Dec. 19, 1944. W. E. BERKEY ET AL 2,365,518

ELECTRIC DISCHARGE DEVICE

Filed Sept. 17, 1941

Fig. 1.

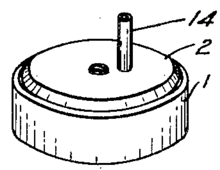


Fig. 2.

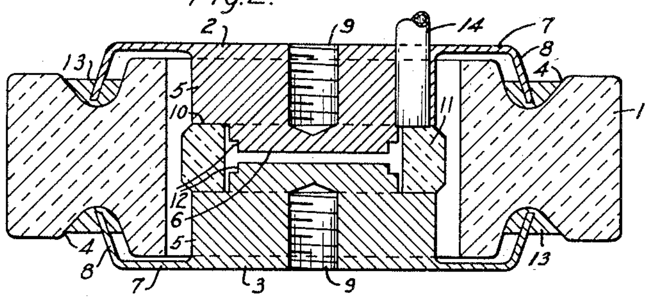


Fig. 3.

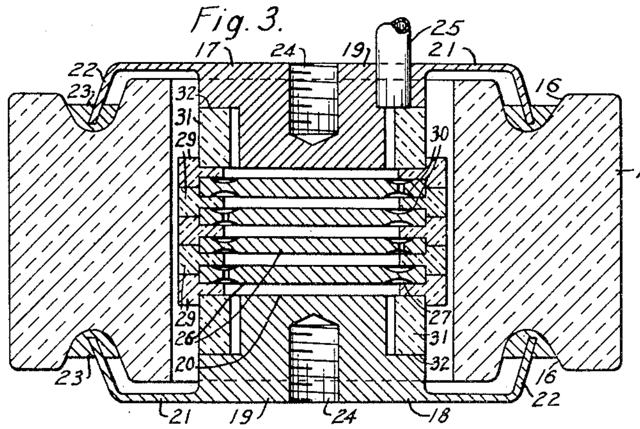
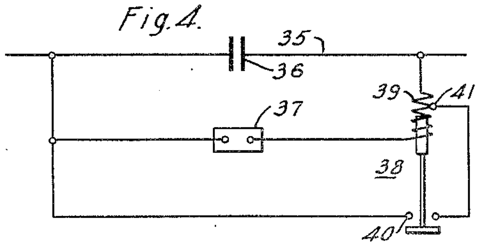


Fig. 4.



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Patented Dec. 19, 1944

2,365,518

UNITED STATES PATENT OFFICE

2,365,518

ELECTRIC DISCHARGE DEVICE

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Application September 17, 1941, Serial No. 411,142

4 Claims. (Cl. 175—30)

The present invention relates in general to electric discharge devices, and more particularly to an improved spark gap device which is suitable for use as a voltage-limiting device to limit the voltage across electrical apparatus, and for other similar protective applications.

It is often necessary to provide protective devices for limiting the voltage that may be applied across electrical apparatus. One important example of this is in the case of series capacitors, which are connected in series in alternating current lines to improve the voltage regulation and to increase the stability limits. Since such capacitors are connected in series, they carry the line current and very high voltages may appear across the capacitor in case of a fault on the line or an abnormal overload. When this occurs, it is necessary to by-pass the capacitor immediately in order to prevent serious damage to it, or even complete destruction of the capacitor. Spark gaps are usually used for this purpose because of their substantially instantaneous operation when the voltage rises above the value for which they are set, and the spark gap device of the present invention is especially suitable for the protection of series capacitors, although it will be obvious that it is also suitable for use as a voltage-limiting device in many other applications.

The spark gap of the present invention is of the low-pressure type described and claimed in the copending application of J. Slepian and W. E. Berkey, Serial No. 358,634, filed September 27, 1940, and assigned to the Westinghouse Electric & Manufacturing Company. As more fully set forth in that application, this type of spark gap has plane electrodes of relatively large area which are separated by air, or other gaseous medium, at a pressure in the range between 0.1 centimeter and 15 centimeters of mercury, and preferably less than 10 centimeters of mercury. Because of the low pressure the current density at the arc terminal is quite low, and there is little or no appreciable burning or erosion of the electrodes, so that they can be closely spaced to give a relatively low breakdown voltage, and the calibration of the gap is not changed even after repeated operation. Because of the low current density, which prevents excessive heating of the electrodes, and the large area of the electrodes, which permits the discharge to spread over their surfaces, such a spark gap has a very high discharge current capacity. The low pressure has the effect of reducing the breakdown voltage, but it has little effect on the extinction or cutoff voltage, so that the ratio of breakdown voltage to cutoff voltage is very low. For this reason, the low-pressure gap is inherently a self-extinguishing device in that the arc is extinguished when the voltage across the gap falls to a value only slightly lower than the breakdown voltage. Because of these characteristics, spark gaps of this type are very desirable for protective or voltage-limiting applications.

