Dec. 25, 1945. E. J. WADE ET AL 2,391,758

PROTECTIVE DEVICE

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Fig. 1.

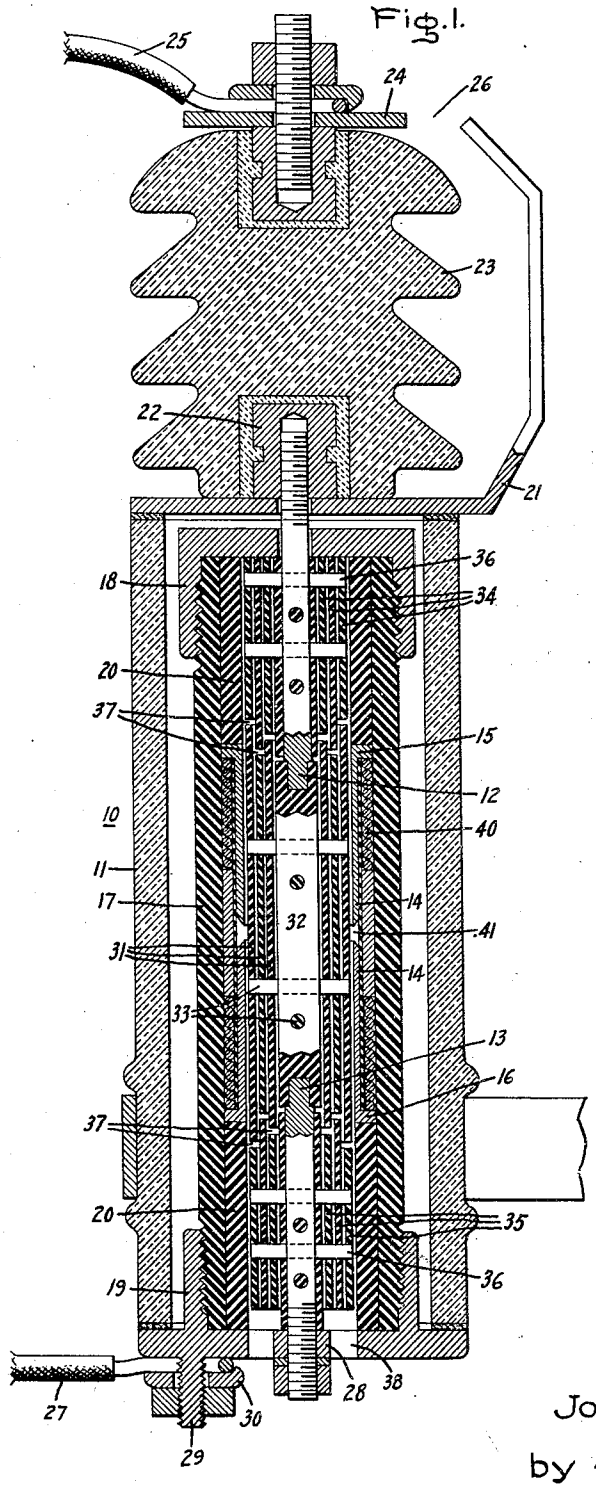
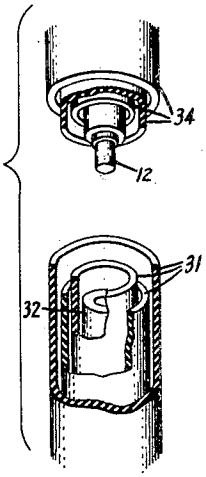


Fig. 2.



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Fig. 3.

