United States Patent [19]

Kawiecki

[11] **3,811,064**

[45] **May 14, 1974**

[54] **SPARK-GAP DEVICE**

[75] Inventor: **Chester J. Kawiecki,** Santa Barbara, Calif.

[73] Assignee: **Joslyn Mfg. and Supply Co.,** Chicago, Ill.

[22] Filed: **Dec. 20, 1972**

[21] Appl. No.: **316,736**

[52] **U.S. Cl.** **313/325,** 313/309, 315/36

[51] **Int. Cl.** **H01j 17/00,** H01j 21/00

[58] **Field of Search** 315/36; 313/325, 309

[56] **References Cited**

UNITED STATES PATENTS

2,290,526	7/1942	Berkey et al.	313/325 X
2,365,595	12/1944	Roman	313/325 X
3,119,040	1/1964	Gardiner et al.	313/309 X
3,588,576	6/1971	Kawiecki	313/325

Primary Examiner—James W. Lawrence
Assistant Examiner—Saxfield Chatmon, Jr.
Attorney, Agent, or Firm—Klarquist, Sparkman, Campbell, Leigh, Hall & Whinston

[57] **ABSTRACT**

A miniature three-element spark-gap device comprises a ceramic enclosure supporting aligned end electrodes extending therewithin, and a solid disc center electrode establishing first and second gaps with the end electrodes. The solid disc center electrode is apertured so that an arc discharge across one gap will illuminate the other, producing ionization and causing immediate breakdown of the other gap.

