

March 31, 1925.

F. W. PEEK, JR

PROTECTIVE DEVICE

Filed May 20, 1918

1,531,971

Fig. 1.

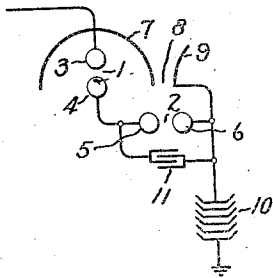


Fig. 2.

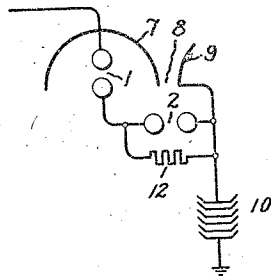


Fig. 3.

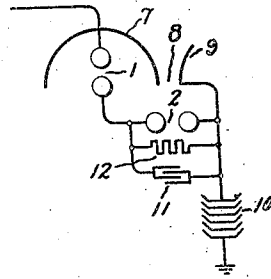


Fig. 4.

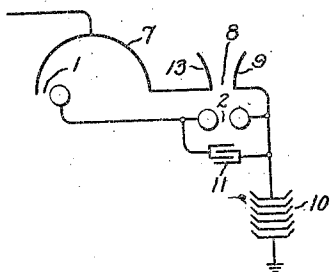


Fig. 5.

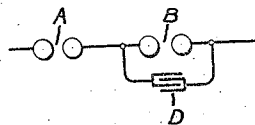
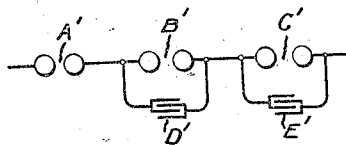


Fig. 6.



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UNITED STATES PATENT OFFICE.

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PROTECTIVE DEVICE

Application filed May 20, 1918. Serial No. 235,451.

To all whom it may concern:

Be it known that I, FRANK W. PEEK, JR., a citizen of the United States, residing at Pittsfield, in the county of Berkshire, State of Massachusetts, have invented certain new and useful Improvements in Protective Devices, of which the following is a specification.

My invention relates to protective devices and particularly to devices for the protection of electrical conductors from conditions of lightning disturbances, transients and other over-voltage phenomena.

The object of my invention is to provide a device which is operative to relieve a conductor from excessive voltage conditions caused by transients, surges and similar phenomena and more specifically to provide a spark gap device for use in outdoor service the discharge of which can be controlled by its dry arc-over voltage setting, which has substantially no time delay between the application of arc-over voltage and the discharge across the device and which is, in general, an improvement on similar devices heretofore known in the art.

It is well known, as described in United States Letters Patent 1,232,467, granted to me that a spark gap device comprising two cooperating electrodes having their proximal surfaces spherical and separated by a certain distance relative to the radius of the spheres, forms a device in which there is no appreciable time delay between the application of arc-over voltage and the discharge across the gap, and in which the impulse ratio is substantially unity, that is, the gap will discharge at its arc-over voltage setting independent of whether the impressed voltage is continuously applied or whether it occurs at successive or intermittent impulses such as caused by transients or surges of steep wave front. Such spark gap devices when used for outdoor service are affected by weather conditions as the accumulation of rain, ice and snow upon the electrodes acts to lower the arc-over voltage setting.

According to my invention, I provide a spark gap device of the generic type described, which is adapted for outdoor service and which comprises a discharge path having a plurality of spark gaps in series, at least one gap being protected from the

weather by a protecting hood or umbrella member and controlling the discharge of the device, and the other unprotected gaps. In order to eliminate any time delay between the discharge of the series gaps, I provide means whereby both said gaps arc-over practically simultaneously. I also have embodied in my device means for simultaneously extinguishing the arcs formed across the gaps before the dynamic current can follow the discharge and have provided improvements in other details that will be hereinafter set forth.

The novel features which I believe to be characteristic of my invention will be definitely indicated in the claims appended hereto, while the features of construction and method of operation will be understood by reference to the accompanying drawings in which:

Fig. 1 is a diagrammatic view of a protective device embodying the features of my invention; Figs. 2, 3, 4, 5 and 6 are diagrammatic views showing modified forms of my invention.