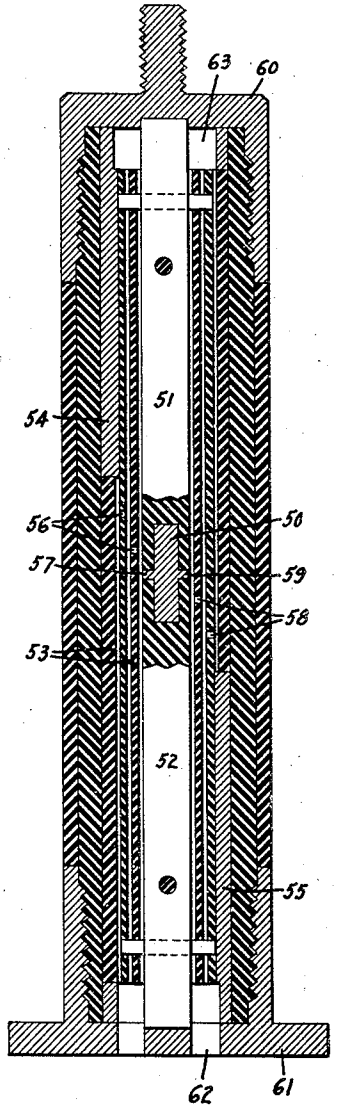
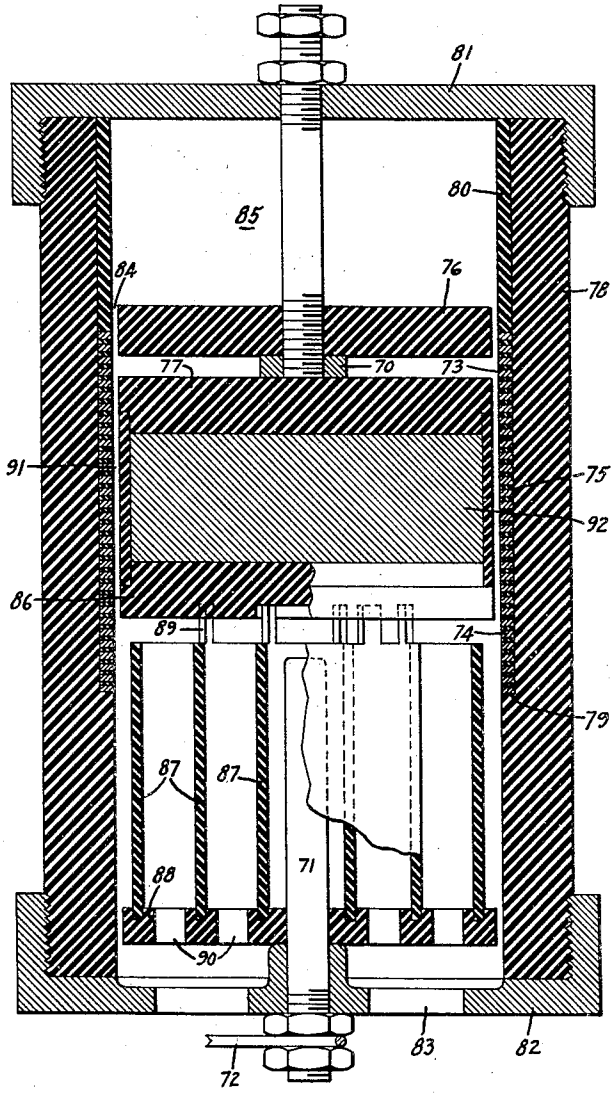


Fig. 4.



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UNITED STATES PATENT OFFICE

2,391,758

PROTECTIVE DEVICE

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Application May 9, 1942, Serial No. 442,338

13 Claims. (Cl. 175—30)

Our invention relates to protective and circuit interrupting devices, and has application to overvoltage protective devices such as lightning arresters, and to fuse devices and electric circuit interrupters.

An object of our invention is to provide an improved protective device which is efficient and reliable in operation and which has a relatively long life.

Another object of our invention is to provide an improved protective device which is efficient in operation over a relatively wide range of circuit conditions.

A further object of our invention is to provide an improved overvoltage protective arrangement which has a relatively rapid insulation recovery characteristic.

A still further object of our invention is to provide an improved circuit interrupting device which is efficient and reliable in operation, and which has a relatively long life in service.

