Dec. 23, 1952 J. W. KALB 2,623,197

SPARK GAP DEVICE

Filed Jan. 22, 1951

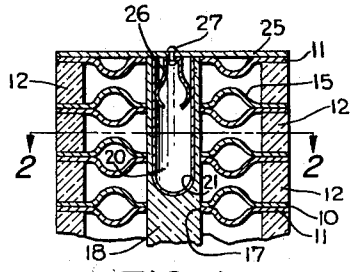


FIG. 1

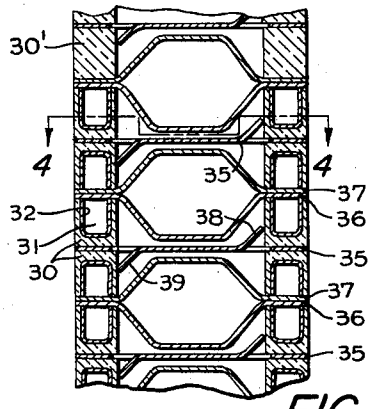


FIG. 3

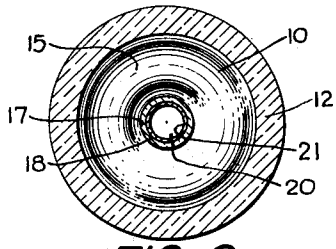


FIG. 2

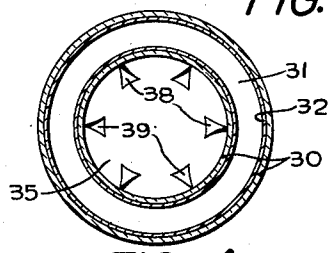


FIG. 4

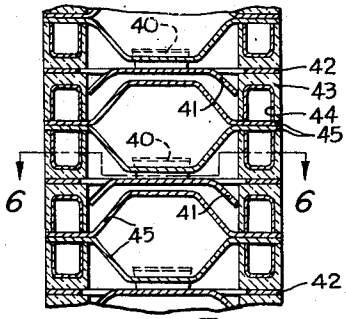


FIG. 5

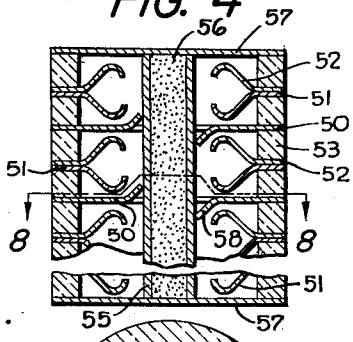


FIG. 7.

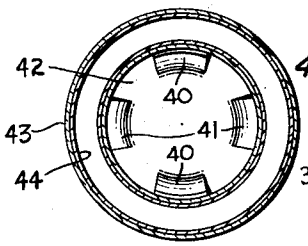
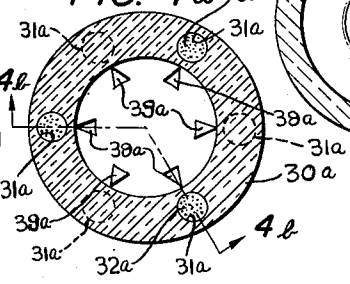


FIG. 6

FIG. 4a



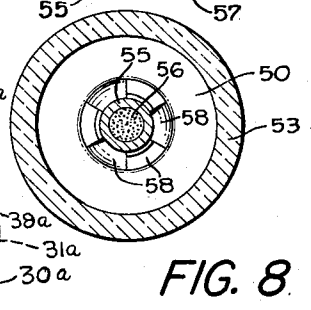


FIG. 8

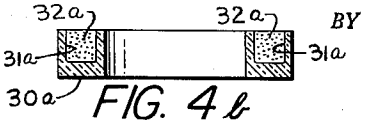


FIG. 4b

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SPARK GAP DEVICE

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Application January 22, 1951, Serial No. 207,183

24 Claims. (Cl. 315—36)

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This invention relates to an improved spark-gap device for a lightning arrester or the like, and an improved element for use therein.

