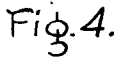
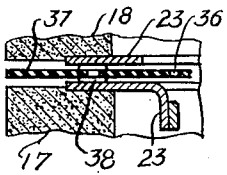
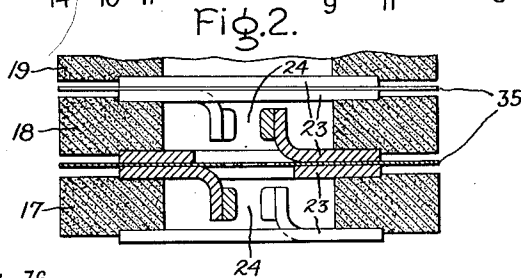
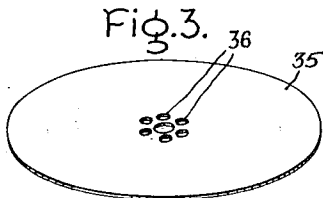


2,495,154

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2,495,154

LIGHTNING ARRESTER

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3 Claims. (Cl. 175—30)

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My invention relates to lightning arresters such as are used for the protection of electric power transmission lines and associated apparatus from the effects of excessive voltages due to lightning, switching operations or other causes. Specifically my invention is an improvement on the disclosure of United States Letters Patent 2,151,559, McEachron, granted March 21, 1939, and assigned to the same assignee as the present application.

Lightning arresters of the type disclosed in the above mentioned McEachron patent, often referred to as station-type lightning arresters, consist in general of a gap structure connected in series with a current limiting element. The current limiting element should have the property of decreasing and increasing its resistance as the discharge current increases and decreases to such a degree that the voltage across the arrester during discharge is held to safe values for connected apparatus. The gap structure performs the function of a circuit breaker by interrupting the power follow current permitted to flow through the arrester by the current limiting element. The gap structure must also be such as to become conducting at a sufficiently low impulse voltage to maintain a proper margin between the gap breakdown voltage and the insulation strength of the apparatus protected by the arrester.

It is an object of my invention to provide an improved lightning arrester so constructed and arranged as to have these desirable features to a high degree.

It is another object of my invention to provide a lightning arrester which will operate satisfactorily under much more severe impulse conditions than similar arresters used heretofore.

Still another object of my invention is to provide a lightning arrester with greatly improved gap sealing ability.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of my invention, reference may be had to the accompanying drawing in which Fig. 1 is a sectional view of a lightning arrester constructed in accordance with my invention; Fig. 2 is an enlarged view, partly in section, of a portion of the gap structure of Fig. 1; Fig. 3 is a perspective view of a portion of the lightning arrester shown in Figs. 1 and

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2 and Fig. 4 is another enlarged sectional view illustrating a modification of my invention.

Referring now to the drawing, I have illustrated a lightning arrester generally indicated at 1 in Fig. 1, which includes an outer casing having a cylindrical wall portion 2 formed of weatherproof insulating material such as porcelain. The cylinder 2 is closed at its upper end by a metal end-fitting or plate 3 secured to the casing by cement so as to form a tight, protective seal. A metal cap 4 is bolted to the end-fitting or plate 3 and is provided with a line terminal 5. A metal supporting base 6 having a ground terminal 7 is bolted to a metal ring 8 which is cemented to the lower end of the insulating cylinder 2. The opening through the ring 8 into the cylinder 2 is closed by a metal plate 9. A metal plate 10 is supported by screws 11 resting on the plate 9, the distance of the plate 10 above the plate 9 being adjustable by means of these screws 11.

A second cylinder 12, formed of porcelain or other insulating material, is arranged inside the cylinder 2, the two cylinders being coaxial. This inner cylinder 12 is closed and sealed at its upper end by a metal cap 13 and at its lower end by a metal cap 14. The inner cylinder 12 is formed with an inner flange 15 forming a shoulder which supports a plurality of coaxial resistance units 16, 17, 18, 19, 20, 21 and 22. The resistance units 16 to 22 inclusive are preferably of the form shown in the above mentioned McEachron patent, although this particular number need not necessarily be used. Each of the resistance units 16 to 22 inclusive is formed as a hollow ring or disk with plane upper and lower faces. Each of the plane faces of each resistance disk has a metal coating to which is soldered a metal plate 23 with a central opening. Projections from the inner edges of the two plates 23 of each resistance unit are bent toward each other, their adjacent ends being spaced to form a discharge gap 24 in the opening through the unit.