In Fig. 1, is shown a protective device comprising a discharge path having, for purposes of illustration, two spark gaps, 1 and 2 arranged in series. As shown in this figure, gap 1 consists of two cooperating electrodes 3 and 4 having their proximal surfaces spherical and gap 2 consists of two similar electrodes 5 and 6, but it is understood that the two pairs of cooperating electrodes may be any surface of revolution. One of the series gaps, for instance, gap 1, is shielded from the weather by a protecting hood or umbrella member 7, preferably of conducting material, which surrounds or partially incloses the electrodes 3 and 4. The umbrella member 7 is adapted to be connected to the conductor to be protected and is also in conductive relation with one of the electrodes of gap 1, electrode 3 for instance. Gap 2, which is in series with gap 1, is unprotected from the weather, electrode 5 of gap 2 being in conductive relation with electrode 4 of gap 1. As shown in Fig. 1 the unprotected gap 2 is mounted adjacent the lower end or edge of the umbrella 7 for the purpose to be specified. By providing a discharge path having two spark gaps in series, I am able to protect one gap from the weather and utilize

the dry arc-over voltage setting of this gap to control the discharge over the path and utilize the unprotected gap as a means for interrupting the discharge, as it has been found that with a discharge path including a single protected gap it is sometimes difficult to extinguish the arc beneath the protecting hood. I prefer generally to have the unprotected gap set at a lower voltage than the protected gap. In practice the unprotected gap may, for instance, be set at 20% of the protected gap. Then if the total dry spark-over is 100 plus 20, or 100 kv. on the protected gap and 20 kv. on the unprotected gap, a reduction in spark-over on the unprotected gap of 25%, or 5 kv., due to rain, etc. reduces the total spark-over to 115 kv., or only about 4%. If the total gap had been exposed the total reduction would have been about 25%, making it necessary to set the total gap at a much higher value of dry spark-over voltage.

In order to extinguish the arcs formed across gaps 1 and 2 when a discharge occurs, I provide a means cooperating with the unprotected gap 2 for taking the arc occurring across the unprotected gap in such a manner as to short circuit both the series gaps 1 and 2 and then extinguish the arc so taken with great rapidity. For this purpose, I provide a discharge path in shunt to the path including the series gaps 1 and 2 and in which is included a horn gap 8 which is so related to the unprotected gap 2 that any arc occurring across the electrodes 5 and 6 of gap 2 is taken or transferred to the horn gap rising on the horns until it is extinguished by attenuation. In order to maintain the horn gap action, I may utilize, as shown in Fig. 1, the contour of the umbrella member 7 to form one electrode of the horn gap 8 and cooperating with the umbrella is an arcing horn member 9. The electrodes 5 and 6, of the unprotected gap, are located in close proximity to the umbrella 7 and horn member 9 respectively so that any arc occurring across the electrodes is transferred to the horn gap.

The horn member 9 and electrode 6 of gap 2 are connected to ground through a device which serves to extinguish the arc which follows the discharge across the horn gap 8, such a device being shown, by way of illustration, as an electrolytic cell 10. As the umbrella electrode 7 is connected to the conductor to be protected and the horn member 9 is connected to ground, the path to ground through horn gap 8 comprises a discharge path which is in shunt to the discharge path including the gaps 1 and 2, in series. Due to the construction of the gaps 1 and 2, such gaps have no appreciable time lag while the horn gap 8 has an appreciable time delay so that excessive potentials will pass to ground over the

path including the series gaps 1 and 2 in preference to the path including the horn gap 8, the discharge being finally transferred to the horn gap where it is extinguished. As soon as the discharge across the unprotected gap 2 is transferred to the horn gap 8, the path including gaps 1 and 2 is short circuited and the arcs across such gaps are quickly extinguished. The shunt path is then subsequently interrupted by the extinguishment of the arc due to the horn gap 8.

With a discharge path including two gaps in series, one protected and the other unprotected, the complete discharge of the gaps is controlled by the dry arc-over setting of the protected gap but in a discharge path including at least two gaps in series whether either of said gaps are protected or unprotected from the weather, unless some provision is made to cause a practically simultaneous arc-over of both series gaps or a complete discharge over the path, a time delay will occur between the discharge of one gap and the discharge of the other gap which is detrimental to the efficient operation of the device. If gap 1, for instance, breaks down first then the discharge path includes gap 2 in series with the resistance of the broken down gap 1 which introduces a time delay before gap 2 arcs over. In order to overcome this disadvantage I provide a means for causing two or more gaps, such as gaps 1 and 2, to arc-over practically simultaneously.