Spark-gap devices are formed of metal electrodes—usually brass—which are spaced by an insulating material which may be porcelain or titanium dioxide (rutile), etc. Some spark-gap devices include, in addition to the spacers, insulating material in the form of a rod or the like which extends through a central opening in the electrodes, from one end of the spark-gap device to the other.

The spark-gap device is designed so that when connected between a line and the ground, the line will carry any usual voltage it is designed to carry, and the spark gaps will prevent this current from flowing into the ground. However, when lightning strikes, or when for any other reason there is an electric surge of high voltage through the line, the current will discharge across the gaps into the ground.

Generally speaking, the more rapidly a spark-gap device discharges the more satisfactory it is. It is recognized that if the air or gas in the space between the electrodes of a spark gap is ionized, the spark gap discharges rapidly when subjected to a high voltage impulse. This discharge occurs at a minimum voltage which is predictable and consistent. In order to ionize the air or gas it has been proposed to have ionization tips of conducting material project from the electrodes of a spark gap and to locate them adjacent insulating material where the voltage is different from the voltage of the respective ionization tips. The nearness of an ionization tip to the insulating material may influence the voltage of the latter by tending to bring it to the voltage of the electrode to which the ionization tip is connected. The greater the area of the ionization tip adjacent the insulating material, the greater the tendency to bring its voltage to the voltage of the electrode.

According to this invention a conducting material is employed in combination with the insulating material to increase the voltage differential between it and one or more ionization tips contiguous to it by maintaining the insulating material at a different voltage level than it would have if the conducting material were not present. For instance, the top of a gap spacer or insulating rod, etc. may be hollowed out and the surface of the hollow coated with the conducting material. Because of the high capacity between this inner coated surface and the exposed surface of the spacer, the latter is maintained at or near the voltage of the conducting coating. If the coating is connected with one electrode of the gap device and a different electrode of the gap structure (or conducting material connected with it) is placed contiguous to the exposed surface of the spacer, so that it is separated from the conducting material by only a thin partition of the insulating material of which the spacer is composed, when a high voltage surge is impressed across the gap device corona discharge will form over the exposed surface of the spacer adjacent the point of contiguity causing rapid and consistent breakdown of the gap. Instead of coating the surface of the hollow with a conducting material, the hollow may be filled with a conducting paste or other body of low resistance.

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Also, according to this invention, resistance material is associated with insulating material adjacent several electrodes operating at different potentials, to maintain in a more positive manner the difference in potential of the portions of the insulating material nearest the different electrodes, thereby to lessen the effect of the ionizing tips in inducing on the insulating material the potentials of the respective electrodes from which they project.

To illustrate, reference is had to a cylindrical porcelain rod located in the central opening through a plurality of electrodes with one ionizing tip from each electrode adjacent the surface of the rod. It is to be understood that the electrodes are shaped so that in an area away from the central opening spark gaps are formed between them. The voltage of each of the electrodes will be induced on the rod, and when a high voltage surge is discharging over the spark gaps, there will be the same voltage drop over the length of the rod as from one end of the spark-gap device to the other. Assuming that the portion of each electrode adjacent the central opening is perfectly flat, and that the ionization tips projecting from the electrodes are contiguous to the porcelain rod in the respective planes of these flat portions of the electrodes, the voltage of the rod adjacent each of the ionization tips will be the same as the voltage of the electrode from which the tip projects. Assuming that the electrodes are all of the same construction and uniformly spaced from one another, and that the ionization tips are all of the same size and all bear the same relation to the porcelain rod, there will be a voltage drop between each two electrodes, and the intermediate portions of the rod will be at a voltage intermediate the voltage of the electrodes.

