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QUICK-RESPONSIVE SPARK GAP DEVICE

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Fig 1

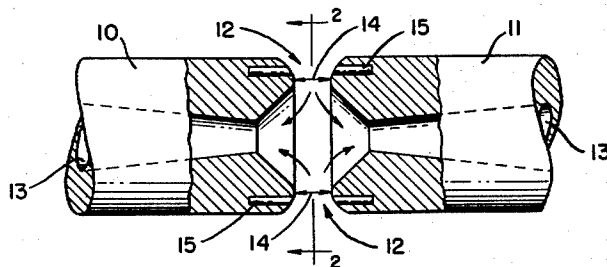


Fig 2

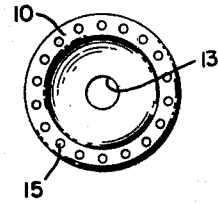


Fig 3

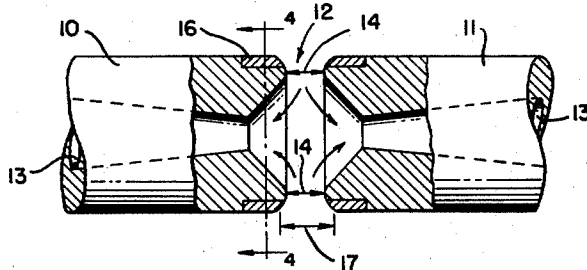


Fig 4

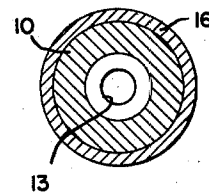


Fig 5

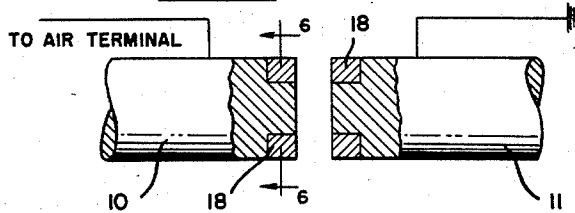


Fig 6

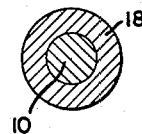
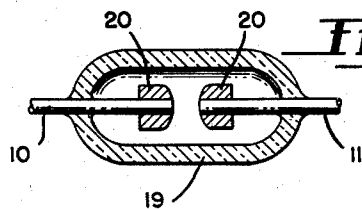


Fig 7



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QUICK-RESPONSIVE SPARK GAP DEVICE

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This invention relates to spark gap devices operating in normal atmospheric environment and is more particularly concerned with improvements directed toward more uniform and continuous operation of such spark gaps as employed in generating voltage impulses and high frequency currents.

Generally, difficulties are encountered in spark gap devices of the type referred to due to the fact that, when impressing steep-fronted voltage impulses having a peak voltage of about 20 percent higher than the breakdown voltage of the spark gap, a time lag exists between the impression of the voltage pulse and initiation of the spark-over. It will be remembered that such time lag is caused by and depends on the surface structure of the spark gap electrodes and the state of their surface oxidation. It is known that metals having a low work function, such as aluminum and magnesium, cause time lags in the order of 10^{-7} second, whereas other metals such as, for instance, copper, are metals of high work function, primarily because they have the tendency to cover themselves very rapidly with a thin coating of oxide which delays or even completely prevents the emission of electrons.

With electrodes of such materials, the time lag between voltage impulse and spark discharge, at peaking voltages about 20 percent higher than the spark gap breakdown voltage, may be several milliseconds. In spite of this slow action, electrodes of copper and other metals of high work function are preferably used for apparatus subjected to continuous operation and heavy loading, such as spark gap high-frequency generators and converters, on account of their long useful life, which is a multiple of that of material with low work function such as aluminum. The drawback of high work function and time lag in spark ignition is not detrimental in some cases, for instance, when it comes to carrying high loads or to producing a high number of impulses of the order of 1000 to 100,000 sparks per second, whereby the time intervals between successive sparks are so short that the electrode material, say copper, finds no time to cover itself with a coating of oxide. In operation under such condition, a time lag occurs only when firing the first spark of a series and not at subsequent sparks. The difficulty arises when such a system must be switched on and off very often, because then, particularly when high-voltage transformers are involved in the circuit, a considerable over-potential will develop at each switching-on operation on account of delayed spark-over caused by the oxide coating formed on the electrodes. An over-potential of that sort represents a heavy burden on high voltage condensers generally included in the network, and if a condenser is not constructed to withstand the highest over-potential that may occur during the switching-on surge, it is liable to fail before the spark gap responds.

