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PROTECTIVE DEVICE

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Fig. 1.

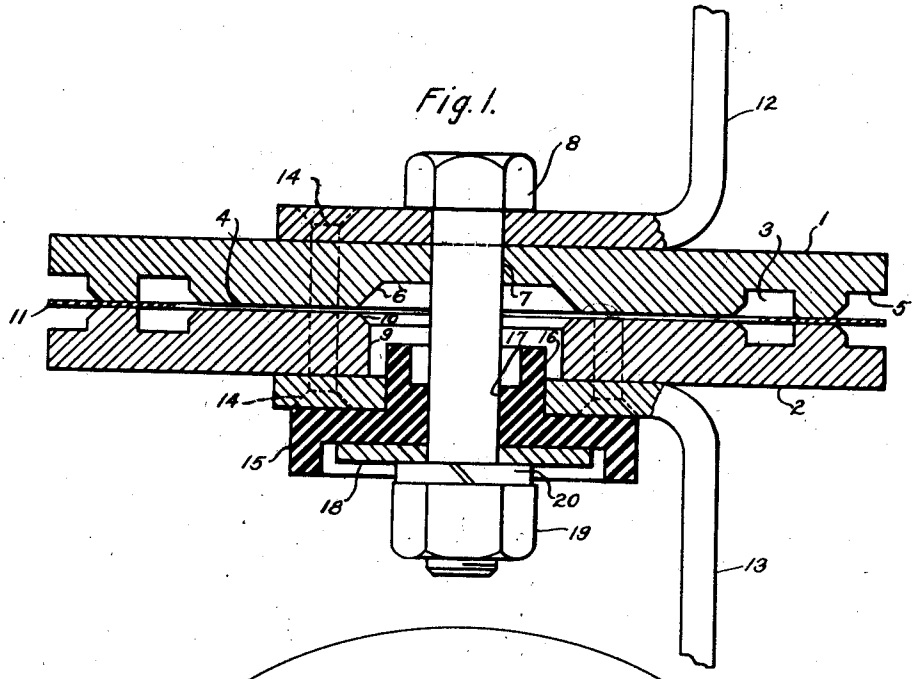
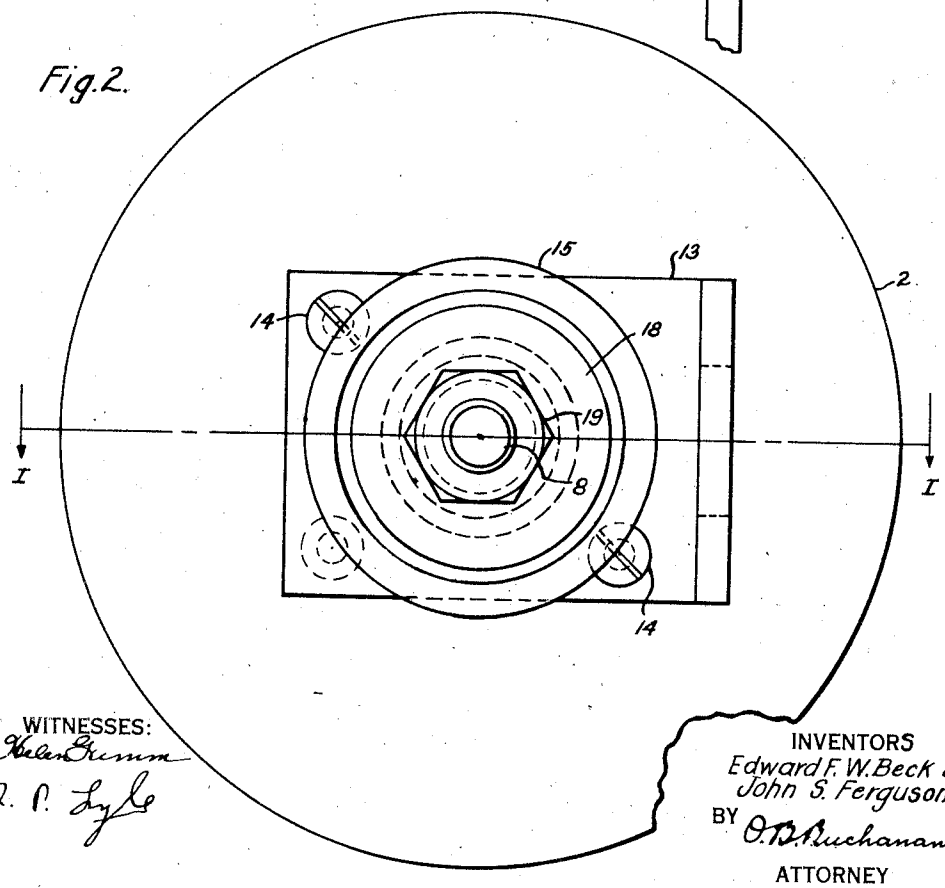


Fig. 2.



