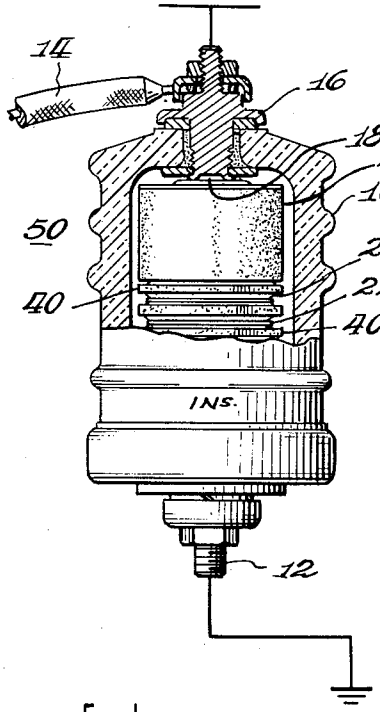
Dec. 18, 1962 F. V. CUNNINGHAM 3,069,589

SPARK-GAP ARRANGEMENT FOR LIGHTNING ARRESTERS

Filed Jan. 19, 1961 2 Sheets-Sheet 1

Fig. 1.



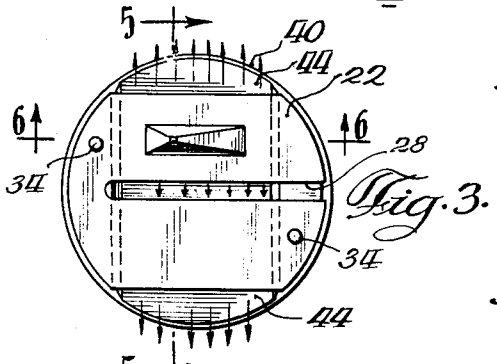


Fig. 3.

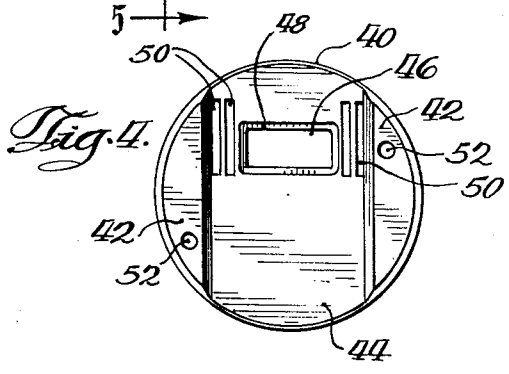


Fig. 4.

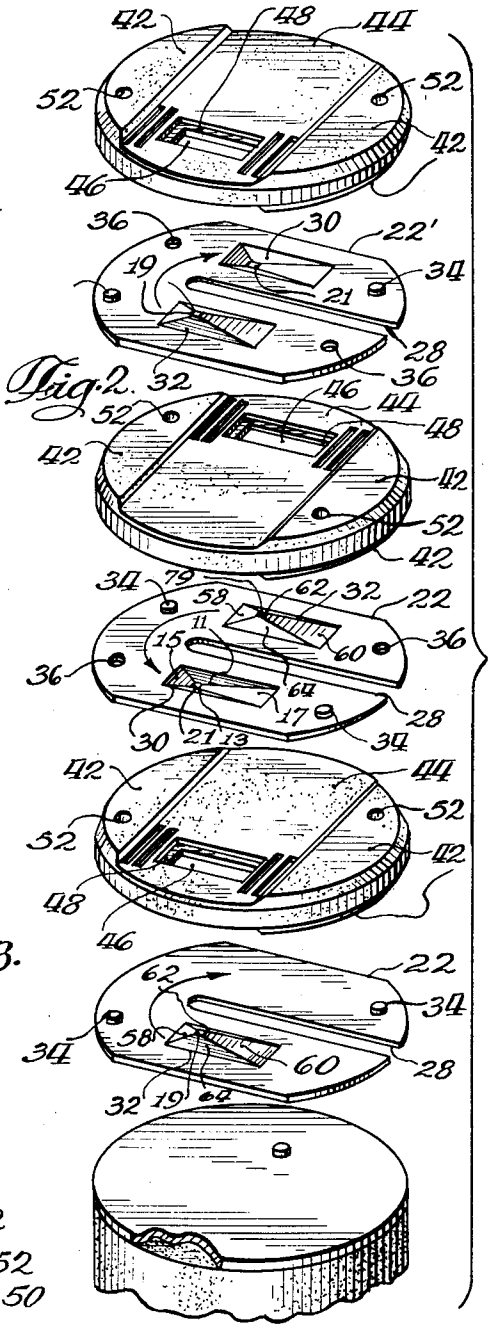


Fig. 2.

INVENTOR.
Francis V. Cunningham
BY
Byron, Hume, Gross & Clement
Attorneys

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SPARK-GAP ARRANGEMENT FOR LIGHTNING ARRESTERS

Filed Jan. 19, 1961 2 Sheets-Sheet 2

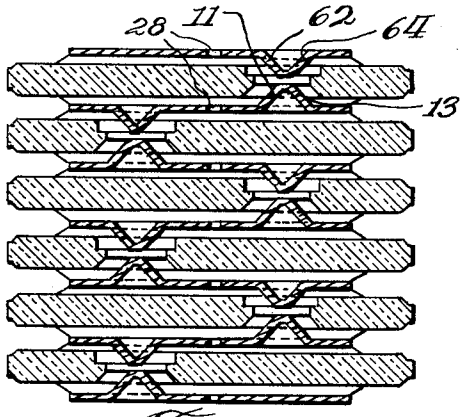


Fig. 5.