However, if the rod is hollow for a portion of

its length, and the surface of the hollow is coated with some conducing material as contemplated by this invention, and that conducting material is connected with one of the electrodes, e. g., the top electrode of the entire spark-gap device, the conducting material will be maintained at the voltage of the top electrode, and likewise, the entire portion of the rod which surrounds this conducting material will tend to be maintained at the voltage of the top electrode. The presence of the other electrodes in the vicinity of the rod will tend to lower the voltage of the rod step by step in the vicinity of each succeeding electrode, but the voltage of the rod in the plane of each electrode will be higher than the voltage of that electrode. Thus, each ionization tip, although in the plane of its electrode, will be contiguous to porcelain which is at a different voltage from the electrode to which the tip is connected, and consequently at a different voltage from the ionization tip. It follows, that when a high voltage surge is impressed upon the spark-gap device, corona discharge will form over the surface of the porcelain rod around each ionization tip and ions will radiate from it. The presence of such ions in the space between the electrodes of several or all of the spark gaps will facilitate the discharge of electricity, making a much faster spark than would otherwise be obtainable, and this discharge will occur at a minimum voltage.

Various embodiments of the invention are possible and a few of these are illustrated in the drawings. In the drawings—

Fig. 1 is a vertical section through the top of a spark-gap device;

Fig. 2 is a horizontal section on the line **2—2** of Fig. 1;

Fig. 3 is a vertical section through an intermediate portion of an alternative spark-gap device;

Fig. 4 is a section on the line **4—4** of Fig. 3;

Fig. 4A is a section similar to the section shown in Fig. 4, but showing a modified type of spacer;

Fig. 4B is a vertical section through the modified spacer;

Fig. 5 is a vertical section through a modification of the device shown in Fig. 3;

Fig. 6 is a section on the line **6—6** of Fig. 5;

Fig. 7 is a vertical section through an alternative spark-gap device; and

Fig. 8 is a section on the line **8—8** of Fig. 7.

Figure 1 shows the upper end of a spark-gap device which includes pairs of electrodes **10** and **11** separated by annular spacers **12**. The electrodes are all of the same size and shape but alternate ones are inverted so that the annular dished portion **15** of the upper electrode **10** of each pair approaches the corresponding dished portion of the lower electrode **11** to form a spark gap. A spacer **12** separates the two electrodes **10** and **11** of each spark gap.

There is a central opening **17** in each electrode and the openings in all of the electrodes are directly above one another. The rod **18** is located in these openings. Figure 2 shows that the central openings in the electrodes are circular; but they may be serrated or have an otherwise irregular edge. The rod **18** need not be in contact with the electrodes as shown in Figs. 1 and 2 but there may be a very small space between them.

The spacers **12** and the rod **18** are made of porcelain or rutile or other insulating material. The electrodes are ordinarily stamped from sheet brass but may be made of any suitable metal. If the rod **18** were of uniform composition and construction throughout, the portion continguous to each electrode would have the voltage of the electrode induced upon it.

When such a spark gap is subjected to an electric surge, the voltage drop from the top of the column to the bottom of the column is the same as the voltage drop between the two terminals of the spark-gap device. However, the column is not of uniform composition and its construction is not uniform throughout. The upper end is hollowed out and the wall of this hollow portion **20** is coated with a thin coating **21** of brass or other metal. This coating may be applied to the surface of the hollow by electroplating, spraying, applying a conducting glaze or in any other manner. There is a metallic end disc **25** which covers the top of the pile of spark-gap units in a customary manner. It lies upon or is held against the top electrode **11**. The metallic spring **26** is fastened to the end disc by the bolt **27**. As is customary, the end disc **25** is maintained at the voltage of the line or other conductor to which the top of the spark-gap device is connected. Through its contact with this disc the spring **26** is maintained at this same voltage. This spring is formed with several narrow, depending arms which are pressed into contact with the coating **21** in several places. In this manner the coating **21** is maintained at the same voltage potential as the end disc **25**. The coating **21** covers a large surface of the column and the voltage of this coating has a greater influence on the voltage of the column than the line contact of the various electrodes.