12 Claims, 5 Drawing Figures

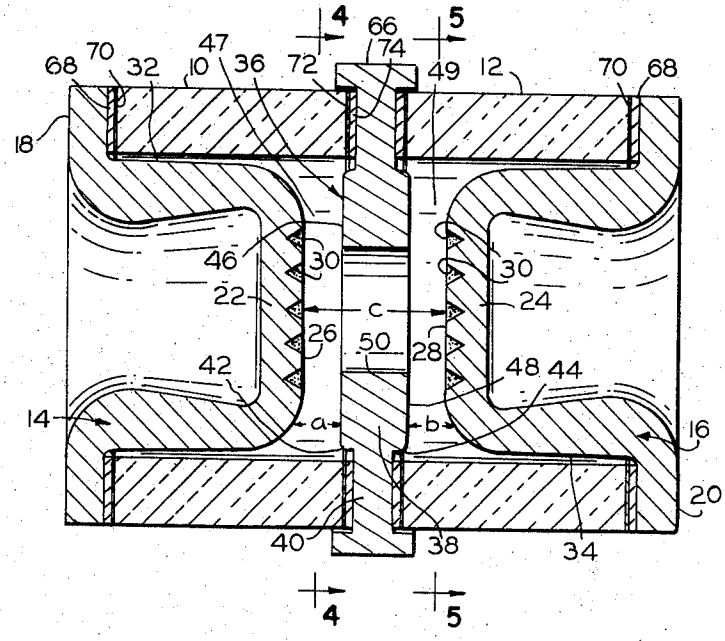


FIG. 1

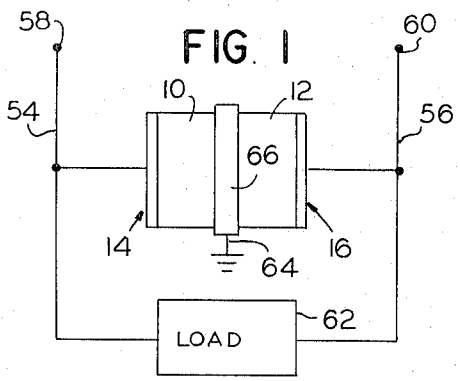
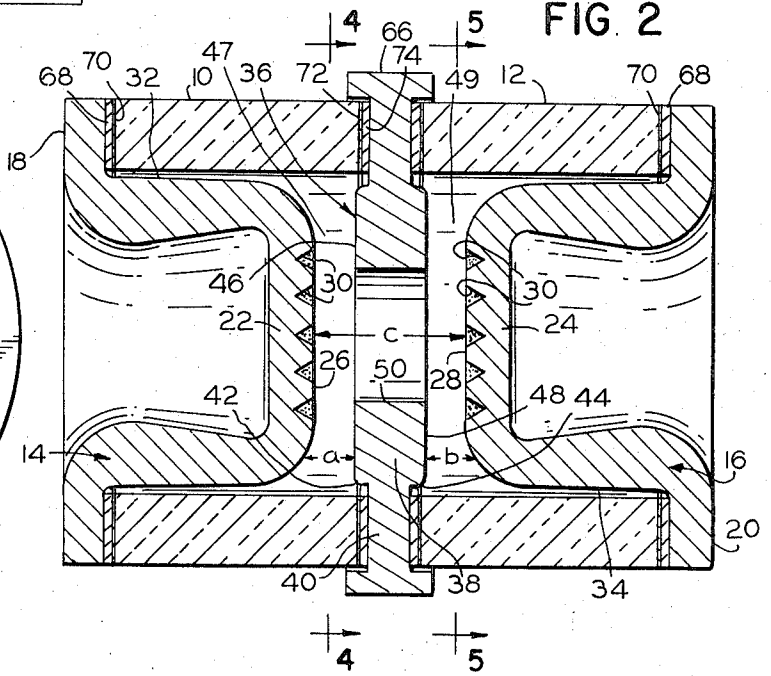


FIG. 2



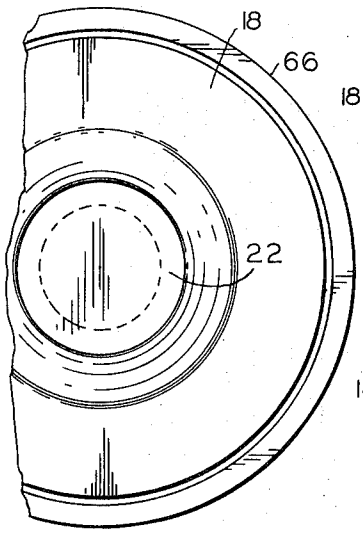


FIG. 3

FIG. 4

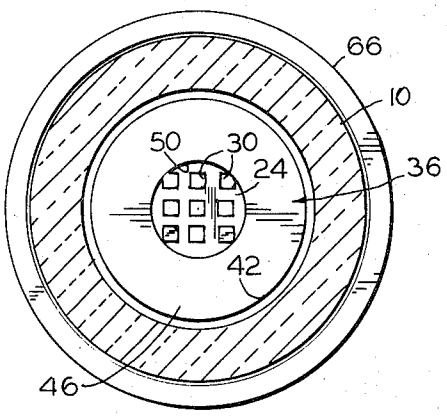
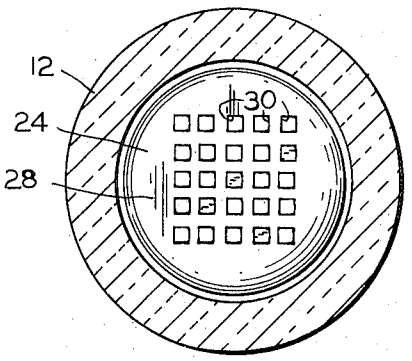


FIG. 5



SPARK-GAP DEVICE

BACKGROUND OF THE INVENTION

Spark-gap devices are frequently employed as protectors across voltage supply lines, telephone lines, and the like, for protecting equipment from transient surges. For example, such a spark-gap device may be employed as a lightning arrester providing a breakdown path to ground when a lightning surge occurs, whereby such surge does not reach and destroy the apparatus connected to the line.