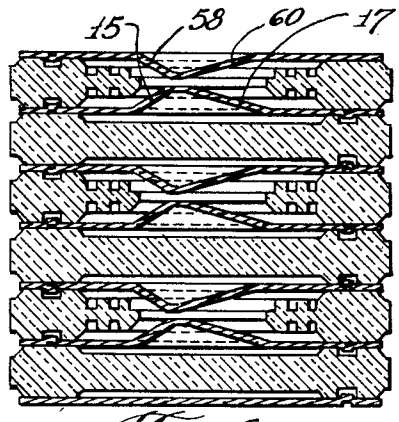


Fig. 6.

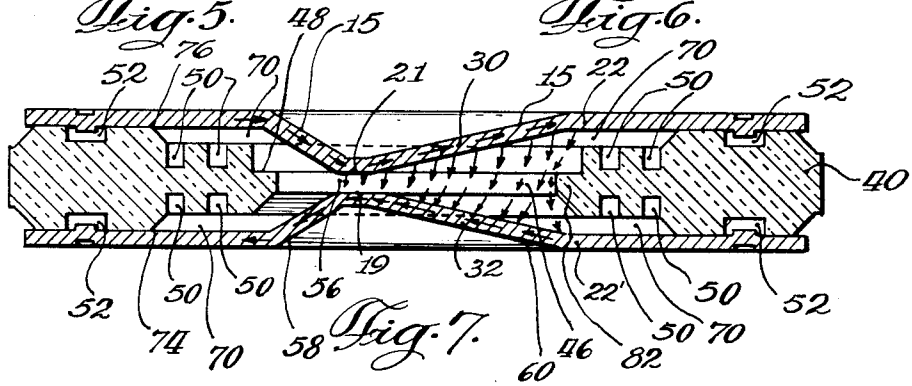


Fig. 7.

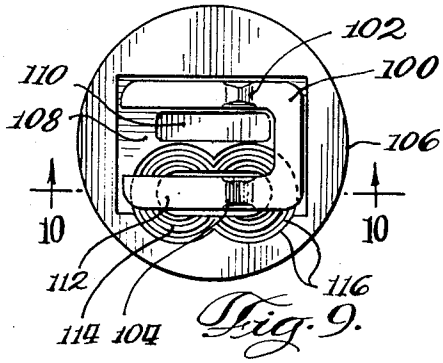


Fig. 9.

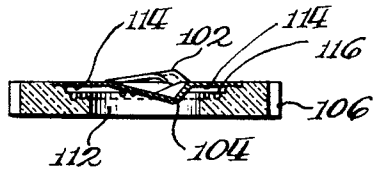


Fig. 10.

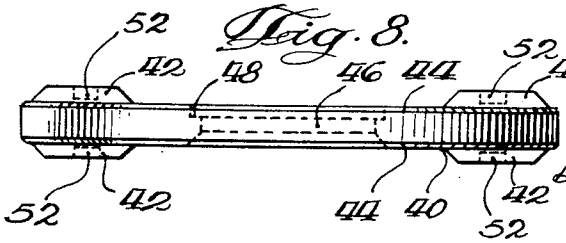


Fig. 8.

INVENTOR.
Francis V. Cunningham
BY
Byron, Thume, Green & Clement
attorneys

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3,069,589
SPARK-GAP ARRANGEMENT FOR LIGHTNING ARRESTERS

Francis V. Cunningham, Western Springs, Ill., assignor to Hubbard and Company, Chicago, Ill., a corporation of Pennsylvania

Filed Jan. 19, 1961, Ser. No. 83,829
14 Claims. (Cl. 315—36)

This invention relates in general to a spark-gap assembly and, in particular, to a spark-gap assembly for a lightning arrester or the like.

Lightning arresters now in use generally have incorporated therein a plurality of spark-gaps connected in series. These arresters are connected to a power line and normally present a relatively high impedance path to ground. In the event of a sudden high voltage surge due to lightning or some other occurrence, the arrester provides a relatively low impedance path to ground, thereby suppressing the voltage surge and protecting the electrical equipment on the power line against damage.

The plurality of spark gaps should be of the type which will permit a dielectric break down of the spark gaps at a given voltage and also permit the arc to be easily extinguished after the voltage surge has passed.

Previous attempts have been made to increase the extinguishing ability of spark gaps by causing the arc to shift away from its initial place of formation by the use of the magnetic blow-out principle. The arc is moved from its initial place of formation between spaced electrodes thus reducing the possibility that pits or beads will be formed on the spaced electrode surfaces which reduce the spark-over potential of the arc initiation point. The movement of the arc also enables the temperature of the air dielectric adjacent the initial place of formation of the arc to cool and to be swept of hot or ionized gases.