When an electric surge is discharged through the spark-gap device there is no voltage differential between the surface of the rod and the top electrode **11** which contacts the end disc **25**. However, there is a substantial differential between each of the next four electrodes and the area of the rod contiguous to each. As a consequence of the difference in potential a corona discharge occurs over the outer surface of the hollow portion of the rod adjacent the inner edge of each of these four electrodes. The electrons produced radiate into the adjacent gap space and ionize the air. As a consequence the upper three gaps break down almost immediately when a surge occurs, and they spark over at a minimum voltage which is always the same. There is no corona discharge over the surface of the lower portion of the rod below the hollow **20**, because there the voltage of the rod is that induced by the adjacent electrodes. These electrodes and the adjacent surface of the rod are at the same voltage. However, the rapid discharge over the top three gaps increases the voltage drop over each of the other gaps, and this increase may be sufficient to hasten the discharge over the balance of the gaps. For instance, if the spark-gap device of Figs. 1 and 2 contains a total of no more than thirty gaps, rapid discharge of an electric surge over the top three gaps, will ordinarily cause the other gaps to discharge substantially simultaneously. This depends upon the design of the device. By providing the metal-coated hollow at one end of the rod, thus insuring ionization of the air in a sufficient per cent of the gaps, all of the gaps discharge rapidly, and at a consistently low and predictable potential.

The electrodes **10** and **11** contact the opposite surface of the wall of the insulating material from that coated with the conducting material. If the electrode and conducting material contacted the same side of the insulating material

it would be difficult to prevent the device from short circuiting.

Figures 3 and 4 show an alternative construction in which one end of each of the spacers **30** is hollowed out at **31** and the surface is coated with a metal or other conducting coating **32**. The top spacer **30'** is not hollowed out. These spacers are made of porcelain or other insulating material. The spark gaps are formed between flat electrodes **35** and dished electrodes **36** and **37**, each of which is formed from a flat disc. Alternate dished electrodes are inverted so that each of the lower electrodes **36** forms a spark gap with the flat disc **35** below it, and each of the upper electrodes **37** forms a spark gap with the flat electrode **35** above it. Ionizing tips **38** are bent upwardly from the flat electrodes and ionizing tips **39** are bent downwardly therefrom. The tips **38** contact the inner wall of the hollow portion of the adjacent spacer **30**. Because of the large area of the conducting surface **32** on the hollow in the spacer, and the fact that this coating is in contact with one of the lower electrodes **36**, the voltage of the inner surface of the spacer contiguous to the ionization tips **38** is the same as, or almost the same as, the voltage of the lower electrode **36**. Because of this difference in potential between the ionization tips **38** and the contiguous surface of the spacer, whenever an electric surge is impressed upon the spark-gap device corona discharge occurs around the tips **38**. The electrons produced radiate into the spark gap space, and it breaks down at a low and consistent value.

The lower ionizing tips **39** are contiguous to the next lower spacer at a point opposite the coated hollow in its lower end. The coating on this hollow portion is in contact with an upper electrode **37** so that the potential of that portion of the spacer which is contiguous to the tips **39** is substantially the same as the potential of the upper electrode **37**. When the spark-gap device is subjected to an electric surge, a corona discharge likewise occurs over the surface of this spacer about the tips **39** with a result comparable to that produced by the corona discharge about the tips **38**.

There may be any desired number of individual spark gaps in a spark-gap device of the type shown in Figs. 3 and 4. One end of each of the spacers may be hollowed out and coated, or only a few of the spacers—for example, ten per cent—may be constructed in this manner. Those so constructed may be located adjacent one another in the spark-gap device, or they may be spaced from one another. Figure 3 illustrates such a construction with the uppermost spacers **30'** shown as not hollowed out. The flat electrodes used between such spacers **30'** may be of the same construction as the electrodes **35**, and it is immaterial whether their ionization tips **38** and **39** are contiguous to surfaces of the spacers **30'** of widely different voltage from the tips or substantially the same voltage as the tips, because it is not necessary to form corona discharge over the surfaces of these spacers **30'**. If a sufficient number of the spacers **30** with coated hollow ends are used, the flat electrodes between the spacers **30'** may be made without ionization tips. For mass production it will ordinarily be desirable to have all of the electrodes of the same construction. It is for this reason that all of the flat electrodes in Fig. 3 are shown with ionization tips **38** and **39**.