I have found that a plurality of gaps in series will break down simultaneously when a voltage is applied across them, if the capacities of the gaps are adjusted so that the division in voltage is in proportion to the break-down voltages of the various gaps. For two gaps in series this result is obtained by shunting one of the gaps by a condenser of such a capacitance or a device having a condenser action such that the ratio of the capacitance of the combination of that gap in parallel with the condenser, to the capacitance of the other gap, is equal to the inverse ratio of the impulse of 60 cycle voltages required to spark over the two gaps taken singly. For example, as shown in Fig. 5, a discharge path includes two sphere gaps, A and B, in series, set to arc-over at 100 kv. and 20 kv. respectively, if taken singly. If the capacitance C_1 of gap A and C_2 of gap B are equal, any applied voltage will divide equally between the gaps and cause gap B to break down first, or as soon as its voltage becomes 20 kv., when the voltage across gap A will also be 20 kv. In order to provide a means whereby applied voltages will divide in the proportion of 100 and 20, I place in shunt to gap B, a condenser D having a capacitance C_3 . As the voltage across the condensers in series divides inversely in

proportion to their capacitance in the example given:

$$\frac{100}{20} = \frac{C_2 + C_3}{C_1}$$

from which we find that $C_3 = 5C_1 - C_2$.

In this case, therefore, to obtain the proper division of voltage between gaps A and B, it is thus necessary to connect across gap B a condenser having a capacitance of $5C_1 - C_2$. When a rising impulse voltage wave reaches the value of 120 kv., 100 kv. will be across gap A and 120 kv. across gap B and a simultaneous breakdown of both gaps will occur.

With more than two gaps in series, for instance three gaps, A', B' and C', as shown in Fig. 6, the simultaneous discharge of these gaps may be obtained by the use of one or more condensers, for instance, condensers D' and E' in shunt to gaps B' and C' respectively, proportioned in the manner described.

I obtain the simultaneous discharge of gaps 1 and 2, according to above description, by providing a condenser 11 in shunt to gap 2 which is so proportioned relative to the capacities of the gaps as to obtain the requisite voltage distribution. With two gaps in series, one of which is protected, I preferably provide the unprotected gap with the condenser shunt.

Instead of a condenser in shunt, I may obtain a simultaneous discharge of the gaps 1 and 2 by the use of a resistance element 12 in shunt to gap 2 as shown in Fig. 2. The resistance is of a value such that the division in voltage across the gaps is in proportion to the break-down voltage of the gaps.

As shown in Fig. 3, I may use the combination of the condenser 11 and resistance 12 in shunt to the gap 2 to vary the capacity of the gap and maintain the proper voltage distribution.

In Fig. 4 I have shown a modified form of my invention in which the umbrella member 7 cooperates with the electrode 4 and serves as one electrode of the protected gap 1. In this modification, cooperating with the horn member 9 to form the horn gap 8 adjacent the unprotected gap 2, is a similar horn member 13 which is in conductive relation with the umbrella member 7. In shunt to gap 2, I provide a condenser 11 for the purpose described but it is understood that I may use instead of a condenser, a resistance element or a combination of a condenser and a resistance, as previously described.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative and

that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In a protective device, the combination with a discharge path including a plurality of gaps of different breakdown voltages in series, of means for causing transient voltages across said gaps to divide across the individual gaps in proportion to their transient break-down voltages.

2. In a protective device, the combination with a discharge path including a plurality of gaps of different breakdown voltages in series, of means for adjusting the relative capacities across said gaps so that transient spark-over will occur practically simultaneously across all said gaps.

3. In a protective device, the combination with a discharge path including a plurality of gaps of different breakdown voltages in series, of devices having a condenser action so related to said gaps that spark over will occur practically simultaneously across said gaps.

4. In a protective device, the combination with a discharge path including a plurality of gaps of different breakdown voltages in series, of condensers for adjusting the capacities across said gaps so that the division in voltage is in proportion to the break down voltages of said gaps.

5. In a protective device, the combination with a discharge path including a plurality of gaps of different breakdown voltages in series, of means for preventing any of said gaps from discharging before the others.

6. The combination with a plurality of gaps in series, of shunt paths to part of said gaps including means for adjusting the capacities across said gaps so that the division in voltage is in proportion to the breakdown voltage of said gaps.

7. A protective device comprising a spark gap protected from weather conditions and a second unprotected gap in series therewith.

8. A protective device comprising a spark gap protected from weather conditions, a second unprotected spark gap in series therewith, and a horn gap for extinguishing the arc formed as said series gaps break down.