Another form of resistance unit 26 is supported in the insulating cylinder 12 between the flange 15 and the lower end cap 14, two such units being shown in Fig. 1. Each resistance unit 26 is in the form of a ring open at one side, the spaced ends 27 of the open ring carrying metal projections extending into the space surrounded by the ring where they are spaced to form the electrodes of a discharge gap. As is clearly disclosed in the above mentioned McEachron patent, one end of the lower resistance unit 26 is secured to a

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tongue 28 bent from a plate 29 clamped between the end cap 14 and the insulating cylinder 12. One end of the upper resistance unit 26 is connected by a strap 30 to an annular metal member 31 resting on the flange 15 under the resistance unit 16. The other two ends of the two resistance units 26 are connected together by a strap 32. The assembly of the resistance units 16 to 22 inclusive and the resistance units 26 with their common casing formed by the insulating cylinder 12 and its end caps 13 and 14 constitutes a sealed gap unit.

The current limiting element of lightning arrester 1 comprises a plurality of resistance plates or disks 33 arranged in a stack between the upper cap 13 of the gap unit and the top plate 3, a spring 34 between the plate 3 and the upper resistance unit 33 being provided to hold the resistance units 33 and the gap unit in place. The pressure of the spring 34 on the resistance units 33 may be regulated by means of the adjusting screws 11. The resistance disks 33 may be spaced from each other by thin metal plates or spacers which are considerably smaller in diameter than the resistance disks 33 as is disclosed in the above mentioned McEachron patent. Preferably, however, the plane surfaces of the disks are covered with a metal coating to provide good conductive contact between adjacent disks as well as between the upper disk 33 and spring 34 and between the lower disk 33 and cap 13.

The resistance material in the resistance units 16 to 22 inclusive and 33 must have a high inverse voltage-resistance characteristic. That is, if a voltage applied across a piece of this resistance material is increased, then the resistance of the material will decrease very greatly and the current flowing through the material will consequently increase very greatly. It is also important that there be very little, if any, time lag between the change in the voltage and the corresponding changes in resistance and current. A suitable resistant material for this purpose is disclosed in United States Patent No. 1,822,742, McEachron, granted September 8, 1931, and assigned to the same assignee as the present application. As disclosed in that patent, the resistance material described therein may have different predetermined characteristics. Thus, although the resistance units 16 to 22, inclusive, are shown as being of similar size and shape, they may have different resistances under the same voltage conditions. As indicated in Fig. 1, the resistances of these resistance units decreases from the unit 16 to the unit 22, the unit 16 having the highest resistance and the unit 22 having the lowest resistance. It is not necessary, however, that the resistances be all different but the units may be arranged in groups, the resistances of the units in each group being of the same value but the resistances of the units in different groups having different values. As shown in Fig. 1, the units 16 and 17 have the highest resistance, the units 18 and 19 have resistances somewhat lower than that of the units 16 and 17, and the units 20, 21 and 22 have still lower resistances. The resistance of each unit 26 should be high which may be partly due to the characteristic of the material used in the unit but also largely due to the considerably smaller cross section and longer current path as compared to the units 16 to 22. The combined resistance of the two units 26

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be comparable to the entire resistance of all the other resistance units.