The principal object of the present invention is to provide a practical construction for spark gap devices of the low-pressure type which has high thermal capacity to permit the discharge of heavy currents, and which can be economically manufactured.

Another object of the invention is to provide a vacuum-tight spark gap structure having a long seal leakage path, and in which the seal can readily be made directly to an insulating containing member by means of an already developed manufacturing technique.

A further object of the invention is to provide a vacuum-tight spark gap structure having electrodes of high thermal capacity which are sealed directly to the insulating container member, and in which sufficient flexibility is provided in the electrodes to prevent putting unduly high stresses on the seal when the electrodes are heated by a discharge.

Other objects and advantages of the invention will be apparent from the following detailed description, taken in connection with the accompanying drawing, in which:

Figure 1 is a perspective view of the spark gap device of the present invention;

Fig. 2 is a transverse sectional view of the spark gap;

Fig. 3 is a transverse sectional view of a further embodiment of the invention; and

Fig. 4 is a wiring diagram showing a typical circuit in which the new gap device may be used.

The spark gap device shown in Figs. 1 and 2 is enclosed in a generally cylindrical container member 1 and has two metal electrodes 2 and 3. The container member 1 is preferably of porcelain, although other suitable insulating materials to which the electrodes can be sealed might be used if desired. Annular grooves 4 are provided in the end surfaces of the container member 1 to facilitate sealing the electrodes to the container as described hereinafter, and the grooves 4 are positioned far enough from the outside edge of the container to provide a long leakage path over the outside surface of the container. The electrodes 2 and 3 are preferably brass, although other metals, such as copper, might be used, and each electrode has a massive central portion 5 with a plane sparking surface 6 of large area, and also has a relatively thin peripheral portion 7, which is bent inward to form an annular flange 8 around the periphery of the electrode. A hole 9 may be drilled in the center of each electrode and tapped for the reception of a terminal stud of any desired type. The massive central portion of each electrode has an annular shoulder, indicated at 10, and the sparking surfaces 6 of the electrodes are spaced apart a definite, predetermined distance by an annular porcelain spacer 11, which engages the shoulders 10 of both electrodes. An annular groove 12 may also be provided about the circumference of the sparking surface of each electrode to prevent the discharge from spreading beyond the central sparking area and damaging the spacer.

In assembling the gap, the electrodes 2 and 3 are sealed directly to the porcelain container member 1 with a gas-tight seal. For this purpose the annular grooves 4 in the end surfaces of the container member are coated with a metallic glaze as described in the Smede and Shand Patent No. 1,852,093, issued April 5, 1932. The annular flanges 8 of the electrodes are then soldered to this glaze, as indicated at 13, forming a strong gas-tight seal. A small metal tube 14 is soldered in the electrode 2 to permit partial evacuation of the gap, and after the electrodes have been sealed to the container 1, the air pressure within the container is reduced to a pressure less than 15 centimeters of mercury, after which the tube 14 is sealed off. To facilitate this operation, the tube 14 may be coated with solder on the inside, so that it can be sealed off merely by pinching it together and heating sufficiently to melt the solder. The exact pressure to which the gap is evacuated is determined by the desired breakdown voltage, which is dependent on the gas pressure and on the spacing of the electrodes. It is also to be understood that the gap may be substantially completely evacuated, and then filled with an inert gas, such as nitrogen or argon, or a mixture of such gases, at the desired pressure.