Figure 4A is a section through a spark-gap device similar to that shown in Figs. 3 and 4, but utilizing a modified type of spacer **30a**. There are spaced hollows or pockets **31a** in the top of this spacer, and the hollows are filled with a graphite paste **32a**, or other low resistance material such as silicon carbide, carbon, etc. The upwardly pointing ionization tips **38a** contact the inner surface of the spacer opposite the several filled hollows. The downwardly projecting tips **39a** are contiguous the exposed inner surface of the next lower spacer, and adjacent each of these is a hollow filled with low resistance material. If the ionization points are staggered, the spacers must likewise be staggered, as indicated, so that there is only a thin partition of the insulating material of the spacer between the ionization point and the low resistance material.

Alternatively, the hollows may extend entirely through the spacer. In this type of spacer the hollows must be filled with high resistance material, such as carbon, graphite, silicon carbide grains, etc. to prevent the electrodes being short circuited through the spacers.

In an alternative type of spacer, an annular band of high resistance material extends from the top to the bottom of the spacer. This is bounded on each side by a thin annular wall of poreclain or other insulating material. Such high resistance prevents the spacer from short circulating the gap. By providing an annular layer of high resistance material, the spacer is uniform throughout, and in building up a spark gap device it is not necessary to arrange the spacers so that pockets of resistance material are opposite the ionization points, because there are no such pockets.

Figures 5 and 6 illustrate a somewhat similar construction, but in this device the portions **40** and **41** of the flat disc electrodes **42** which are bent upwardly and downwardly to contact the inner surface of the spacers **43** are not pointed, but make line contact with the spacers. The spacers are made of insulating material. Such line contact might be objectionable if the spacers were not hollowed out at one end and lined with a metal coating **44** which contacts the electrodes, because the line contact might be sufficient to induce in the spacer a potential substantially the same as the potential of the flat disc electrode. That would prevent the formation of corona discharge over the surface of the spacer. However, the influence of the metal coating over the large surface of the hollow of the electrode is sufficient to maintain the hollow portion of the spacer contacted by the ionization flanges or tips **40** and **41** at a potential substantially that of the dished electrodes **45**. Thus, when an electric surge is impressed upon the spark-gap device there is a voltage differential between the tips **40** and **41** and the contiguous surfaces of the spacers. Corona discharge occurs along the line of contact and over the surface of the spacers, and electrons radiate into the gap space and assure rapid spark-over at minimum potential.

Although generally the hollow of the rod or spacer will be coated with a conducting material, as illustrated in Figs. 1–6, alternatively the hollow may be filled with a paste or other body of low resistance. For example, a carbon or graphite powder or paste may be used. If a high resistance material were used there would be a voltage drop within the hollow, and there would be less voltage differential between the material within the hollow and the ionization

tip, etc. contiguous to the outer surface of the rod or spacer.

Figures 7 and 8 illustrate a different construction. There are flat disc electrodes **50** and also electrodes **51** and **52** the inner portions of which are dished to form annular spark gaps with the disc electrodes **50**. The electrodes **51** and **52** are identical in construction, one being inverted with respect to the other. They are arranged in pairs between spacers **53** which are made of insulating material. The upper electrode **52** of each such pair forms an annular spark gap with the flat disc electrode **50** immediately above it, and the lower electrode **51** in each pair forms a similar spark gap with the flat disc electrode **50** immediately below it. There is a central opening through the spark-gap device in which the hollow rod **55** is located. This rod is thin-walled porcelain, rutile or the like, and is filled with high resistance material such as a carbon resistance element, graphite or silicon carbide grains or the like, designated **56**. This filling of resistance material is in contact with an end plate **57** at both the top and bottom of the rod. Thus there is a surface gradient along the outer surface of the rod, the same as though a plain rod were used. However, the potential of the rod is maintained in a more positive manner. It is not so easily affected by contiguous ionization tips.