The arrangement described thus far is not my invention but is disclosed and claimed in McEachron Patent 2,151,559, mentioned above. In the disclosure of this McEachron patent it was important that the discharge gaps 24 and also the gaps associated with the units 26 occur with as little time delay as possible after the voltages across these gaps have risen to the predetermined value at which the discharges should take place. In the McEachron Patent 2,151,559 the electrodes of the discharge gaps are arranged side by side so that a discharge across any gap will illuminate the adjacent gap or gaps. This illumination or electron radiation has the effect of ionizing the adjacent gap or gaps and reducing the time lag between the application of voltage and the discharge. Thus after the first gap of units 26 breaks down the remaining gaps will break down in succession with substantially no time lag. In order that the discharge gaps 24 may break down in succession, the discharge gap 24 of the resistance unit 16 is a little shorter than that of the resistance unit 17. If, however, the lengths of the gaps are successively increased, they will soon become so long that flash-over will occur across the surfaces of gap shunting resistances 16, 17, 18, etc. rather than across the gaps 24 as intended. Also the impulse breakdown of the arrester becomes too high with long gap settings. As the size of a gap increases with a corresponding increase in the voltage applied to it, the efficiency of the gap from the point of view of its ability to interrupt a discharge or flow of current across it decreases. In order therefore that the discharge gap 24 of the resistance unit 18 may not be too long this gap may be made as short as that of resistance unit 16 but the resistance of the resistance unit 16 is smaller than that of the resistance unit 18. The voltage at any time across the discharge gap of the resistance unit 16 will thus be greater than that across the gap of the resistance unit 18 and the former gap will thus break down first. In like manner the resistances of the resistance units 18 and 19 may be of the same value but the length of the discharge gap of the resistance unit 19 may be slightly greater than that of the discharge gap of the resistance unit 18.

As has been pointed out in the preceding paragraph, the unsatisfactory operation of the lightning arrester will result if the gap length is increased together with a corresponding increase in voltage. I have discovered that a lightning arrester of the type described above can be made to operate satisfactorily under much more severe impulse conditions than present lightning arrester constructions if the possibility of a single arc across several of the gaps 24 is completely eliminated. To this end I interpose between the respective units 16 to 22 disk-like barriers or members 35. These disk-like barriers are preferably constructed of conducting material, such as copper, thereby to partition off the gap structure with equal potential surfaces and divide up the ionized space into separate compartments. With this arrangement greatly increased gap sealing ability is provided by introducing definite potential drops along any ionized path which may be established through the gap, thereby breaking up any long, relatively stable arc into shorter, less stable arcs. The ionization resulting from a severe discharge through the gaps in the arrester

may cause an arc to strike across several of the gaps 24, as for example, from one of the electrodes in resistance unit 16 to one of the gap electrodes connected to resistance unit 19, thus by-passing the gaps in resistance units 16, 17, 18, and 19. As a result of this arc, the follow current interrupting ability of the arrester is reduced because of the number of gaps in series with the arc in this example are reduced from 9 to 6. This undesirable arc path may occur even though the discharge started across the electrodes of each of the gaps that are connected in parallel with the resistance units, 16 to 22 inclusive, and 26 and 27. These series arcs might transfer to the undesirable path short circuiting several of the series gaps after the discharge was started due to the great amount of gaseous ionization resulting from carrying a severe discharge. With barriers 35 in place, the number of gaps in series with the arc and hence the current interrupting ability will not be reduced even though the arc may transfer from the intended electrodes 24 to the surfaces of the conducting barriers 35 at each end of the resistance unit that is connected in parallel with the gap.

Because of the volume differences and because of the different times and energy associated with each of the arc segments there will tend to be established a gaseous flow within the arc which will serve to disturb the stability of these short arc segments and favor arc extinction when current flow is diminished, as when current direction reverses at two times during the period of one cycle on an alternating current circuit.

Although the disks 35 will greatly increase the current interrupting ability of the lightning arrester and therefore enable it to operate satisfactorily under much more severe impulse conditions, these disks without more will increase the spark potential of the arrester very appreciably if they are opaque to electron radiations since they will interfere with one gap illuminating the other. To overcome this difficulty each of the disks is provided with a plurality of openings 36. Actually a single opening in each disk, if these openings were all in alignment so that radiation from one gap might affect the next gap, would be satisfactory. It is quite possible, however, that the disks 35 may be shifted slightly so that a single opening in each disk might not be in alignment with arcs between the electrodes of the gap above and the gap below the disk 35. Therefore, to guard against stopping the inter-gap illuminating path a multiplicity of holes 36 are provided arranged somewhat in the manner of the holes in a salt shaker top, thereby allowing illumination without requiring any particular hole to be in alignment with other holes or openings. The size of the holes in disks or barriers 35 is not important insofar as they do not become so small as to be mechanically difficult to produce or so large that they do not serve as proper shields or conducting surfaces if constructed of metal. I have discovered that holes as large as one-quarter inch in diameter are unsatisfactory, while holes as small as forty thousandths of an inch were found very satisfactory.