It has been previously thought that an external magnetic field should be provided to cause the magnetic blow-out. However, further development showed that arc electrodes of a special design would generate a field which would tend to forcibly bring about the desired migration of the arc from the initial place of formation. It was known, however, that the magnetic force in the spark gaps bearing the specially designed arc electrodes was inadequate to move an arc along the electrodes into an area of increasing gas pressure which occurs when the specially designed electrodes are totally confined within restricting arcing chambers. Accordingly, a remotely spaced vent normal to the arc was utilized to effect movement of expanding gas along the direction of intended arc movement. Such means was relatively successful, and is shown in my previous U.S. Patent No. 2,917,662. I have since determined that with specially designed electrodes the magnetic force is sufficient to properly move an arc, provided that the thermally expanding gases are dispersed in such manner as to allow free movement of the arc in the direction dictated by the magnetic force. In fact, arc movement is so effective under such conditions, that means is required to prevent arc movement from causing complete flashover of the device.

The resultant device, while smaller than spark gaps using external magnetic means to move internal arcs, has been proven capable of successfully interrupting power follow current forced by up to fifty percent (50%) higher voltage over the operating voltage of present spark gap designs. Thus, when used in a 9 kv. distribution valve arrester, present spark gap designs utilize 9 or more series gaps, whereas my device uses only 6 series gaps.

It is, therefore, an object of my invention to provide an improved arc arresting spark gap assembly.

It is a further object to this invention to provide an efficient arc arresting spark gap assembly wherein arc migration is accomplished without the aid of an external magnetic means.

A further object of this invention is to provide an improved arc arresting spark gap assembly wherein the arc is moved along the spark gap electrodes by the magnetic field associated with the spark gap electrodes.

It is another object of my invention to provide means for dispersing expanding gas in such manner as to allow free movement of the arc in the direction dictated by the magnetic force associated with the spark gap electrodes.

Another object of my invention is to limit arc travel so as to prevent total flashover of the spark gap structure.

It is a further object of the invention to provide an arc arresting spark gap assembly which is relatively small in size in comparison to the magnitude of the current passing therethrough.

It is another object of this invention to provide an arc arresting spark gap assembly wherein spaced electrodes are disposed such that initial arcing takes place at one predetermined point and extended arcing takes place sequentially at different predetermined points on the spaced electrodes and wherein prolonged arcing will not affect the initial spark-over characteristics of the initial spark gap area.

It is a further object of this invention to provide a series of spark gap electrodes for a valve type lightning arrester which may be used in any multiple depending upon the voltage rating desired.

It is another object of this invention to provide spark gap structures which are: exceedingly compact; self-locking; have very close but easily accomplished manufacturing tolerances; and, are easily shipped and stored.

Briefly, the invention comprises an arc arresting spark-gap assembly wherein the magnetic effect provided by the spark-gap structure of the spark-gap assembly itself will induce an arc initiated within the spark gap-assembly to shift or migrate down the electrodes of the spark gap structure. The structure enables the magnetic field created by the current passing through the arc and the electrodes of the spark gap structure to alone produce the shifting or migration of the arc down the electrodes of the spark gap structure. Means are provided whereby the resultant hot gases formed by the arcing are readily dispersed so as not to interfere with the movement of the arc by the magnetic field.

The invention, both as to its organization and method of operation, taken with further objects and advantages thereof, will best be understood by reference to the following description taken in connection with the accompanying drawings in which:

FIGURE 1 is a front elevational view of a lightning arrester with portions cut away so as to present a partial view of the interior;

FIGURE 2 is a perspective exploded view illustrating an embodiment of the invention;

FIGURE 3 is a plan view of a spark gap electrode positioned on a spacing insulator of the type illustrated in FIGURE 2;

FIGURE 4 is a plan view of a spacing insulator of the type illustrated in FIGURE 2;

FIGURE 5 is a cross-sectional view taken along the line 5—5 as in FIGURE 3 of a stacked group of spark gap electrodes and spacing insulators of the type illustrated in FIGURE 2;

FIGURE 6 is a cross-sectional view taken along the line 6—6 as in FIGURE 3 of a stacked group of spark

gap electrodes and spacing insulators of the type illustrated in FIGURE 2;

FIGURE 7 is a cross-sectional view as in FIGURE 6 illustrating two spaced spark gap electrodes and an interspaced insulator of the type illustrated in FIGURE 2;

FIGURE 8 is a front elevational view of the insulator illustrated in FIGURE 4 wherein some dotted lines are omitted for clarity;

FIGURE 9 is a plan view of another form of the electrodes and spacing insulators; and

FIGURE 10 is a cross-sectional view taken along the line **10—10** of FIGURE 9.

Referring now to the drawings there is illustrated therein in FIGURE 1 a hermetically sealed valve type lightning arrester **50** which comprises a housing **10** which may be composed of an insulating material such as porcelain or the like. It should be understood that the inventor is not restricted to a valve type lightning arrester. One end of the lightning arrester **50** is connected to ground as at **12** and the other end of the lightning arrester **50** is connected to the equipment which is desired to be protected through a conductor such as conductor **14**. A conductive protective cap **16** is positioned at the top of the lightning arrester **50** as viewed in FIGURE 1 and is held in place by suitable potting material. A metallic conducting member **18** is mounted on the top of the non-linear resistance material **26** in electrical contact with the protective cap **16**. Therefore, an electrical path exists through the hermetically sealed arrester **50** from conductor **14** through the conducting cap **16** and metallic conducting member **18**, through the non-linear resistance material **26**, the spark gap electrodes **22** and **22'**, the spark gaps between **22** and **22'** through suitable electrical connectors (not shown) to end portion **12** of the arrester **50** and to ground.