A suitable spark-gap configuration for protecting equipment connected to a line pair comprises a three-terminal arrangement by means of which a high voltage transient on either or both lines may be shunted to ground. A pair of spark-gaps with each one disposed between a line and ground may be employed, but in such case the two devices may not discharge simultaneously, often leaving an unbalanced high voltage coupled to the device to be protected. One popular configuration comprises a three electrode device including end electrodes in juxtaposed relation, and a cylindrical ground electrode surrounding the gap between the end electrodes. While arcing desirably takes place between each end electrode and the grounded cylinder at substantially the same time, a discharge may occur between the end electrodes without involving the grounded electrode.

A highly advantageous three-element construction which may be utilized to provide the desired grounding protection is disclosed and claimed in my U.S. Pat. No. 3,535,582 entitled, "Unitary Series Spark-gap with Aligned Apertures" issued Oct. 20, 1970, and assigned to the assignee of the present invention. In the construction according to the previous patent, a pair of spark-gap devices are aligned in end-to-end relation with a passage communicating between the gaps illuminating one gap when the other discharges, whereby substantially immediate ionization takes place bringing about a discharge across both gaps. The gap according to the present invention is an improved construction of this general type.

SUMMARY OF THE INVENTION

In accordance with the present invention, a spark-gap device includes first and second aligned conductive end electrodes disposed at respective ends of a hollow enclosure. A third or center electrode located therebetween is supported by the enclosure and comprises a solid disc forming first and second gaps with the end electrodes, the disc having a direct passage therethrough providing a line-of-sight pate for bringing about substantially simultaneous ionization of the gaps. The center electrode has lateral faces exposed in facing longitudinal juxtaposition with exposed arc supporting surfaces of the end electrodes to provide the first and second gaps and insure the involvement of the third electrode in such discharges as may take place, whereby effective grounding may occur. The present device is particularly adapted for service wherein it is desired to shunt discharges to ground, and thus the center electrode is generally grounded.

The device according to the present invention having the solid disc center electrode has the advantage of sturdy but compact construction whereby the device is able to withstand heavier surges and conduct a greater number of surges during its operating lifetime than the last mentioned two-gap device. The present device, also being shorter, provides faster communication of ionization between the two gaps. Since the device is smaller in overall size, it is more compatible with the modern day miniature equipment and is also easier and more economical to produce than other devices of this type.

It is accordingly an object of the present invention to provide an improved spark-gap device which effectively and substantially simultaneously grounds a pair of lines in the event of a transient surge.

It is a further object of the present invention to provide an improved spark-gap device of the three element type for shunting high voltage surges to ground, wherein such device is sturdy in construction and capable of withstanding heavier surges and a greater number of surges during its operating lifetime.

It is a further object of the present invention to provide an improved three-element, two-gap device providing faster communication of ionization between its two gaps.

It is another object of the present invention to provide an improved spark-gap device which is smaller, more compact, less costly, and more compatible with miniature equipment than has been the case in prior devices.

It is a further object of the present invention to provide an improved miniature spark-gap device which is extremely small in size but offers enhanced grounding protection by shunting discharges from line to ground for protecting equipment connected therewith.

The subject matter which I regard as my invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. The invention, however, both as to organization and method of operation, together with further advantages and objects thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings wherein like reference characters refer to like elements.

DRAWINGS

FIG. 1 is a side view of a spark-gap device according to the present invention, connected in circuit with a load;

FIG. 2 is an enlarged longitudinal cross-section of the spark-gap device according to the present invention;

FIG. 3 is an end view of such spark-gap device;

FIG. 4 is a first transverse cross-sectional view of the spark-gap device according to the present invention taken at 4—4 in FIG 2; and

FIG. 5 is a second transverse cross-sectional view of the spark-gap device according to the present invention taken at 5—5 of FIG 2.