Since the new gap operates at low pressure, it can be calibrated for a relatively low breakdown voltage, such as a few hundred volts, and it will retain its calibration unchanged even after repeated operation, because of the absence of burning of the electrodes. The large sparking area of the plane electrodes, which permits the discharge to spread over a large surface, together with the low current density and the high thermal capacity of the massive electrodes, which prevent excessive heating of the electrodes, gives the gap a very high current carrying capacity, so that it can be used safely in applications where very large currents are to be discharged. The thin peripheral portions 7 of the electrodes provide sufficient flexibility to avoid placing any undesirably large stresses on the seal when the electrodes expand as a result of heating by a discharge. At the same time, the thin, flexible peripheral portions 7 are held under sufficient strain, and have sufficient stiffness, to hold the shoulders 10 of the electrodes firmly against the spacer 11, as previously described. The electrodes are sealed directly to the porcelain container to provide a very simple and mechanically reliable gastight structure which can be economically manufactured because of its simplicity and because it employs a sealing technique which is already developed and in commercial use. The design of the container member 1 with the vacuum-tight seal made in grooves in its end surfaces is such that a long leakage path is provided across the outside of the container, as clearly seen in Fig. 2, thus obviating any danger of flashover between the electrodes on the outside of the container. It will be apparent, therefore, that a spark gap device has been provided which is of simple and inexpensive construction, and which has the advantages of low and unchanging breakdown voltage, high discharge current capacity, and low ratio of breakdown voltage to cutoff voltage.

For applications in which a higher breakdown voltage is desired than can readily be obtained with the single gap of Figs. 1 and 2, the multiple gap structure of Fig. 3 may be utilized. In this embodiment of the invention, the gap has a cylindrical container member 15 of porcelain, which is generally similar to the container member 1 described above, and which has annular grooves 16 in its end surfaces disposed so as to provide a long leakage path over the outside of the container. The gap device also has top and bottom electrodes 17 and 18, which are similar to the electrodes 2 and 3 previously described, having massive central portions 19, with large plane sparking surfaces 20, and thin peripheral portions 21. The outer edge of each electrode is bent down to form an annular flange 22 which is soldered to a metallic glaze in the grooves 16 of the container 15, as indicated at 23. Tapped holes 24 may be provided in the electrodes 17 and 18 for the reception of terminal studs, and a metal tube 25 is soldered in the electrodes 17 to permit partial evacuation of the device after the electrodes have been sealed to the container.

Within the container 15 a plurality of intermediate electrodes 26 are placed between the top and bottom electrodes 17 and 18. Each of the intermediate electrodes 26 has a plane sparking surface on both sides of the same area as the sparking surfaces 20 of the electrodes 17 and 18, and a shallow peripheral groove 27 to prevent the discharge from spreading beyond the sparking surface. Each of the electrodes 26 also has a small hole 28 drilled in it at one side to provide communication between the enclosed spaces between the electrodes, so as to insure that the gas pressure will be the same in all parts of the gap device. The electrodes 26 are separated by annular spacers 29 of porcelain, or other suitable insulating material. Each of the spacers 29 has an annular internal rib 30 which engages the adjacent electrodes and spaces them the desired distance apart, while the thickness of the spacers 29 is such that the adjacent spacers are in contact so as to form a solid stack which prevents any possibility of flashover between the outer edges of the electrodes 26. The top and bottom spacers 29 bear against annular porcelain spacers 31 which engage shoulders 32 on the electrodes 17 and 18 and which space the sparking surfaces 20 of the electrodes 17 and 18 the desired distance from the top and bottom intermediate electrodes 26.

It will be seen that with this construction the spacers 29 and 31 form a rigid stack between the electrodes 17 and 18 in which the intermediate electrodes 26 are firmly held. After the assembly of electrodes and spacers has been placed in position in the container 15, the top and bottom electrodes 17 and 18 are sealed to the container, as described above, with a gastight seal, and the device is then evacuated to the desired pressure through the tube 25, which is then sealed off. It will be apparent that this device has the same advantages as the single gap of Fig. 2 and operates in the same manner, but it is suitable for applications where a relatively high breakdown voltage is desired, because it provides a number of individual gaps in series.