Further objects and advantages of our invention will become apparent from the following description referring to the accompanying drawings, and the features of novelty which characterize our invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

Fig. 1 is a sectional side elevation of an overvoltage protective device which is provided with an embodiment of our invention; Fig. 2 is an exploded perspective view of a portion of the protective device illustrated in Fig. 1; Fig. 3 is a sectional side elevation of a modification of the device illustrated in Fig. 1, and Fig. 4 is a sectional side elevation of a modification of the over-voltage protective devices illustrated in Figs. 1, 2, and 3.

In the arrangements illustrated in the drawings, we have shown our invention as applied to an overvoltage protective device which will pass high current impulses such as those caused by switching impulses or lightning discharges, but it is to be understood that our invention has application to any other suitable protective device or circuit interrupting device which may provide a path for surges of short duration, or such devices as may be called upon to interrupt a power follow current, or interrupt an electric circuit. One of the illustrated embodiments of our invention includes a pair of axially disposed electrodes and a tubular arrangement radially spaced from the axial electrodes and having electrode portions at either ends thereof providing radial arc gaps with the adjacent ends of the axially disposed electrodes. A plurality of spaced barriers or radially spaced concentric cylinders are provided between each of the axially disposed electrodes and the adjacent electrode portion of the cylindrical member. In order to provide an arc path the concentric cylinders have openings adjacent the electrodes. These openings may be staggered in any suitable direction, such as an axial direction so as to provide a circuitous or zig zag arc path between each axially disposed electrode and the adjacent end of the tubular member. The pair of gaps may be serially connected across an apparatus in any suitable manner such as by connecting one of the axial electrodes to a suitable apparatus to be protected and the other one to ground. One of the ends of the concentric cylinders may be closed by a cap member, the opposite end being open so that gases formed by an arc passing between the adjacent electrodes may flow axially through the spaces between the concentric conductors and across the arc, thus extinguishing it.

Referring more particularly to Fig. 1 of the drawings, we have illustrated an overvoltage protective device 10 which may be placed in any suitable housing 11 of insulating material. The protective device includes a pair of axially disposed electrodes 12 and 13 which may have any suitable shape such as a rod shape. To cooperate with the electrodes 12 and 13 we provide a suitable electrode arrangement, and in the structure illustrated in Fig. 1 this includes a tubular arrangement 14 having an electrode portion 15 at one end and an electrode portion 16 at the opposite end. Since these portions 15 and 16 are adjacent to but spaced from the electrodes 12 and 13, respectively, it will be seen that the electrodes 12 and 15 form one gap and the electrodes 13 and 16 form a second gap. These gaps may be connected in series in any suitable manner such as by forming the tubular arrangement 14 of a conducting material with portions 15 and 16 providing the electrodes. A discontinuity, however, is provided in the tubular arrangement 14 for reasons which will be brought out below. A tubular member 17 of suitable insulating material surrounds the tubular member 14, and the end members or caps 18 and 19 relatively rigidly support the tubular member 14 intermediate the ends of the insulating member 17 by spacers 20. The electrode assembly including the pair of gaps may be connected across any suitable circuit or apparatus, and in the arrangement illustrated in the drawing the electrode 12 is adapted to be connected to a transmission line through a conducting member 21 which is electrically connected to the opposite end of the rod which forms the electrode 12 by means of a nut 22. An insulator 23 is supported on top of the conducting member 21, and the upper end of the insulator 23 supports a conducting member 24 which may be attached to the transmission line through a conductor 25. A conventional gap

26 is provided between the adjacent portions of the conductor 24 and the conducting strap 21. The electrode 13 may be in turn connected to ground through a conductor 27. The cap member 19 has an integral central portion 28 which supports the electrode 13, and another integral portion 29 of the cap 19 is electrically connected to the conductor 27 through a connector 30. When a high voltage surge occurs on the transmission line to which the electrode 12 is connected the gap 26 will spark over and an arc will be formed between the electrodes 12 and 15. The electrical impulse will then pass to the electrode 16 and form another arc between it and the cooperating electrode 13. The surge may then pass through the electrode 13 and the conductor 27 to ground.