9. In a protective device, the combination with a discharge path including a spark gap protected from the weather, a second unprotected gap in series therewith, means for causing a spark over of said gaps simultaneously, and means for interrupting said discharge path after said gaps break down.

10. In a protective device, the combination with a discharge path including two spark gaps in series, of means for protecting one of said gaps from weather conditions, and means for causing both said gaps to arc-over practically simultaneously.

11. In a protective device, the combina

tion with a discharge path including two spark gaps in series, of shielding means for one of said gaps, a second discharge path in shunt to said gaps, and means in said

5 shunt path for taking the discharge over said gaps and subsequently interrupting it.

12. In a protective device, the combination with a protected spark gap, of an unprotected spark gap in series therewith, and means responsive to a discharge over said

10 series gaps for short circuiting said gaps and subsequently interrupting said short circuit.

13. In a protective device, the combination with a protected spark gap, of an unprotected spark gap in series therewith, means for causing said gaps to arc-over

15 practically simultaneously, and means responsive to a discharge over said gaps for completing a path in shunt thereto and subsequently opening said shunt circuit.

14. In a protective device, the combination with a spark gap, an umbrella member enclosing said gap, and means for extinguishing the arc across said gap comprising

20 a second gap in series with said first mentioned gap, a shunt circuit to both said gaps to which the discharge across said second gap is transferred, and means for interrupting said shunt circuit.

15. In a protective device, the combination with a discharge path including two

25 gaps in series, of shielding means for one of said gaps, a horn gap adjacent the other of said gaps in a discharge path in shunt to said path including said series gaps, and means for causing said series gaps to arc-over practically simultaneously.

16. In combination, a plurality of gaps

30 in series forming a discharge path, means for distributing the voltage across said gaps to cause said gaps to break down practically simultaneously, and means including a portion only of said gaps for controlling the discharge of said gaps independent of weather conditions.

17. A protective device comprising a spark gap protected from the weather, a

35 second gap in series therewith, and means cooperating with said second gap to enable an applied voltage to so divide across both said gaps that both gaps discharge practically simultaneously, and means for short circuiting said gaps in response to their discharge and subsequently opening said short circuit.

18. A protective device comprising a discharge path including two spark gaps in series, an umbrella member protecting one

40 of said gaps, a horn member in shunt to said gaps cooperating with said umbrella and spaced apart therefrom to provide a horn gap, said horn gap being so related to the other of said gaps to take the arc formed as said gap discharges.

19. A protective device comprising a spark gap, an umbrella member protecting said gap from the weather, a second unprotected gap in series therewith, a member in shunt to said gaps cooperating with said

45 umbrella member to form a horn gap, said horn gap having such a relation to said unprotected gap that discharges across said unprotected gap are transferred to said horn gap and extinguished.

20. An outdoor arrester for protecting electrical systems against abnormal voltage comprising a spark gap provided with cooperating electrodes having their proximal surfaces substantially spherical and

50 spaced apart to provide a uniform dielectric field in which corona does not precede spark-over and spaced to permit spark-over if wet at a voltage lower than the predetermined voltage at which spark-over is desired but, when dry, to permit spark-over at such predetermined voltage and to resist spark-over at lower voltages, and a shield for protecting said gap from the weather whereby the gap will discharge at its dry

55 arc-over voltage setting independently of weather conditions.

21. In a protective device, the combination with a discharge path including a plurality of differently formed gaps in series, of means for causing voltages across said gaps to divide across the individual gaps in proportion to their breakdown voltages.

22. In a protective device, the combination with a discharge path including two

60 or more spark gaps in series, one of said gaps being protected from the weather, and means whereby said gaps are short circuited in response to an arc discharge across said gaps and the discharge interrupted in a circuit in shunt to said gaps.

23. In a protective device, the combination with two cooperating electrodes spaced apart to form a spark gap, of an umbrella member in conductive relation with one of

65 said electrodes and enclosing said gap to protect the gap from the weather.

24. In a protective device, the combination with two cooperating electrodes spaced apart to form a spark gap, of means in conductive relation with one of said electrodes and capable of causing said gap to discharge at the same breakdown voltage independent of the weather.

25. In a protective device, the combination with cooperating electrodes spaced apart to form a spark gap, of a protective member cooperating with said gap for causing the gap to always discharge at its dry arc-over setting, and means for short circuiting said gap including said protective member.

In witness whereof, I have hereunto set my hand this 14th day of May, 1918.

FRANK W. PEEK, JR.