Fig. 4 shows a typical circuit in which the new gap may be used. As previously explained, the low pressure type of spark gap is very well suited for voltage-limiting protective applications because of the fact that it can be accurately calibrated for relatively low breakdown voltages, and because of its high discharge current capacity as well as its low ratio of breakdown voltage to cut-off voltage. These characteristics make it very well suited for the protection of series capacitors against overvoltages. In Fig. 4, an alternating-current line is indicated at **35** and a capacitor **36** is connected in series with the line **35**. A low-pressure spark gap device **37**, such as is shown in either Fig. 2 or Fig. 3, is connected across the capacitor **36** to protect it from overvoltages. In some cases where the maximum current that may pass through the gap **37** is not too high, the gap may be connected directly across the terminals of the capacitor **36**, since the gap will cease discharging and restore the capacitor to service after the occurrence of an abnormal voltage as soon as the line current has fallen to its normal value, because of the inherent self-extinguishing characteristics of the low-pressure gap. In most cases, however, it is desirable to short-circuit the gap and relieve it from carrying the heavy short-circuit current for more than a few half-cycles. For this purpose, a contactor **38** is provided with its operating coil **39** connected in series with the gap **37** and its contacts **40** connected to short-circuit both the gap and the capacitor. Thus, if the overvoltage persists for more than a few half-cycles, the contactor **38** will have time to close its contacts **40** and short-circuit the gap, extinguishing the arc. Preferably, the contacts **40** are connected to a tap **41** in the coil **39**, so that after the contacts close, a part of the coil remains energized to function as a holding coil which maintains the contacts closed until the line current drops to its normal value, when the contactor drops out to restore the capacitor **36** to service. Thus, by the use of the new gap device, a simple and inexpensive means is provided for the protection of series capacitors, instead of the complicated and expensive arrangements previously used, involving auxiliary spark gaps, transformers and special contactors, which have greatly restricted the use of series capacitors because of the cost of the necessary protection equipment. It is to be understood that, although the new gap device is especially suitable for the protection of series capacitors, as just described, its usefulness is not restricted to this application, but it is also suitable for many other applications as a voltage-limiting or protective device.

It should now be apparent that a low-pressure spark gap device has been provided which is of simple and inexpensive construction, and which provides a practical structure embodying all the advantages of the low-pressure type of spark gap, as described above. It is to be understood that, although certain specific embodiments of the invention have been shown and described, it is not restricted to the precise details of construction shown, since various changes and modifications may be made without departing from the spirit of the invention, and the invention, therefore, includes all equivalent embodiments and modifications which come within the scope of the appended claims.

We claim as our invention:

1. A spark gap device comprising a generally cylindrical container member of insulating material, said container member having an annular groove in each of its end surfaces, a pair of metal electrodes disposed at opposite ends of the container member, each of said electrodes having a massive central portion which extends into the container and a relatively thin peripheral portion, the central portion of each electrode having a plane sparking surface of large area within the container, and the peripheral portions of the electrodes having annular flanges which extend into the grooves in the end surfaces of the container, means for fastening the annular flanges of the electrodes in the grooves of the container to form a gas-tight seal, and insulating spacing means within the container for spacing the sparking surfaces of the electrodes a predetermined, uniform distance apart.

2. A spark gap device comprising a generally cylindrical container member of insulating material, said container member having an annular groove in each of its end surfaces, a pair of metal electrodes disposed at opposite ends of the container member, each of said electrodes having a massive central portion which extends into the container and a relatively thin peripheral portion, the central portion of each electrode having a plane sparking surface of large area within the container, and the peripheral portions of the electrodes having annular flanges which extend into the grooves in the end surfaces of the container, means for fastening the annular flanges of the electrodes in the grooves of the container to form a gas-tight seal, and insulating spacing means within the container for spacing the sparking surfaces of the electrodes a predetermined, uniform distance apart, the container being filled with a gaseous medium at a pressure less than 15 centimeters of mercury.

3. A spark gap device comprising a generally cylindrical container member of insulating material, said container member having an annular groove in each of its end surfaces, a pair of metal electrodes disposed at opposite ends of the container member, each of said electrodes having a massive central portion extending into the container member and a relatively thin peripheral portion, the central portion of each electrode having a plane sparking surface of large area within the container, and the peripheral portions of the electrodes having annular flanges extending into the grooves in the end surfaces of the container, and means for fastening the annular flanges in said grooves to seal the electrodes to the container with a gas-tight seal.

4. A low-pressure, partially evacuated spark gap device comprising an annular housing member of an insulating material which is susceptible of having a closely adhering metallic coating applied to its surface, said housing member having an annular groove in each of its end surfaces, the surface of each groove having a closely adhering metallic coating thereon, a pair of terminal electrode members of metal, each electrode member having an inwardly bent peripheral flange extending into the annular groove at its end of the housing member, and a mass of solder filling each groove for making an air-tight soldered seal between the electrode and the housing member.

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