Although I have found it preferable to employ disks 35 formed of conducting material, satisfactory operation can be obtained with barriers or disks formed of insulating material, such as fiber. If insulating barriers are used, provision must be made for conducting current from gap to gap. Fig. 4 illustrates such an arrangement wherein a barrier or disk 37 is employed which

is similar to disk 35 except that it is made of insulating material and a plurality of spaced rivets 38 of conducting material are provided therein to conduct current from gap to gap or between adjacent electrode plates 23. It will be obvious that if the barrier 37 is made of a material transparent to the active radiations which aid in setting off the successive gaps, the openings or holes 36 may be dispensed with. For example, if the barriers were made of quartz, which is not a barrier to the ultra violet illumination which is the effective illumination to aiding the gap breakdown, openings 36 might be dispensed with entirely.

In view of the detailed description included in McEachron Patent 2,151,559, the operation of the lightning arrester embodying my invention will be obvious particularly in the light of the detailed discussion included above. With the inter-gap barriers 35 the effect of ionized air allowing the arc to communicate between electrodes of adjacent gaps is completely eliminated. I have discovered that on tests made at impulse currents of the order of 10,000 amperes, a marked increase in satisfactory follow current interruptions occurred when employing the inter-gap barriers of my invention whereas unsatisfactory operation resulted with lightning arresters constructed in accordance with the prior art.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. A lightning arrester including a pair of coaxially arranged hollow rings of resistance material, a metal plate with a central opening secured to each face of each ring and having a projection from the inner edge of said opening, the ends of the projections associated with each ring forming a pair of spaced electrodes within the hollow of each ring and defining an arc gap therein, and a plurality of disk-like elements of metal respectively interposed between and in physical contact with said metal plates positioned between each pair of adjacent rings to prevent an arc from extending between electrodes of different gaps, each of said disk-like elements having a plurality of staggered openings therein for permitting an arc at one of said gaps to illuminate the other gaps through one or more of said openings in said disk-like elements even though said disk-like members are not in alignment.

2. A gap structure comprising a plurality of series arc gaps, each gap being positioned between a pair of coaxially arranged spaced metal plates each of which has a central opening and a projection from the edge thereof, the ends of the projections associated with each of said pair of plates forming a pair of spaced electrodes between the pair of plates and defining an arc gap therein, and a barrier of conducting material interposed between and in physical contact with the adjacent plates of each two adjacent pairs of plates for preventing an arc from striking between an electrode of the gap within one of said adjacent pairs of plates and an electrode of another gap in said structure, said barrier having an opening therein through which radiation effective to irradiate other gaps may pass.

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3. A gap structure comprising a plurality of series arc gaps, each gap being positioned between a pair of coaxially arranged spaced metal plates each of which has a central opening and a projection from the edge thereof, the ends of the projections associated with each of said pair of plates forming a pair of spaced electrodes between the pair of plates and defining an arc gap therein, and means for establishing electrical connection between a plate of one of said pair of plates and the adjacent plate of an adjacent pair of plates including a barrier interposed between and in physical contact with the adjacent plates of each two adjacent pairs of plates for preventing an arc from striking between an electrode of the gap within one of said adjacent pairs of plates and an electrode of another gap in said

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structure, said barrier having a plurality of openings therein through which radiation effective to irradiate other gaps may pass.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,561,249	Kraut	Nov. 10, 1925
1,664,194	Creighton	Mar. 27, 1928
2,151,559	McEachron	Mar. 21, 1939
2,279,249	Roman	Apr. 7, 1942