Referring now to FIGURES 2, 3 and 4 for the overall general configuration of the spark gap electrodes **22** and **22'** and the spacing insulators **40**. There is shown therein the spark gap electrodes **22** and **22'** composed of a suitable metallic conductive material and which may be considered as disc shaped with segments of the disc removed on opposite sides. Discs **22** and **22'** have formed therein a longitudinal slot **28**. On one side of the elongated slot **28** there is provided a spark gap electrode terminal **30** and on the other side of the longitudinal slot **28** is the spark gap electrode terminal **32**. At this point it is apparent and as illustrated in FIGURE 2 that the spark gap electrodes **22** and **22'** are not identical in that the terminals **30** and **32** of the electrode **22** are on reverse sides of the elongated slot **28** as the terminals **30** and **32** on the electrode **22'**. Inasmuch as there is no need for two terminals on the upper and lower discs of a stacked disc arrangement the bottom disc or spark gap electrode **22'** in FIGURE 2 is illustrated with only one terminal portion **32**. The spark gap electrode terminal **32** is the convex terminal as seen in FIGURE 2 and the spark gap electrode terminal **30** is the concave terminal as seen in FIGURE 2.

The convex spark gap terminal **32** as seen in the drawings comprises four walls **58**, **60**, **62** and **64**, all lying on intersecting planes and an initial arcing area **19**. The concave spark gap terminal **30** comprises four similar walls **15**, **17**, **11** and **13** and an initial arcing area **21**. Positioned on the electrodes **22** and **22'** are aligning pins **34** which are useful in properly positioning and assembling the stacked arc arresting spark-gap assembly.

Referring particularly to FIGURES 4 and 8 wherein the spacing insulator **40** is illustrated, the spacing insulator **40** comprises two pair of raised shoulder portions **42**, one pair on each side of the insulator **40**. The shoulder portions **42** serve to accurately space the spark gap electrode terminals **30** and **32** of the spark gap electrodes **22** and **22'**, respectively, a predetermined distance from one another. The spacing insulator **40** may be preferably made of a non-organic type of insulating material and it may be cast and baked. The shrinkage which is normally encountered in the manufacture of these insulators results in a wide variation in the overall thickness of these discs. Therefore, if the shoulder portions **42** are cast and baked oversize, they may be conveniently ground to size by a plane grinder and the spacing provided by the insulator **40** may be controlled within very fine tolerances.

As can be seen, the electrodes **22** and **22'** are substantially disc shaped and are formed such that they are positioned on the shoulders **42** of insulator **40** and, therefore, the spacing between the spark gap electrode terminals **30** and **32** of the spark gap electrodes **22** and **22'** is accurately determined by the thickness of the spacing insulator **40**.

The spacing insulator **40** has a central or main portion **44** and positioned within the main portion **44** is the spark gap electrode terminal aperture **46**. Formed within the aperture **46** is ledge **48**.

Positioned within the main portion **44** of the insulator **40** and on either side of insulator **40** are a plurality of slots **50**, as can be readily seen in FIGURE 7. The function of the slots **50** is to increase the creepage distance. Also positioned within the spacing insulator **40** are the plurality of alignment holes **52** which are designed to correspond to the corresponding aligning pins **34** of the spark gap electrodes **22** and **22'**.

The arrester **50** may be readily increased in capacity by merely stacking up more spark gap electrodes **22** and **22'**, interspaced by insulator **40**, upon one another. As can be seen in the drawings spark gap electrodes **22** and **22'** are disc shaped and provide a large cross-sectional area through which the surge current passes and similarly terminals **30** and **32** of the spark gap electrodes **22** and **22'** present a comparatively large cross-section area for the surge current. Therefore, spark gap electrodes **22** and **22'** have comparatively large current handling capacities.

The spark gap structure is assembled such that a spark gap exists between adjacent electrodes. Oppositely directed electrode terminals **30** and **32** form such spark gaps and extend into the electrode terminal aperture **46** in the insulator **40** as can be seen in FIGURES 5, 6 and 7.

The lightning arrester **50** is connected across the electrical equipment to be protected and normally presents a high impedance path to ground. Under normal operating conditions the voltage applied across the plurality of spark gaps formed by the spark gap electrodes **22** and **22'** and the spacing insulators **40** between opposed pairs of terminals **30** and **32** as best seen in FIGURES 6 and 7 is insufficient to cause the air dielectric in the spark gap to become conductive. Therefore, the lightning arrester **50** in normal operation appears as a comparative open circuit. As soon as a large voltage surge appears across the electrical equipment the spark gaps in the lightning arrester **50**, formed between opposed pairs of terminals **30** and **32**, spark over and a comparatively low impedance conducting path is provided from the line through the conductor **14**, the conducting cap **16**, the metallic conducting member **18**, the non-linear resistance material **26**, the plurality of spark gap electrodes **22** and **22'** and consequently the spark gaps provided therebetween, through suitable electrical connections (not shown) to the lower conductive end **12** of the lightning arrester **50** to ground.