Between the gaps provided by the electrodes 12 and 15 and the electrodes 13 and 16 we have provided a plurality of radially spaced concentric cylinders 31 which, in the arrangement illustrated in Fig. 1, are coaxial with the axially-spaced electrodes 12 and 13. Any suitable number of cylinders 31 may be provided, and in Fig. 1 three are shown. These cylinders are supported through an insulating member 32 which spans the space between the electrodes 12 and 13. Pins 33 of suitable insulating material pass through the member 32 and cooperating apertures in the cylinders 31 so as to support them in proper spaced relationship. As will be seen in Figs. 1 and 2 these insulating cylinders 31 are of different lengths and the opposite ends thereof cooperate with concentric insulating cylinders 34 and 35, these latter cylinders being supported in proper spaced relationship by means of a plurality of pins 36 which are supported by the electrodes 12 and 13 and which pass through cooperating apertures in the cylinders. Openings or slots 37 are formed between the ends of the cylinders 31 and the adjacent ends of the cylinders 34 and 35 which are not in contact. These slots define arc paths through which an arc may pass between the cooperating electrodes 12 and 15, and 13 and 16. By properly dimensioning the cylinders 31, 34, and 35, the openings 37, as will be seen in Fig. 1, are staggered so as to provide a zig zag or circuitous arc path between the electrodes 12 and 15, and 13 and 16. Instead of axially staggering the openings 37, it is to be understood that the openings may take any other suitable relationship to each other. Furthermore, instead of forming the passages 37 by cooperating ends of separate cylinders a single integral cylinder may be employed which merely has openings or slots therein, as is illustrated in Fig. 3.

When a sufficiently high voltage is impressed across the electrodes 12 and 13, it will be seen that a pair of arcs will be formed between the cooperating electrodes 12 and 15, and 13 and 16. In order to enhance the rate at which gases will be formed when an arc takes place, the cylinders 31, 34, and 35 may be made of insulating material such as hard fiber which has the property of giving off deionizing or un-ionized gases when heated. Let us assume that a high voltage surge of short duration causes the gaps formed by the electrodes to arc over. The power follow current will then continue to cause an arc to be formed in the gaps and during increasing values of the power follow current cycle, gases of the deionizing type will be formed at an increasing rate. These gases will flow in both directions and in flowing upwardly towards the end cap 18 a pressure will be developed in the spaces between the radially spaced concentric cylinders. Then as the power follow current cycle approaches zero, the pressure in the space between the upper arc and the end cap 18 will be greater than the pressure at the open or opposite end of the cylinders. As will be seen in Fig. 1, vent openings 38 are provided in the end cap 19 so that the adjacent ends of the concentric cylinders will be open to the atmosphere. The pressure thus developed at the end of the tube adjacent the enclosing cap 18 will cause the gases to be blown downwardly toward the vent openings 38. Since the arc paths between the cooperating electrodes 12 and 15, and 13 and 16 are relatively far apart the gases will become cooled and deionized as they pass between the concentric tubes towards the vent openings 38. Furthermore, the gases formed by the upper arc will contribute to the production of the pressure to extinguish or blowout the arc formed between the electrodes 13 and 16 as the power follow current passes through zero and the recovery voltage is immediately impressed across the protective device. By blowing the gases over the cylindrical or peripheral surfaces of the concentric tubes and by spacing the parallel disposed gaps a relatively great distance apart and further by providing a zig zag arc path between the electrodes, we have found that the resulting protective device has a relatively high insulation recovery strength.