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PROTECTIVE DEVICE

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The present invention relates to protective gap devices, and more particularly to a protective gap for heavy-current discharges in which the electrodes of the gap weld, or fuse together.

The protective gap of the present invention is especially adapted for applications where protection is required against voltage surges such as may be caused by switching operations or circuit interruption, and where very heavy currents, such as currents of the order of several thousand amperes, may flow through the gap for appreciable periods of time. In such applications, and especially on direct-current circuits, it is not practical to use a self-restoring device which is capable of interrupting the heavy current, and it is desirable to utilize a device in which the electrodes of the gap weld, or fuse together, to provide a continuous metallic path which is capable of carrying the current without burning or excessive heating. Such a device, of course, must be replaced after it has operated, but this is not objectionable since operation of the gap occurs relatively infrequently, and as a result of known conditions such as switching operations.

The principal object of the invention is to provide a protective discharge gap which breaks down and becomes conducting upon the occurrence of a predetermined overvoltage, and in which the electrodes weld together to form a continuous metallic path which is capable of carrying heavy currents.

More specifically, the object of the invention is to provide a protective discharge gap for heavy-current discharges in which the electrodes weld together when a discharge occurs, and which is capable of discharging very heavy currents without overheating, and without continued arcing, emission of flame, or other noticeable disturbance.

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 transverse sectional view of a gap device embodying the invention, approximately on the line I—I of Fig. 2, and

Fig. 2 is an end elevation of the gap shown in Fig. 1.

In the preferred embodiment of the invention shown in the drawing, the protective discharge gap device comprises two closely spaced metal electrodes 1 and 2, which are preferably made of copper. Each electrode has an annular groove 3 near its periphery to confine the discharge to the central plane sparking surface 4, and has an annular recess 5 around its outer periphery to increase the creepage distance between the electrodes and prevent discharges across the outside of the gap. The sparking surfaces 4 are of relatively large area so as to be capable of carrying heavy discharge currents, and the electrodes are preferably made relatively thick and massive so as to have high thermal capacity. The large sparking surfaces also insure consistency of the break-down voltage of the gap. The electrode 1 has a recess 6 formed in the center of its sparking surface and surrounding a hole 7 for the reception of a bolt 8. The electrode 2 has a central opening 9, which may be of larger size, and which has its edges beveled, as indicated at 10, to coincide with the recess 6 in the electrode 1, so that the recess 6 and opening 9 together form an open chamber in the center of the sparking area of the gap. The electrodes are separated and spaced apart by an annular washer 11 of mica, or other suitable insulating material, which insulates the electrodes from each other under normal conditions, and which spaces their sparking surfaces 4 the desired distance apart. The washer 11 completely encloses the sparking surfaces so as to prevent the entrance of dirt or other contaminating substances.

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The gap device is mounted in position by means of mounting brackets 12 and 13, which are also used to effect electrical connection to the electrodes, and the brackets 12 and 13 are preferably secured to the electrodes 1 and 2, respectively, by means of screws 14. An insulating bushing 15 is provided, having a portion 16 which is adapted to extend through an opening in the bracket 13 and into the opening 9 in the electrode 2, and an outer portion of larger diameter which extends over the outer surface of the electrode and the bracket 13. The bushing 15 has a central hole 17 for the reception of the bolt 8. The gap device is held together by means of the bolt 8 which, as shown, passes through the bracket 12 and the hole 7 in the electrode 1 and through the hole 17 in the bushing 15, which insulates the bolt from the electrode 2. A washer 18 is placed in a recess in the bushing 15, and a nut 19 on the bolt 8 bears against the washer 18, a lock washer 20 being preferably also provided to prevent movement of the nut 19 after the gap has been assembled, which might change the spacing between the electrodes. The recessed outer portion of the bushing 15 provides a long leakage path between the bolt 8 and the bracket 13, while the inner portion 16 of the bushing similarly provides a long leakage path between the bolt 8 and the electrode 2, the latter leakage path being pro-

tected against dirt, or other conducting or semiconducting particles which might reduce the resistance to leakage currents. The bushing 15, in conjunction with the bolt 8, also serves to align the electrodes and thus facilitates assembly of the gap.

Since the electrodes are intended to weld together when the gap operates, they are closely spaced, the exact spacing depending, of course, upon the desired breakdown voltage. Thus, in a typical embodiment of the invention, the thickness of the mica washer 11 may be made such that the sparking surfaces 4 of the electrodes 1 and 2 are spaced apart a distance of the order of 10 to 25 mils, so that the gap breaks down on a voltage of the order of 2000 to 3000 volts. When a voltage in excess of the predetermined breakdown voltage appears across the gap, it will commence discharging, and with a heavy discharge current, the electrodes 1 and 2 will weld together almost immediately, so that the heavy current is discharged to ground through a continuous metallic path and the device does not become overheated, and no continued arcing or emission of flame or other undesirable phenomena occur.