As soon as the voltage surge has passed, it is desired to have the lightning arrester **50** again present a high impedance path to the power line. The non-linear resistance material **26** is voltage sensitive and the resistance of the resistance material **26** increases when the voltage applied thereto is decreased and decreases when the voltage applied thereto is increased. During the voltage surge the non-linear resistance material **26** decreases in resistance and after the voltage surge has passed the non-linear resistance material **26** returns to its initial resistance value. It would appear at first glance that as soon as the voltage surge appearing across the spark gaps

formed by the opposed pairs of terminals **30** and **32** has passed that the impedance presented to the power line by the spark gaps would return to its normal value. However, this does not occur as long as sufficient hot or ionized gas is still present between the opposed pairs of terminals **30** and **32** of the spark gap electrodes **22** and **22'**. Hot or ionized gases are comparatively good conductors of electricity and will maintain the arc conductive under very low voltage circumstances unless the hot or ionized gases are dispersed from the area between the opposed pairs of terminals **30** and **32**. This flow of current through the lightning arrester after the voltage surge has passed is generally termed the power follow current.

Turning now to FIGURE 2 it can be seen that the surge current will enter the top electrode (not shown) from the non-linear resistance material **26** and will travel in a U-shaped direction in the spark gap electrodes **22** and **22'**. The direction of the current as it moves from spark gap electrode to spark gap electrode will also be in a U-shape as can be best seen in FIGURE 7. The U-shaped current path in each spark gap electrode will be similar to the U-shaped path in the spark gap electrode above or the spark gap electrode below. However, the direction of the current flow will be reversed in each electrode, i.e. the current in the upper and the current in the lower spark gap electrode of each individual electrode will be traveling in opposite directions. The current in one electrode will be making or traversing a U-shaped path from left to right, for example, while the current in the upper electrode or lower electrode will be traversing a U-shaped path from right to left.

Referring now to FIGURE 7 it can be seen that arcing occurs initially between portions **21** and **19** of terminals **30** and **32**, respectively. The arcing causes the gases between terminals **30** and **32** to heat and to expand. The electrode terminal aperture **46** substantially surrounds the electrode terminals **30** and **32** on four sides. However, electrodes **22** and **22'** are spaced from the main portion **44** of the insulator **40** as indicated at **70** in FIGURE 7. Therefore, the hot gases leave the vicinity of the terminals **30** and **32** through the dispersion chamber **70** between the electrodes **22** and **22'** and the insulator **40** in a manner which does not interfere with movement of the arc by the magnetic field, as is seen and indicated with arrows in FIGURE 3.

The path of current flow is indicated by arrows in FIGURE 7 and it can be seen that current flows in opposite directions in adjacent electrodes **22** and **22'**, respectively. The current enters and leaves from the short side of terminals **30** and **32**, that is, the side of terminals **30** and **32** having side wall portions **15** and **58**, respectively, as best seen in FIGURE 7. It can also be seen that the direction or path of the arcing between adjacent terminals **30** and **32** of electrodes **22** and **22'** is substantially normal to the direction of the current flow in terminals **30** and **32**.

The magnetic field created by the current flowing in the electrode terminals **30** and **32** pushes the arc into the area of increased spacing between terminals **30** and **32** and also the area of increased current path length passing through the terminals **30** and **32** as can be seen in FIGURE 7. The arc can move only in the direction illustrated in FIGURE 7 and cannot move in the opposite direction. Further, the arc can move only so far as is shown in FIGURE 7 where movement is finally restricted by impingement of the arc against the confining wall portion **82** of aperture **46**. Thereafter the arc maintains itself for the duration of power following current at this point. The confining and limiting effect of the insulator **40** upon the travel of the arc prevents the arc from continued movement from between the confines of adjacent electrodes in such manner as to cause total flashover of the complete gap structure. Herein, "flashover" is a term used to identify a damaging arc established across the external surface of the structure.

The spacing insulators **40** are designed to permit the hot gases formed by the creation of the arc to move out of the area between the electrodes **22** and **22'** so as not to interfere with movement of the arc by the magnetic field. The hot gases will initially move in all directions but the path of least resistance will be in a direction perpendicular to the direction of the progression of the arc as best seen in FIGURE 3. Insulator **40** obstructs the movement of hot gases past the ends of adjacent spaced electrodes in the direction of the movement of the arc as can be seen in the drawings. Therefore, if the movement of hot gases in the direction of the progression of the arc is not permitted to extend past the ends of the adjacent spaced electrodes, "flashover" will be prevented.

It has been previously thought that the movement of the hot gases themselves was a prime reason for the movement of the arc and that the arc would not effectively move unless the gases were moved in a controlled manner along a specific path. Designers were aware that the spark gap electrodes could be constructed so that the magnetic field created by the current flowing through the spark gap electrodes would aid in the migration of the arc along the spark gap electrodes. However, the designers did not rely upon this effect and believed that it was too weak to effectively move the spark gap arc any length or distance in a relatively short period of time. The reason therefor was that the hot gases were not moving at the rate that the arc had a propensity to move and were actually inhibiting the movement of the arc along the spark gap electrodes. Previous designs failed to disperse the hot or ionized gas.