In order to further improve the operating characteristics of the device, a coil 40 may be provided with opposite ends electrically connected to the electrode portions 15 and 16, respectively. The conducting tubular arrangement 14 is provided with a radial discontinuity 41, or the portions of tubular arrangement 14 having electrode portions 15 and 16 are spaced apart so as to provide a gap in parallel with the coil 40 whereby the power follow current will traverse the coil and cause the arcs between the cooperating electrodes to rotate. This gap shunting the coil also helps to prevent impulse currents from flowing through the coil. Movement or rotation of the arc helps to prevent localized burning and to cool the arc at low currents and it will cause the arc to pass over a relatively large portion of the gas evolving material thus contributing to a relatively rapid rate of evolution of deionizing gas. Furthermore the staggering of the gaps or slots in the concentric cylinders contributes to the relatively high insulation recovery characteristics which we have found our device possesses. The idea of coupling a coil with one electrode to rotate the power arc is described in further detail and claimed in application S. N. 442,337, Wade, filed concurrently with the present application and assigned to the same assignee as this present invention.

Referring to Fig. 3 of the drawings, we have illustrated a modification of our improved protective device which includes an electrode 50 which is supported by a pair of insulating columns 51 and 52. We have provided a plurality of concentric cylinders 53 which are coaxial with the longitudinal axis of the center electrode 50. An electrode arrangement is provided on the outside of the cylinders 53 including electrodes 54 and 55. These electrodes are placed on opposite sides of the outer concentric cylinders 53 and are also axially disposed from the adjacent ends of the electrode 50. Each of the concentric cylinders 53 is provided with any suitable

number of openings 56 which may be staggered so as to provide an arc path between the electrode 54 and an electrode portion 57 of the electrode 50. Similar openings 58 are provided between the electrode 55 and the electrode portion 59 of the electrode member 50. The electrode 54 may be supported and electrically connected to an end cap 60 while the electrode 55 may be in turn supported by an opposite end cap 61. The end cap 61 is provided with vent openings 62 which communicate with the spaces between the concentric cylinders, while the end cap 60 provides an enclosing member so as to provide a space 63 between the ends of the concentric cylinders 53 and the end cap 60. The end caps 60 and 61 may, therefore, be connected across the apparatus which is to be protected, and when a sufficient voltage is impressed across the protective device an arc will be formed between the electrodes 54 and 57 through the openings 56 and between the electrodes 59 and 55 through the openings 58. The concentric cylinders may be composed of any suitable material such as one having the property of giving off the deionizing or un-ionized gases when heated, and during increasing values of power follow current a pressure will be developed in the reservoir 63, which during decreasing values of power follow current, will cause the gases to move outwardly through the vent passages 62. The gases flow across the arc path and introduce gas of a relatively high dielectric strength into the arc stream by turbulent flow which contributes to the rapid recovery insulation strength at the current zero.

In Fig. 4 we have illustrated a further modification of our protective device including an upper electrode 70 which may be connected to a line or apparatus to be protected, and a lower electrode 71 which may be connected to ground through the conductor 72. A pair of gaps are provided between the electrode 70 and an adjacent electrode 73 which is radially spaced therefrom. Another gap is provided between an electrode 74 and the center electrode 71. The electrodes 73 and 74 may be of any suitable construction and in the arrangement illustrated in Fig. 4 they include opposite ends of a spaced wound coil 75. An arc path is provided between the electrodes 70 and 73 by insulating disks 76 and 77. The coil 75 is carried by an insulating housing 78 and is spaced therein between a shoulder 79 and a cylinder 80. The housing is tightly enclosed at one end by a metal cap 81 and the other end is enclosed by a metal cap 82 having vent openings 83. The insulating disk 76 is spaced from the inner walls of the insulating cylinder 80 providing a passage 84 which leads to a reservoir 85. The arc path between the electrodes 71 and 74 is provided by an insulating circular plate 86 and a plurality of concentric cylinders 87 which are supported at their lower ends by an insulating member 88. Teeth 89 are provided at the opposite end of the cylinders 87, which teeth extend into cooperating slots in the plate 86. Vent openings 90 are provided in the disk 88, which openings communicate with the spaces between the concentric cylinders 87. The outer edge of the insulating plates 77 and 86 are spaced from the inner surface of the coil 75 so as to provide a passage 91 which communicates with the arc spaces between the electrodes 70 and 73, and 71 and 74.