In order to obviate the shortcomings pointed out above, the present invention contemplates to provide improved spark gap devices in which the spark-gap-forming electrodes constitute a combination of materials of both low and high work function and in which the first spark-over

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after the switching-on operation occurs between points of material of low work function without time lag or "inertia-poor," and in which subsequent sparks are driven by spark contracting action to more burn-off-resisting points of material of high work function.

For a better understanding of the present invention, there will now be described a few examples of embodiments in connection with the accompanying drawing in which

Fig. 1 is a longitudinal view, partly in section, of a pair of electrodes provided with pins of a material of low work function;

Fig. 2 shows a plan view of the face of one electrode viewed in the direction of the arrows 2—2 in Fig. 1;

Fig. 3 is a longitudinal view, partly in section, of a modified form of a pair of electrodes in which the material of low work function is applied in the form of rings;

Fig. 4 is a transverse section on the line 4—4 of Fig. 3, viewed in the direction of the arrows;

Fig. 5 is a longitudinal view, partly in section, of an embodiment of the invention as preferably employed in lightning protective devices;

Fig. 6 is a transverse section on the line 6—6 of Fig. 5, viewed in the direction of the arrows; and

Fig. 7 is a longitudinal section of a spark or arc gap according to this invention, sealed in a glass envelop.

Referring particularly to Fig. 1 of the drawing there are shown the oppositely arranged electrodes 10 and 11 of a spark gap for operation in a stream of air, and the direction of the introduced stream of air or gas for guiding the spark is indicated by arrows. Thus the air enters at 12 and leaves in coaxial direction with the electrodes through a center bore 13. The closest spacing between the electrodes is at 14 where generally the spark-over occurs. Now, in accordance with this invention, there are arranged a plurality of pin-shaped inserts 15 consisting of another metal, for example, aluminum, at a somewhat larger diameter around the closest spacing 14, as can best be seen in Fig. 2. In operation, whenever a peak voltage develops, the first spark caused by a series of voltage impulses will initiate between the active surfaces of sets of oppositely arranged pins 15, whereupon immediately thereafter the sparks travel to the closest spacing 14 assisted by the radially inwardly directed blast of air. Subsequent sparks of the series occur then without disturbance consistently only in the spacing 14 so that practically no burning-off of the pin-shaped units 15 takes place.

A modified pair of electrodes is depicted in Fig. 3. Here, instead of pins, rings 16 of material of low working function form the outer periphery of the electrodes. It will be noted that the oppositely arranged rings 16 are of such dimension that the spacing at 17 is somewhat wider than the closest electrode spacing at 14. In a practical example, for instance, the ring spacing was 3.5 millimeters at 17 and electrode spacing 3.0 millimeters at 14. If in manufacture the spacings at 14 and 17 would be made alike, then at the beginning of operation, all sparks would jump across the spacing established by the material of low work function, that is, between the pins 15 in Fig. 1 or between the rings 16 in Fig. 3, and would have no tendency to travel to the spacing formed by the material of high work function of which the electrodes proper are made. Such functioning would result in a rapid burning-off of the low-work-function material at the pin spacing 15 (Fig. 1) and ring spacing 17 (Fig. 2), and after a certain time of operation the proper relationship between spacings 14 and 15 or 14 and 17 respectively, would be established. However, during such burning-in period the characteristics of the spark gap would continuously change and no consistent operation could be assured. For this reason it is advisable to con-

struct the spark gap with proper spacing relationship between the metals of low and high work function and thus assure stable operating condition from the beginning.

For operation by direct current, whereby anode and cathode become established, the electric spark discharge is primarily initiated at the cathode by photo-electron emission beginning with dark discharges. Therefore, for direct-current operation, it is only necessary to provide the cathode with active low-work-function material portions, or to employ a cathode consisting completely of low-work-function material, such as aluminum, and to make the anode of another material having a higher work function and being more resistive against burning-off. For simplified fabricating and servicing it is, however, of advantage to employ only one type of electrodes in symmetrical arrangement as shown in the figures.