FIGURES 9 and 10 illustrate another form of the invention and there is illustrated a substantially U-shaped electrode **112** having formed thereon in opposite legs of the U-shaped electrode a convex terminal portion **102** and a concave terminal portion **104**. Insulator **106** is provided with a depressed central portion **108** having an undepressed section **110** positioned therein for properly positioning the substantially U-shaped electrode **112**.

The insulator **106** is further provided with a gas expansion chamber **114** having a plurality of substantially circular grooves **116** formed therein so as to increase the creepage distance between adjacent electrodes. Also formed within insulator **106** is an electrode terminal aperture **112** into which the concave terminal **104** extends.

The main surface of the electrode **112** lies in substantially the same plane as the top surface of insulator **106**, as can be seen in FIGURES 9 and 10. The only extending portion being the convex terminal portion **102**.

Therefore, a stacked series of spark gap structures may be formed by stacking insulators similar to insulator **106** on top of one another with the appropriate electrodes **112** positioned so as to form spark gaps between adjacent electrodes.

The current flowing in adjacent electrodes **112** will flow in similar paths but in opposite directions. One of the more significant provisions of the combination including the electrode **112** and the insulator **106** is the expansion chamber **114** which is enclosed on four sides by its own construction and which permits hot or ionized gas to be dispersed from the space between the terminal portions **102** and **104** of adjacent electrodes **112** to thereby enable the magnetic field created by the design of the electrodes **112** to cause the arc formed between adjacent terminal portions of adjacent electrodes to migrate down the terminal portions of the adjacent electrodes.

While several embodiments described herein are at present considered to be preferred, it is understood that various modifications and improvements may be made therein, and it is intended to cover in the appended claims all such modifications and improvements as fall within the true spirit and scope of the invention.

What is desired to be claimed and secured by Letters Patent of the United States is:

1. An arc gap structure comprising a pair of spaced

electrodes, said pair of spaced electrodes forming a substantially U-shaped current path including an arcing path through a portion of the space between said pair of spaced electrodes, said pair of spaced electrodes provided with initial arcing portions through which said arcing path initially traverses and spaced further arcing portions through which said arcing path subsequently traverses, said pair of spaced electrodes arranged such that the magnetic field provided by current passing through said substantially U-shaped path drives said arcing path from said initial arcing portion to said spaced further arcing portions, spacing means separating said pair of spaced electrodes providing a dispersion chamber arranged to permit the flow of hot gases formed by the current passing through said arcing path.

2. An arc gap structure comprising a pair of spaced electrodes, said pair of spaced electrodes forming a substantially U-shaped current path including an arcing path through a portion of the space between said pair of spaced electrodes, said pair of spaced electrodes provided with initial arcing portions through which said arcing path initially traverses and spaced further arcing portions through which said arcing path subsequently traverses, said pair of spaced electrodes arranged such that the magnetic field provided by current passing through said substantially U-shaped path drives said arcing path from said initial arcing portions to said spaced further arcing portions, a spacing insulator separating said pair of spaced electrodes providing a dispersion chamber arranged to permit flow of hot gases formed by the current passing through said arcing path from between said pair of spaced electrodes in such a manner as to allow free movement of said arcing path in the direction dictated by said magnetic field.

3. An arc gap structure comprising a pair of spaced electrodes, said pair of spaced electrodes forming a substantially U-shaped current path including an arcing path through a portion of the space between said pair of spaced electrodes, a spacing insulator separating said pair of spaced electrodes, said spacing insulator provided with a dispersion chamber through which said arcing path traverses, said pair of spaced electrodes provided with initial arcing portion through which said arcing path initially traverses and spaced further arcing portions through which said arcing path subsequently traverses, said pair of spaced electrodes arranged such that the magnetic field provided by current passing through said substantially U-shaped path drives said arcing path from said initial arcing portions to said spaced further arcing portions, said dispersion chamber arranged to permit the flow of hot gases formed by the current passing through said arcing path from between said pair of spaced electrodes in such a manner as to allow free movement of said arcing path in the direction dictated by said magnetic field.

4. An arc gap structure comprising a plurality of spaced electrical conducting electrodes, said plurality of spaced electrodes forming a plurality of substantially U-shaped current paths including a plurality of arcing paths through a portion of the spaces between said plurality of spaced electrodes, said plurality of spaced electrodes provided with initial arcing portions through which said arcing paths initially traverse and spaced further arcing portions through which said arcing paths subsequently traverse, said plurality of spaced electrodes arranged such that the magnetic fields provided by the current passing through said substantially U-shaped paths drives said arcing paths from said initial arcing portions to said spaced further arcing portions, and spacing means separating said plurality of spaced electrodes providing a plurality of dispersion chambers arranged to permit the flow of hot gases formed by the current passing through said arcing path.