When a voltage of sufficient magnitude is impressed across the electrodes 70 and 71, arcs will be formed in the gaps provided between the electrodes 70 and 73, and 71 and 74. In order to enhance the quantity of gas which is given off due to the heat of the arc the insulating plates 76, 77, and 86, and the concentric cylinders 87 may be made of any suitable insulating material, such as hard fibre which has the property of giving off deionizing or un-ionized gases when heated. During increasing values of the power follow current cycle, gases will be formed by the upper gap, part of which will flow into the reservoir 85. As the power follow current decreases and approaches zero the pressure in the chamber 85 will be greater than at the open end thereof so that the gases will flow across the upper gap, down the peripheral or cylindrical passage 91 and across the arc between the electrodes 71 and 74, thus providing for a relatively rapid insulation recovery characteristic of the protective device.

Since the electrode 75 is in the form of a spaced wound coil, the power follow current will flow through the turns of the coil and cause the arcs to rotate. Since the coil has gaps impulse currents will jump the gaps between each turn instead of flowing around the coil. A plug 92 of suitable magnetic material such as iron may be provided between the insulating plates 77 and 86 for enhancing the electromagnetic force available for rotating the arc.

Although we have shown and described particular embodiments of our invention, we do not desire to be limited to the particular embodiments described, and we intend in the appended claims to cover all modifications which do not depart from the spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent in the United States is:

1. A protective device including a substantially rod-shaped metal electrode, a second metal electrode having a tubular shape spaced from and surrounding said first electrode to form a gap, and a plurality of substantially concentric insulating radially spaced cylinders between said electrodes, said cylinders formed of an insulating material which gives off an arc-extinguishing gas when subjected to the heat of an electric arc, said cylinders having staggered openings defining a circuitous arc path through which an arc may strike between said electrodes.

2. A protective device including a tubular shaped electrode, a rod shaped electrode concentric with said tubular electrode and having a portion within said tubular electrode, and a plurality of radially spaced substantially concentric insulating cylinders between said electrodes formed of a material which gives off a gas when subjected to the heat of an electric arc, said cylinders having openings axially staggered defining a circuitous arc path through which an arc may strike between said electrodes.

3. A protective device including a plurality of radially spaced substantially concentric insulating cylinders, first electrode means inside said cylinders and second electrode means outside said cylinders defining two spaced arc gaps, said cylinders having at least two groups of openings defining at least two radially extending arc paths between said first and said second electrode means, and means for enclosing the adjacent ends of one end of said cylinders the opposite end of said cylinders being substantially unobstructed so that gases formed due to arcs may flow from the enclosed end of said cylinders between said cylinders and across the arcs between said gaps.

4. A protective device including a plurality of radially spaced substantially concentric insulating cylinders formed of gas-evolving material, a first metal electrode having a portion within said cylinders, a second metal electrode outside said cylinders, said cylinders having substantially radially extending openings defining an arc path between said electrodes, and means for enclosing one end of said cylinders the other end thereof being open so that gases evolved from said cylinders during arcing between said electrodes may flow from said enclosed end through the spaces between said cylinders across the arc and out the open end of said cylinders.

5. A protective device including a plurality of radially spaced substantially concentric insulating cylinders of a type which give off a gas when subjected to the heat of an electric arc, a solid electrode having a portion within said cylinders, a tubular electrode surrounding said cylinders, said cylinders having substantially radially extending openings defining an arc path between said electrodes, and means for enclosing one end of said cylinders the other end thereof being open so that gases evolved from said cylinders during arcing between said electrodes may flow from said enclosed end through the spaces between said cylinders across the arc and out the open end of said cylinders.

6. A protective device including a pair of axially spaced electrodes, tubular means radially spaced from said first-mentioned electrodes and having electrode portions at each end providing arc gaps with the adjacent of said first-mentioned electrodes, and a plurality of substantially concentric insulating cylinders between said first-mentioned electrodes and said tubular means electrode portions, said insulating cylinders having openings adjacent said electrodes providing a pair of arc paths for the arc gaps.