The tips need not terminate in a point. Fig. 8 shows the inner edge of the disc electrode **50** slit at six places, and the segments **58** thus formed are bent alternately up and down. The inner edges of the segments are contiguous to the rod a short distance above or below the plane of the disc **50**. Here the potential of the rod is different from the potential of the electrode, and the resistance filling within the rod inhibits the potential of a segment from being induced in the portion of the rod contiguous to it. Thus a difference in potential is maintained which causes corona discharge over the surface of the rod when an electric surge is impressed upon the spark-gap device.

As shown in the drawing, ionizing tips or flanges **58** project both upwardly and downwardly from the flat electrodes **50**. Alternatively, the ionizing tips might project only upwardly or only downwardly from these flat electrodes. The tips are blunt and, as shown in Fig. 8, they form a line contact with the surface of the rod which is sixty degrees in length. The voltage gradient over the length of the rod is not greatly affected even by such line contact because of the filling **56**, whereas without the filling the voltage of the respective electrodes would be induced in the rod, lessening the differential in voltage between each tip and the rod. When an electric surge is impressed upon the spark-gap device, corona discharge occurs over the surface of the rod about each tip. Ions produced by these discharges radiate into the annular gap spaces between the electrodes **50** and the dished electrodes **51**. The presence of these ions causes a rapid discharge over the gap space at a minimum and constant potential.

The foregoing are merely illustrative of constructions which produce ions which radiate into the gap spaces between the eelctrodes. Hollow spacers may be filled with resistance material to lessen the effect of contiguous ionization tips on the potential of the spacer. Many other modifications are possible.

The word "contiguous" is used herein to mean touching, and also near although not in contact.

The invention is defined in the appended claims.

What I claim is:

1. A spark-gap device formed in part of an element of insulating material and having at least two electrodes therein with a spark gap between them, a portion of one of the electrodes being contiguous to one surface of the element of insulating material, the opposite surface of the said element being contacted by conducting material connected to a conducting element of the spark-gap device maintained at a different potential from said electrode portion when an electric surge is impressed upon the spark-gap device.

2. A spark-gap device formed in part of insulating material and having a plurality of electrodes therein with at least one spark gap between them, an ionization tip projecting from an electrode and terminating contiguous to the surface of the insulating material, the insulating material being contacted by conducting material which is in contact with a conducting element of the spark-gap device through which current flows at a voltage level substantially different from the voltage level of the electrode from which the ionization tip projects, when an electric surge is impressed upon the spark-gap device, whereby the voltage of the insulating material contiguous to the ionization tip is made to approach the voltage of said conducting element and to produce a voltage differential between the ionization tip and the contiguous surface of the insulating material so that corona discharge will occur over said surface of the insulating material and about the ionization tip when the electric surge is impressed upon the spark-gap device.

3. A spark-gap device composed of conducting material and insulating material, said conducting material including a plurality of electrodes adapted to be maintained at different voltages, conducting material unitarily united with one surface of a thin portion of the insulating material and connected with conducting material in the spark-gap device which is at a different voltage from one electrode, said electrode being contiguous to the other surface of the thin portion of the insulating material.

4. A spark-gap device which includes spaced electrodes having an opening therethrough, the electrodes forming spark gaps therebetween, a rod composed of insulating material extending through the opening with its surface contiguous to the surrounding electrodes, that portion of said rod which extends through the plane of several of the electrodes being hollow, the surface of said hollow being contacted by a conducting material which is connected to other conducting material which, when an electric surge is impressed upon the device, is at a different voltage potential from at least some of said electrodes.

5. The spark-gap device of claim 4 in which the conducting material contacting the surface of the hollow is united thereto.