5. An arc gap structure comprising a plurality of substantially U-shaped spaced electrical conducting electrodes, said plurality of spaced, substantially U-shaped electrodes forming a plurality of substantially U-shaped current paths including a plurality of arcing paths through a portion of the spaces between said plurality of spaced, substantially U-shaped electrodes, said plurality of spaced, substantially U-shaped electrodes provided with initial arcing portions through which said arcing paths initially traverse and spaced further arcing portions through which said arcing paths subsequently traverse, said plurality of spaced, substantially U-shaped electrodes arranged such that the magnetic fields provided by the current passing through said substantially U-shaped paths drives said arcing paths from said initial arcing portions to said spaced further arcing portions, and spacing means separating said plurality of spaced, substantially U-shaped electrodes providing a plurality of dispersion chambers arranged to permit the flow of hot gases formed by the current passing through said arcing path.

6. An arc gap structure comprising a pair of spaced substantially U-shaped electrical conducting electrodes, said pair of spaced electrodes forming a substantially U-shaped current path including an arcing path through a portion of the space between said pair of spaced electrodes, said pair of spaced electrodes provided with initial arcing portions through which said arcing path initially traverses and spaced further arcing portions through which said racing path subsequently traverses, said pair of spaced electrodes arranged such that the magnetic field provided by current passing through said substantially U-shaped path drives said arcing path from said initial arcing portion to said spaced further arcing portions, and a spacing insulator separating said pair of spaced electrodes providing a dispersion chamber arranged to permit the flow of hot gases formed by the current passing through said arcing path from between said pair of spaced electrodes in such a manner so to allow free movement of said arcing path in the direction dictated by said magnetic field.

7. An arc gap structure comprising a plurality of spaced electrical conducting electrodes, said plurality of spaced electrodes forming a plurality of substantially U-shaped current paths including a plurality of arcing paths through a portion of the spaces between said plurality of spaced electrodes, said plurality of spaced electrodes provided with initial arcing portions through which said arcing paths initially traverse and spaced further arcing portions through which said arcing paths subsequently traverse, said plurality of spaced electrodes arranged such that the magnetic fields provided by the current passing through said substantially U-shaped paths drives said arcing paths from said initial arcing portions to said spaced further arcing portions, and a plurality of spacing insulators separating said plurality of spaced electrodes providing a plurality of dispersion chambers arranged to permit the flow of hot gases formed by the current passing through said arcing path from between said plurality of spaced electrodes in such a manner as to allow free movement of said arcing paths in the directions dictated by said plurality of magnetic fields.

8. An arc gap structure comprising a plurality of spaced electrical conducting electrodes, said plurality of spaced electrodes forming a plurality of substantially U-shaped current paths including a plurality of arcing paths through a portion of the spaces between said plurality of spaced electrodes, said plurality of spaced electrodes provided with initial arcing portions through which said arcing paths initially traverse and spaced further arcing portions through which said arcing paths subsequently traverse, said plurality of spaced electrodes arranged such that the magnetic fields provided by the current passing through said substantially U-shaped paths drives said arcing paths from said initial arcing portions to said spaced further arcing portions, and a plurality of spacing insulators separating said plurality of spaced electrodes providing a plurality of dispersion chambers arranged to permit the flow of hot gases formed by the current passing through said arcing path from between

said plurality of spaced electrodes in such a manner as to allow free movement of said arcing paths in the directions dictated by said plurality of magnetic fields, said plurality of spacing insulators providing a plurality of arc confining walls generally disposed normal to said movement of said arcing paths in the directions dictated by said plurality of magnetic fields.

9. A spark-gap assembly comprising a pair of spaced electrical conducting electrodes, a spacing insulator electrically separating said electrodes, said spacing insulator having a dispersion chamber formed therein, said conducting electrodes substantially U-shaped and each electrode having a terminal indentation formed thereon, said terminal indentations of said pair of electrodes oppositely directed in the area of said electrodes adjacent said dispersion chamber, said terminal indentations extending into said dispersion chamber and spaced a minimum distance from one another at an initial arcing point and progressively spaced from one another adjacent said initial arcing point, said spacing insulator formed such that said electrodes are electrically separated from one another by said spacing insulator except in the areas of said electrodes adjacent said dispersion chamber, at least one of said electrodes being spaced from said insulator in the area of said dispersion chamber, said pair of electrodes adapted such that current flows in a substantially U-shaped path through said oppositely directed terminal indentations, the current path between said oppositely directed terminal indentations generally normal to the current path in said terminal indentations whereby the provided arc creates a self-generated magnetic repulsion to provide a magnetic movement of the arc along the terminal indentations.

10. A spark-gap assembly comprising a pair of spaced electrical conducting electrodes, a spacing insulator electrically separating said electrodes, said spacing insulator having an aperture formed therein, said electrodes substantially U-shaped and each electrode having a pair of substantially arcuately formed terminal indentations thereon, said terminal indentations of said pair of electrodes oppositely directed in the area of said electrodes adjacent said aperture, said terminal indentations extending into said aperture and spaced a minimum distance from one another at an initial arcing point and progressively spaced from one another on either side of said initial arcing point, said spacing insulator formed such that said electrodes are electrically separated from one another by said spacing insulator except in the areas of said electrodes adjacent said aperture, said electrodes being spaced from said insulator in the area of said aperture, said pair of electrodes adapted such that current flows between said terminal indentations in a substantially U-shaped path, the arc initiating path between said terminal indentations generally normal to the current path in said terminal indentations whereby the provided arc creates a self-generated magnetic repulsion to provide a magnetic movement of the arc are along the terminal indentations in adjacent electrodes.