DETAILED DESCRIPTION

Referring to the drawings and particularly to FIG. 1, a spark-gap device according to the present invention includes hollow enclosure means comprising cylindrical aligned spacer tubes 10 and 12 preferably taking the form of glass or ceramic tubes. The device is quite small and in a particular instance had a total length of approximately 0.46 inch, with each of the cylindrical spacer tubes being approximately 5/16 inch in diameter and approximately 3/16 inch in length. The spacer tubes are more clearly shown in FIG. 2 wherein the

spark-gap device according to the present invention is illustrated in enlarged cross section.

The device further includes thin walled, hollow, conductive electrodes **14** and **16** which are cup-shaped, overall. The electrodes are inserted into opposite ends of the aligned spacer tubes, and have radial flanges **18** and **20** located at respective first ends thereof which are joined to the spacer tubes in sealing relationship. Second closed ends, **22** and **24**, of the electrodes are positioned within the respective spacer tubes and extend laterally nearly across the spacer tubes to provide fairly large, lateral, arc-supporting surfaces **26** and **28** disposed in opposed or facing relation. The surfaces **26** and **28** are suitably substantially perpendicular to the axial or longitudinal center line of the device and are preferably substantially planar over the major portion thereof. Each of these surfaces is desirably provided with a plurality of cavities **30** containing a low work function material such as potassium chloride for supplying a source of electrons and inhibiting electrode erosion due to cathode sputtering. The hollow electrodes **14** and **16**, suitably formed of Kovar, may be generally cylindrical between their aforementioned first and second ends. Cylindrical outer walls **32** and **34** thereof are adjacent the inner walls of spacer tubes **10** and **12** and shield the spacer tube inner walls from electrode sputtering. The ceramic spacer tubes **10** and **12** are preferably formed of alumina.

A third conductive electrode **36** is disposed between the first and second electrodes **14** and **16** where it is supported by spacer tubes **10** and **12.** The third electrode comprises a solid disc including a first portion **38** having a first thickness in a direction axial of the device, and a peripheral portion **40** of reduced thickness disposed between and joined in sealing relation to second ends of the aligned spacer tubes **10** and **12.** The electrode **36** is further provided with an axial flange **66** at the outer edge of peripheral portion **40,** such flange extending longitudinally over spacer tubes **10** and **12** for a short distance. The flange provides a good exterior contact and is also useful in centering tubes **10** and **12** during manufacturing of the device.

The portion **38** having the said first thickness extends laterally across most of the cross-sectional area inside the spacer tubes, defining rounded outer shoulders **42** and **44** where the said first portion is joined to the peripheral portion **40** of reduced thickness. Shoulders **42** and **44** are adjacent the spacer tubes **10** and **12** and protect the joint formed between portion **40** and the spacer tubes from the electrode arcing within the device. The electrode portion **38** thus protrudes longitudinally within the second ends of spacer tubes **10** and **12,** presenting substantially parallel lateral faces **46** and **48** which are in exposed juxtaposition with the exposed lateral arc-supporting surfaces **26** and **28** of electrodes **14** and **16,** forming gaps **47** and **49.** The surfaces **26, 46, 28,** and **48** are substantially parallel to one another and the gap distances for gaps **47** and **49** are substantially equal.

The central portion **38** of electrode **36** is provided with an axial bore **50,** desirably of constant diameter, forming a passage between the aforementioned gaps whereby an arc discharge across one of said gaps will immediately illuminate the other and cause substantially simultaneous breakdown and discharge across the second gap. The diameter of this axial bore is desirably between approximately 1/3 and 3/4 the diameter of the arc-supporting surfaces **26** and **28,** i.e., the bore is not so large that spark-gaps **47** and **49** no longer exist in longitudinal direction between substantially lateral and parallel electrode surfaces of substantial size. Then, principal discharges occur between surfaces **26** and **46,** and between surfaces **28** and **48,** with electrode **36** grounded. Electrode **36** intercepts or becomes involved in longitudinal discharges because it is interposed as a partial barrier between arc-supporting surfaces **26** and **28.**