The improved spark gap means, as provided by this invention, are not only useful for generating voltage impulses and high frequency current, but the principle can be applied to rotary high frequency rectifiers and inverters. In order to prevent inconsistencies in operation of such equipment it is of importance to obtain a spark discharge as soon as possible after the voltage has passed through zero or after an electrode approach. Thus, in accordance with the teachings of this invention, a material of low work function would analogically be employed for the first initiation of spark-overs, whereas the main arc discharge continues to take place between the burn-off-resisting electrodes as usual in prior devices for that purpose.

To mention another field of application for the new spark gap means, the same principle can be employed in lightning protective devices, where a quick acting spark gap is desirable. An arrangement for this purpose is illustrated in Figs. 5 and 6. The electrodes 10 and 11, the former to be connected to air terminals of lightning rods (not shown) and the latter to ground, are provided around their periphery with rings 18 of low-work-function material causing a negligible time lag in lightning discharges. After the discharge has started between the rings 18, the thermal load is primarily carried by the high-temperature-resisting main portions of the electrodes due to self-contracting effect of the arc, whenever the lightning intensity of the stroke is high enough to develop an arc. Somewhat similar protective spark gap means, as provided by this invention, can be used for overhead power lines and other structures requiring such protection.

Where fire hazard is involved or other objections exist against an open spark gap, it is advisable to include the gap in a sealed envelop of glass or the like and such a construction is shown in Fig. 7. Here the electrodes 10 and 11, serving simultaneously as lead-ins sealed in the envelop 19, consist of burn-off resisting material and carry at their spark-gap-forming points collars 20 of low-work-function material. Practical experience with spark gaps of this construction has shown that the beneficial results of the combination of two different materials at the active portion of the electrodes are not materially impaired when locating the material of low work function at the center and the burn-off resisting material at the periphery. The proper spacing relationship for quick response and burn-off endurance will in time be established automatically by corresponding burn-off of the low-work-function material in each case.

From the description of some embodiments of the invention it will become apparent to those skilled in the art that various changes and modifications may be made which fall within the true spirit and scope of the present invention as aimed to be covered by the appended claims.

That what is claimed is:

1. A spark or arc gap device for operation in normal atmospheric environment comprising at least two electrodes facing each other in spaced relation, each electrode having an active face portion consisting of a com-

bination of at least two different conductive materials, one material of low work function and another of higher work function and higher burn-off resistance, said material of low work function arranged toward the periphery of said face portion, and said material of higher work function arranged toward the center thereof and conductively connected to said material of low work function.

2. A spark or arc gap device as specified in claim 1, wherein said material of low work function arranged toward the periphery of said face portion is in the form of a plurality of inserts in the material of higher work function.

3. A spark or arc gap device as specified in claim 1, wherein said material of low work function arranged toward the periphery of said face portion constitutes a ring surrounding a portion of said material of higher work function.

4. The device as claimed in claim 1, wherein said material of low work function comprises aluminum and said material of higher work function, copper.

5. The arrangement of a spark or arc gap device comprising a plurality of electrodes facing each other in spaced relation, each electrode having an active face portion consisting of a combination of two different conductive materials, one of said materials located toward the periphery of said active work face portion and being of low work function for quick response at the beginning of operation, the other of said materials located toward the center of said active face portion being of higher work function and burn-off resisting for sustained operation said materials being conductively connected, whereby the spacing between oppositely located active face portion of material of low work function is greater than the spacing between face portion of material of higher work function.

6. A spark or arc gap device for operation in a stream of air or gas comprising at least two electrodes facing each other in spaced relation, each electrode having a center bore and an active face portion consisting of a combination of at least two different conductive materials, one of said materials being of higher work function than the other material and burn-off resisting and forming an annular ridge surrounding said center bore, the other of said materials being of lower work function and being located radially outwardly around said first-named material and conductively connected thereto.

7. In a lightning protective device, in combination, one electrode to be connected to air terminals of lightning rods, another electrode to be connected to ground, both electrodes having active face portions and facing therewith in spaced relation oppositely an arc gap, said active face portions of each electrode consisting of a center portion of burn-off resisting conductive material and a peripheral portion of conductive material of low work function said materials being conductively connected, whereby the arc relieving the protected system of excessive voltage forms readily at the periphery of the gap between said low-work-function material and is immediately driven to the burn-off resisting portion at the center of the gap to relieve the burden on said material of low work function for increasing the life of said electrodes.

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