11. A spark-gap assembly comprising a plurality of spaced electrical conducting electrodes, a plurality of spacing insulators electrically separating said electrodes, said spacing insulators having an aperture formed therein, said electrodes substantially U-shaped and each electrode having a plurality of oppositely directed substantially arcuately formed terminal indentations thereon, said plurality of electrodes and said pluralty of spacing insulators arranged such that the terminal indentations of said plurality of electrodes are oppositely directed in the area of said electrodes adjacent said apertures in said spacing insulators, said terminal indentations extending into said apertures in said spacing insulators and spaced a minimum distance from one another near one end of said terminal indentation and progressively spaced from one another on either side of said minimum distance position, said spacing insulators formed such that said electrodes are electrically separated from one another by said spacing insulators except in the areas of said electrodes adjacent said apertures in said insulating spacers, at least one of said electrodes adjacent each aperture in said spacing insulator being spaced from said insulator in the area of said aperture, said plurality of electrodes adapted such that current flows in a substantially U-shaped path between adjacent terminal indentations, the arc initiating path between said terminal indentations generally normal to the current path in said terminal indentations whereby the provided arc creates a self-generated magnetic repulsion to provide a magnetic movement of the arc along the terminal indentations.

12. A spark-gap assembly comprising a plurality of spaced electrical conducting electrodes, a plurality of spacing insulators electrically separating said plurality of electrodes, said spacing insulators having an aperture formed therein, said electrodes substantially U-shaped and each electrode having a plurality of oppositely directed substantially arcuately formed terminal indentations thereon, said terminal indentations of said plurality of electrodes oppositely directed in the area of said electrodes adjacent said aperture of said spacing insulators, said terminal indentations extending into said apertures and spaced a minimum distance from one another at one end of said terminal indentations and progressively spaced from one another on either side of said minimum distance position, said spacing insulator formed such that said electrodes are electrically separated from one another by said spacing insulator except in the areas of said electrodes adjacent said aperture, said plurality of electrodes being spaced from said spacing insulator in the area of said apertures, said plurality of electrodes adapted such that current flows in substantially U-shaped paths but in opposite directions between adjacent terminal indentations, the arc initiating path between said terminal indentations generally normal to the current path in said terminal indentations whereby the provided arc creates a self-generated magnetic repulsion to provide a magnetic movement of the arc along the terminal indentations.

13. A spark-gap assembly comprising a plurality of electrode plates and a plurality of substantially disc-shaped spacing insulators, said plurality of substantially disc-shaped spacing insulators each having formed therein an aperture, said plurality of electrode plates each having formed therein oppositely directed substantially arcuately formed terminal indentations, said terminal indentations formed in said plurality of electrode plates in the area of said electrode plates adjacent said apertures in said plurality of spacing insulators, said electrode plates positioned such that said terminal indentations are oppositely directed in the area of said electrode plates adjacent said apertures, said oppositely directed terminal indentations of said electrode plates extending into said apertures of said spacing insulators and spaced a minimum distance apart at one end of said terminal indentations and progressively spaced on either side of said minimum distance point, said plurality of electrical spacing insulators electrically separating said plurality of electrode plates except in the areas of said electrode plates adjacent said apertures in said spacing insulators, said plurality of electrode plates spaced from said spacing insulators in the area of said spacing insulators adjacent said aperture, said plurality of electrode plates having a substantially U-shaped current flow path between adjacent terminal indentations of adjacent electrode plates, said electrode plates arranged such that initial arcing occurs at said minimum distance point of said terminal indentations such that the current flow through said arc and said terminal indentations provides a magnetic field which causes the arc formed to be repulsed along said terminal indentations and in a direction to increase the total length of the path of said current flow.

14. A spark-gap assembly comprising a pair of spaced electrical conducting electrodes, a spacing insulator elec-

trically separating said electrodes, said spacing insulator having an aperture formed therein, said conducting electrodes substantially U-shaped and each electrode having a terminal indentation formed thereon, said terminal indentations of said pair of electrodes oppositely directed in the area of said electrodes adjacent said aperture, said terminal indentations extending into said aperture and spaced a minimum distance from one another at an initial arcing point and progressively spaced from one another on either side of said initial arcing point, said spacing insulator formed such that said electrodes are electrically separated from one another by said spacing insulator except in the areas of said electrodes adjacent said aperture, said pair of electrodes being spaced from said insulator in the area of said electrodes adjacent said aperture whereby an expansion chamber is provided between said electrodes and said spacing insulator, said pair of

electrodes adapted such that current flows in a substantially U-shaped path between adjacent terminal indentations, the arc initiation path between said terminal indentations generally normal to the current path in said terminal indentations whereby the provided arc creates a self-generated magnetic repulsion to provide a magnetic movement of the arc along the terminal indentations, said expansion chamber providing means whereby hot gases provided by said arc are dispersed from the area between adjacent terminal indentations of said pair of electrodes.

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