6. The spark-gap device of claim 4 in which the hollow does not extend through the rod.

7. The spark-gap device of claim 4 which includes an electrode the plane of which does not intersect the hollow, this electrode serving as the other conducting material with which the conducting material which contacts the hollow is connected.

8. A spark-gap device which includes a spark

gap formed of two electrodes spaced by an insulating spacer which embodies conducting material which is nearer one of the electrodes than the other, said conducting material being in contact with other conducting material in the spark-gap device which when an electric surge is impressed upon the device is at a voltage different from the voltage of said other electrode, a portion of said other electrode being contiguous to the spacer.

9. The spark-gap device of claim 8 in which one end of the spacer is hollow and is coated with the conducting material which is said to be embodied in the spacer.

10. The spark-gap device of claim 8 in which the said electrode is at one end of the spacer and the conducting material which is at a different voltage therefrom is the electrode at the other end of the spacer.

11. A spark-gap device which includes spaced electrodes having an opening therethrough, the electrodes forming spark gaps therebetween, a hollow rod of insulating material extending through the opening with its outer surface contiguous to the surrounding electrodes, the hollow containing resistance material which at opposite ends of the rod is connected to conducting materials in the spark-gap device which are maintained at different potentials when an electric surge is impressed upon the spark-gap device.

12. The spark-gap device of claim 11 in which the hollow is filled with the resistance material.

13. A rod of insulating material adapted for use in a spark-gap device, the rod being hollow from one end to the other with conducting material in contact with the surface of the hollow.

14. The rod of claim 13 in which the conducting material is an integral coating on the surface of the hollow.

15. A rod of insulating material adapted for use in a spark-gap device, one portion of the rod being hollow and the balance not being hollow, with conducting material in contact with the surface of the hollow.

16. The rod of claim 14 in which the conducting material is an integral coating on the surface of the hollow.

17. A rod of insulating material adapted for use in a spark-gap device, the rod being hollow from one end thereof to the other, there being resistance material in the hollow which is continuous from one end of the hollow to the other.

18. The rod of claim 16 in which the hollow is filled with the resistance material.

19. An insulating spacer for a spark gap, in one end of which spacer there is at least one hollow, the spacer including conducting material (which may be material of low resistance) which is in contact with the surface of said hollow.

20. The spacer of claim 18 in which the conducting material forms a coating on the surface of the hollow.

21. An insulating spacer for a spark gap containing high resistance material therein separated from the outer wall of the spacer by a thin partition of the insulating material of which the spacer is largely composed, said high resistance material extending from the top to the bottom of the spacer.

22. A spark-gap device comprising a plurality of spaced electrodes forming spark gaps therebetween, thin porcelain means extending at right angles to the plane of the electrodes, at least one electrode of each pair of adjacent electrodes which form a gap being provided with ionizing means contiguous to the outer surface of the porcelain means, the portion of the porcelain means opposite the said ionizing means being provided with conducting means, whereby there is capacity between said conducting means and the surface of the porcelain means contiguous to the ionizing means.

23. A spark-gap device comprising a plurality of spaced electrodes forming a spark gap between adjacent pairs of electrodes, porcelain means associated with the electrodes, the porcelain being hollow for at least a part of the length thereof, means projecting from one or more electrodes in contiguous relation to the porcelain means, and conducting means within the hollow connected with another of said electrodes, whereby there is capacity between said conducting means and the surface of the porcelain means contiguous to the projecting means.

24. A rod of insulating material adapted for use in a lightning arrester provided with a spark-gap device having a plurality of spark gap spaces, the rod provided with a bore extending from end to end thereof, and conducting means positioned in the bore and extending from one end of the bore to a point spaced from the other end of the bore, the said space being not less than the sum of the gap spaces in series, whereby electrostatic influence may be exerted on the gaps thereby influencing the early breakdown of the gaps.

JOHN W. KALB.

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The following references are of record in the file of this patent:

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