The provision of the central space or chamber between the electrodes, formed by the opening 9 and recess 6, is an important feature of the invention, since it has been found that unless this space is provided, the electrodes will not weld together in the desired manner. Our present theory of the necessity of this space for satisfactory operation of the gap is that when a heavy-current discharge occurs, the heated gas and metal vapor in the restricted space between the electrodes tend to increase in pressure very rapidly because of the high temperature caused by the heavy current, and because of vaporization of the metal. If an expansion space is provided in the center of the sparking area of the gap, these heated gases and metal vapors can expand into this space and relieve the pressure in the sparking area, and welding of the electrodes occurs rapidly. If no such space is provided, however, the pressure between the electrodes can not be relieved and rapidly builds up to such a high pressure that welding of the electrodes is prevented, and the arc travels around between the electrodes, causing excessive heating and emission of flame from the gap. High pressure is also likely to blow the arc out to the outside of the mica spacer. These effects, of course, are highly objectionable, and a gap which does not weld, and in which continuous arcing and emission of flame or other visible disturbances occur is not satisfactory.

Whatever may be the theoretical reason for the necessity of the expansion space between the electrodes, however, our tests have shown conclusively that satisfactory operation can not be obtained unless such a space is provided. If it is provided, welding of the electrodes occurs almost immediately upon the occurrence of a discharge, and the operation is entirely satisfactory. Thus, in one particular embodiment of the invention, a gap of the construction shown in the drawing was designed to withstand 700 volts direct current continuously, and to commence discharging at a voltage of about 2400 volts direct current. The electrodes of this gap welded together substantially immediately upon the occurrence of a discharge, and the gap was capable of carrying 7500 amperes for as long as 30 seconds without excessive heating and without noticeable arcing or other objectionable phenomena. In a gap of similar construction, however, but in which the central expansion space was blocked off by a mica washer, the electrodes did not weld and the discharge was accompanied by violent arcing, emission of flame from the gap, and excessive heating and burning of the electrodes. Thus, the expansion space between the electrodes is essential to the satisfactory operation of a discharge gap of the type described.

A specific embodiment of the invention has been shown and described for the purpose of illustration, but it will be apparent that various modifications and other constructions are possible within the scope of the invention, and it is to be understood, therefore, that the invention is not limited to the specific embodiment shown, but in its broadest aspects it includes all equivalent modifications and embodiments which come within the scope of the appended claims.

We claim as our invention:

1. A protective discharge gap comprising a pair of flat, relatively thick metal electrodes having opposed plane sparking surfaces, an annular insulating spacer member separating said electrodes with their sparking surfaces closely spaced so that the electrodes are capable of fusing together when a heavy current is discharged, said spacer member completely enclosing the space between the electrodes, and at least one of said electrodes having a central recess of substantial depth therein to form an expansion space, the volume of said expansion space being large as compared to the volume of the space between the sparking surfaces.

2. A protective discharge gap comprising a pair of flat, relatively thick metal electrodes having opposed plane sparking surfaces, an annular insulating spacer member separating said electrodes with their sparking surfaces closely spaced so that the electrodes are capable of fusing together when a heavy current is discharged, said spacer member completely enclosing the space between the electrodes, and at least one of said electrodes having a central recess therein, the depth of said recess being greater than the spacing between the sparking surfaces to form an expansion space of relatively large volume between the electrodes.

3. A protective discharge gap comprising a pair of flat, relatively thick metal electrodes having opposed plane sparking surfaces, an annular insulating spacer member separating said electrodes with their sparking surfaces closely spaced so that the electrodes are capable of fusing together when a heavy current is discharged, said spacer member completely enclosing the space between the electrodes, one of said electrodes having a central recess of greater depth than the spacing between the sparking surfaces, the other of said electrodes having a central opening therethrough corresponding in position to said recess, the recess and opening forming an expansion space between the electrodes, securing means passing through the recess and opening for holding the electrodes together, and means for closing the opening.

4. A protective discharge gap comprising a pair of flat, relatively thick metal electrodes having opposed plane sparking surfaces, an annular insulating spacer member separating said electrodes with their sparking surfaces closely spaced so that the electrodes are capable of fusing together when a heavy current is discharged, said spacer member completely enclosing the space between the electrodes, one of said electrodes having a central recess of greater depth than

the spacing between the sparking surfaces, the other of said electrodes having a central opening therethrough corresponding in position to said recess, means for closing said opening, an insulating bushing member extending into the opening, the bushing being of smaller diameter than the opening, and a bolt passing through the bushing and through a central hole in the first-mentioned electrode to hold the electrodes together, the bolt being of smaller diameter than said recess and said opening.

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