means located at the inner periphery of each of said annular runners, said conducting means being spaced radially-inwardly from the location of said trigger gap.

4. The circuit controller of claim **1** in combination with a second trigger gap mounted in the other of said arc runners in a position located radially outward from its associated contact.

5. The circuit controller of claim **1** in which said contacts are shaped to force current flowing therethrough via an arc therebetween to follow a radially-outwardly bowing loop-shaped path, thereby developing a radially-outward magnetic force on the arc.

6. The circuit controller of claim **1** in which said second contact is of a cup-shaped configuration and comprises a base engageable with said first contact and a tubular wall extending from said base in a direction away from the location of said first contact, said second annular arc runner surrounding said tubular wall and physically separated therefrom by said clearance space.

7. The circuit controller of claim **1** in combination with a second trigger gap mounted in the other of said arc runners in a position located radially outward from its associated contact, said two trigger gaps being disposed in locations widely offset from each other.

8. The circuit controller of claim **7** in which said trigger gaps are disposed in their annular arc-runners at generally diametrically-opposed locations.

9. The circuit controller of claim **7** in combination with means for forcing the net current flowing through said arc runners to the locations at which substantially all arcs are initiated therebetween by operation of said trigger gaps to follow a radially-outwardly bowing path in the region of said arcs.

10. A triggerable vacuum type circuit controller comprising:

(a) a pair of spaced-apart electrodes defining a primary gap therebetween,

(b) a pair of conductors respectively connected to said electrodes and located centrally of said electrodes for carrying current to or from the electrodes when an arc is present across said primary gap,

(c) said electrodes extending radially outward beyond the periphery of their respective conductors,

(d) means including a pair of trigger gaps mounted in the respective electrodes in positions spaced radially outward from the associated conductor for injecting a concentration of charged conduction carriers into said primary gap in response to a predetermined signal being applied across either of said trigger gaps, thereby causing an arc to be established between said electrodes,

(e) said trigger gaps being disposed in locations widely offset from each other circumferentially of said electrodes, and

(f) a highly evacuated envelope in which said electrodes and said trigger gaps are located.

References Cited

UNITED STATES PATENTS

3,211,866	10/1965	Crouch et al.	
3,323,002	5/1967	Lafferty ------------	315—36

FOREIGN PATENTS

616,849	3/1961	Canada.

ROBERT S. MACON, Primary Examiner

U.S. Cl. X.R.

313—307; 315—36; 317—11