Arc-supporting surfaces **26** and **46** may be thought of, in a narrow sense, as comprising the end parts of electrodes **14** and **16** for which it can be said the sum of distances a and b is less than c, along substantially any longitudinal line intersecting the electrode ends. Thus arcing will preferentially take place in gaps **47** and **49** rather than along path c. Even though the faces **26** and **28** or peripheral portions thereof can be somewhat rounded, severly tapered end electrodes are not as desirable since the center electrode could then lie outside a principal longitudinal arcing path between the end electrodes. The construction according to the present invention is unlike prior constructions employing a cylindrical center electrode radially spaced from the arcing path between principal end electrodes. Thus, according to the present invention the tendency will be for arcing to take place to the center electrode **36** for grounding the transient, with such electrode **36** further forming a barrier, subsequently acting to break up the arcing path and extinguish the discharge.

In assembling the spark-gap device according to the present invention, the ends of the ceramic spacer tubes are suitably metallized as indicated at **70** and **72** with a high temperature metal or alloy, i.e., molybdenum plus manganese. Brazing washers **68** and **74,** which may be formed of an alloy of silver and copper, may be positioned on the metallized ends, and electrodes **14** and **16** are inserted into the first open ends of tubes **10** and **12.** The tubes are aligned with electrode **36** interposed therebetween, the outer axial flange **66** assisting in the correct alignment of the structure. The assembly as described, with brazing washers in place, is suitably raised in temperature to braze the assembly with the interior thereof being evacuated and suitably provided with an internal gaseous environment at less than atmospheric pressure facilitating breakdown at fairly low transient voltages. A radioactive material may be provided. The completed structure provides hermetically sealed chambers for the respective gaps **47** and **49,** said chambers being joined by the bore **50** in electrode **36.** Although the disc-shaped electrode **36** may be formed of Kovar, i.e., the material from which electrodes **14** and **16** are formed, the electrode **36** is more suitably formed of copper and fabricated by means of a coining operation.

A spark-gap according to the present invention is connected to a line to be protected as illustrated in FIG **1** wherein electrodes **14** and **16** are connected respectively to conductors **54** and **56** extending from a main line or source of power at terminals **58** and **60** to a load or other utilization device **62.** A ground connection **64** is also provided which is connected to outer flange **66** of center electrode **36.**

When a predetermined voltage level is reached, e.g., as a result of a high voltage transient on the line, gaps **47** and **49** break down into an arc discharge, thereby shorting out the high voltage transient to ground and

protecting load 62 or other equipment on the line. Usually the same value of high voltage transient will appear on each line, and as the lines are connected to ground by the present device, the voltages effectively cancel at load 62. As a result of the passage provided by axial bore 50 in central electrode 36, substantially simultaneous ionization takes place at both gaps. Not only does direct gas ionization take place through the passage, but also the initiation of an arc discharge across one gap provides radiation illuminating the region of the other gap. This illumination produces photoelectrons at an electrode surface of the opposite gap, which in turn causes ionization of the gas in the region of such gap. For example, assuming gap 47 is the first to break down, the arc discharge at gap 47 will illuminate surface 28 of electrode 16 through bore 50. The photons reaching surface 28 will produce photoelectrons which will be emitted from surface 28 then, which in turn will cause ionization of gap 49. As a result, gap 49 breaks down substantially immediately into an arc discharge. The time lag during which the foregoing events take place is such that both gaps break down at substantially the same time. The terms illumination and radiation employed above are meant to comprehend ultraviolet and/or visible radiation.

Thus both gaps break down to ground at the same time, usually shorting the same voltage to ground in a balanced manner and providing optimum protection to equipment. Even though a line-to-line dischage may be present or may start first, each line is effectively grounded because of the intercepting interposition of electrode 36. Therefore the cooperation achieved with electrode 36 is such that arcs are struck to the center electrode in a simultaneous, balanced manner.