7. A protective device including a pair of axially spaced electrodes, tubular means radially spaced from said first-mentioned electrodes and having electrode portions at each end providing arc gaps with the adjacent of said first-mentioned electrodes, a plurality of substantially concentric insulating cylinders between said first-mentioned electrodes and said tubular means electrode portions, said insulating cylinders having openings adjacent said electrodes providing a pair of arc paths for the arc gaps, and means for enclosing one end of said cylinders so that gas formed by the arc of one gap will flow between said cylinders and across the arc of the other gap.

8. A protective device including a pair of axially spaced electrodes, tubular means radially spaced from said first-mentioned electrodes and having electrode portions at each end providing arc gaps with the adjacent of said first-mentioned electrodes, and a plurality of substantially concentric insulating cylinders between said first-mentioned electrodes and said tubular means electrode portions, said insulating cylinders having openings adjacent said electrodes providing a pair of arc paths for the arc gaps, and coil means for providing a field to rotate the arcs in said arc paths.

9. A protective device including a pair of axially spaced electrodes, tubular means radially spaced from said first-mentioned electrodes and having electrode portions at each end providing arc gaps with the adjacent of said first-mentioned electrode, a plurality of substantially concentric insulating cylinders between said first-mentioned electrodes and said tubular means electrode portions, said insulating cylinders having openings adjacent said electrodes providing a pair of arc paths for the arc gaps, means for connecting one of said axially spaced electrodes to an electrical apparatus to be protected and the other of said axially spaced electrodes to ground, an electrical coil surrounding said tubular means and having ends connected to said electrode portions so that the power follow current will flow through said coil and rotate the arcs in said arc paths.

10. A protective device including a pair of axially spaced electrodes, tubular means radially spaced from said first-mentioned electrodes and having electrode portions at each end providing arc gaps with the adjacent of said first-mentioned electrodes, a plurality of substantially concentric insulating cylinders between said first-mentioned electrodes and said tubular means electrode portions, said insulating cylinders having openings adjacent said electrodes providing a pair of arc paths for the arc gaps, means for connecting one of said axially spaced electrodes to an electrical apparatus to be protected and the other of said axially spaced electrodes to ground, an electrical coil surrounding said tubular means and having ends connected to said electrode portions so that the power follow current will flow through said coil and rotate the arcs in said arc paths, said tubular means having a discontinuity to provide a gap in shunt with said coil.

11. A protective device including a solid electrode, substantially concentric insulating cylinders radially spaced and coaxial with an axis of said electrode, said cylinders being formed of a material which evolves an arc-extinguishing gas when subjected to the heat of an electric arc, and second and third solid electrodes adjacent the outer of said cylinders, said cylinders having substantially radially extending openings defining arc paths between said first mentioned electrode and said second and third electrode.

12. A protective device including a plurality of radially spaced substantially concentric cylinders formed of gas evolving insulating material, electrode means forming a plurality of arc gaps, said cylinders having at least one group of openings defining at least one radially extending arc path for one of said arc gaps, and means for enclosing the adjacent ends of one end of said cylinders the opposite end of said cylinders being substantially unobstructed so that gases evolved from said cylinders when arcs are formed across said gaps may flow from the enclosed end of said cylinders between said cylinders and across the arc in said arc path formed by said cylinder openings.

13. A protective device including a pair of axially spaced electrodes, electrode means radially spaced from said first-mentioned electrodes and having electrode portions providing arc gaps with the adjacent of said first-mentioned electrodes, plate means defining an arc path for one of said arc gaps, a plurality of substantially concentric insulating cylinders having openings providing an arc path for another of said arc gaps, means providing a passage communicating with said arc paths, means providing a reservoir communicating with said one of said arc gaps and said passage, and a vent means communicating with said other of said arc gaps.

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