A further advantage of the present invention, as indicated above, is action of electrode 36 in breaking up or extinguishing the arc discharge when an over-voltage condition is removed. The arc discharge more easily extinguishes than has frequently been the case with prior art three-electrode devices, after the high voltage transient has subsided. The electrode 36 acts as a barrier for quenching arcs in the extended arc path therethrough.

There is provided according to the present invention a small size spark-gap device which is suitably constructed to break down and provide arc discharges to ground at relatively low transient voltage values. Moreover, discharge to ground occurs between each electrode and the center or grounded electrode, substantially simultaneously, enhancing the protection afforded. At the conclusion of the high voltage transient, the spark gap device according to the present invention more quickly extinguishes the arc with the center of grounded electrode acting as a barrier for helping to quench the discharge. The device is structurally strong, enabling the same to withstand heavier sruges and a greater number of surges during its operating lifetime. Furthermore, the three-electrode device according to the present invention is extremely compact and compatible with miniature equipment, being nearly as small as prior two-electrode devices, while also being simple and economical to fabricate. The shortness of the device, and particularly, the shortness of electrode 36, brings about faster communication of ionization between gaps 47 and 49.

The device according to the present invention is susceptible to variation without departing from the inventive concept. For example, the center electrode 36 is illustrated as having an axially wider central portion 38, which is of advantage in providing shoulders 42 and 44 for protecting the joint between tubes 10 and 12 and electrode 36. Moreover, the added thickness aides in positioning the ceramic tubes and in decreasing the gap distances for gaps 47 and 49 while lengthening the gap distance directly between surfaces 26 and 28. However, in many instances the disc electrode 36 is suitably entirely flat, i.e., with central portion 38 no wider than peripheral portion 40.

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

I claim:

1. A spark-gap device suitable for providing transient protection to a line above a predetermined voltage level, said device comprising:

a first and second aligned conductive end electrode means, and hollow enclosure means therebetween, said electrode means extending into said hollow enclosure means in opposed relation,

and a third electrode means disposed between said first and second electrode means and supported by said enclosure means, said third electrode means comprising a solid conductive disc provided with a direct passage therethrough providing a line-of-sight path between said first and second electrode means, said disc having lateral faces exposed in facing, longitudinal juxtaposition with exposed arc-supporting surfaces of said first and second electrode means to provide spark-gaps between said first and second electrode means and said disc, said disc forming an effective barrier between exposed arc-supporting surfaces of said first and second electrode means except for said passage so that said disc becomes involved in arc discharges which occur in said device,

said end electrode means, said disc and said hollow enclosure means being joined to provide closed chambers between said end electrode means and said disc joined by the passage in said disc.

2. A spark-gap device suitable for providing transient protection to a line above a predetermined voltage level, said device comprising:

hollow cylindrical insulating spacer means open at opposite ends thereof,

a first conductive electrode which is substantially cup-shaped in overall configuration having a radial flange at its first end extending over and joined to a first end of said insulating spacer means, the second end of said conductive electrode being closed and disposed within said spacer means to provide an exposed lateral arc-supporting end surface within said spacer means oriented longitudinally inwardly thereof,

a second conductive electrode which is substantially cup-shaped in overall configuration having a radial flange at its first end extending over and joined to the second end of said insulating spacer means, the second end of said second conductive electrode being closed and disposed within said spacer means to provide an exposed lateral arc-supporting end

surface within said spacer means oriented longitudinally inwardly thereof toward the second end of the first electrode,

and a conductive solid disc peripherally supported by said spacer means and positioned between second ends of said conductive electrodes, said disc having a central axial bore providing a passage exposing said arc-supporting end surfaces to one another, said disc having its opposite lateral faces exposed in facing juxtaposition to substantially parallel exposed arc-supporting end surfaces of said first and second conductive electrodes to provide longitudinal gaps between the lateral faces of said disc and said first and second conductive electrodes.

3. A spark-gap device suitable for providing transient protection to a line above a predetermined voltage level, said device comprising:

a first cylindrical insulating spacer provided at first end thereof with a first conductive electrode which is substantially cup-shaped in overall configuration having a radial flange at its first end extending over and joined to the first end of the first insulating spacer, the second end of said conductive electrode being closed and disposed within said spacer to provide an exposed lateral arc-supporting end surface within said spacer oriented longitudinally inwardly thereof,

a second cylindrical insulating spacer axially aligned with the first spacer and provided at a first end thereof with a second conductive electrode which is substantially cup-shaped in overall configuration having a radial flange at its first end extending over and joined to the first end of the second insulating spacer, the second end of said second conductive electrode being closed and disposed within said second spacer to provide an exposed lateral arc-supporting end surface within said spacer oriented longitudinally inwardly thereof toward the second end of the first electrode,

and a conductive solid disc peripherally joined to said first and second spacers at second ends thereof, said disc having a central axial bore providing a passage exposing said arc-supporting end surfaces to one another, said disc having opposite lateral faces exposed in facing juxtaposition to substantially parallel exposed arc-supporting end surfaces of said first and second conductive electrodes to provide longitudinal gaps between the lateral faces of said disc and said first and second conductive electrodes, said electrodes, said disc and said spacers being peripherally joined to provide hermetically sealed chambers between said electrodes and said disc joined by the bore in said disc.

4. The device according to claim **3** wherein said disc has a first thickness extending within said spacers providing said opposite faces in juxtaposition with said exposed arc-supporting end surfaces, said disc having a peripheral portion of reduced thickness between and joined to said spacers, with said disc just inwardly from said peripheral portion defining a shoulder adjacent joints formed between said peripheral portion and said spacers.

5. The device according to claim **4** wherein said disc is further provided with an axial flange at the outer edge of said peripheral portion of reduced thickness, said axial flange extending adjacent and over a portion of at least one of said cylindrical insulating spacers.

6. The device according to claim **3** wherein said central axial bore in said disc has a diameter between approximately one-third and three-fourths of the diameters of said end surfaces of said conductive electrodes.

7. The device according to claim **3** wherein the second ends of said first and second conductive electrodes providing said arc-supporting end surfaces are substantially planar over the major portion thereof.

8. The device according to claim **3** wherein the second ends of said first and second conductive electrodes providing said arc-supporting end surfaces are provided with a plurality of small cavities containing low work function material.

9. The device according to claim **3** wherein the sum of the longitudinal distances between said arc-supporting end surfaces and the lateral faces of said disc along substantially any longitudinal line intersecting said arc-supporting end surfaces is less than the closest longitudinal distance between said arc-supporting end surfaces.

10. The device according to claim **9** wherein the diameter of the bore in said disc is between approximately one-third and three-fourths of the diameter of the said arc-supporting end surfaces.

11. The device according to claim **3** wherein the portions of said electrodes between the ends thereof are substantially cylindrical and closely adjacent the cylindrical interior walls of said spacers.

12. The device according to claim **3** wherein said spacers are formed of ceramic material.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,811,064 Dated May 14, 1974

Inventor(s) Chester J. Kawiecki

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 54, "pate" should be --path--.

Column 4, line 1, "surfacces" should be --surfaces--.

Column 5, line 54, "of" should be --or--.

Column 5, line 57, "sruges" should be --surges--.

Column 6, line 5, "aides" should be --aids--.

Column 7, line 18, after "at" insert --a--.

Column 8, line 22, "diameters" should be --diameter--.

Signed and sealed this 5th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
☆ U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,811,064 Dated May 14, 1974

Inventor(s) Chester J. Kawiecki

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 54, "pate" should be --path--.

Column 4, line 1, "surfacces" should be --surfaces--.

Column 5, line 54, "of" should be --or--.

Column 5, line 57, "sruges" should be --surges--.

Column 6, line 5, "aides" should be --aids--.

Column 7, line 18, after "at" insert --a--.

Column 8, line 22, "diameters" should be --diameter--.

Signed and sealed this 5th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334