C. FIELD-FRANK.

ELECTRIC DISCHARGE APPARATUS.

APPLICATION FILED JAN. 27, 1916.

1,238,660. Patented Aug. 28, 1917.

Fig. 1.

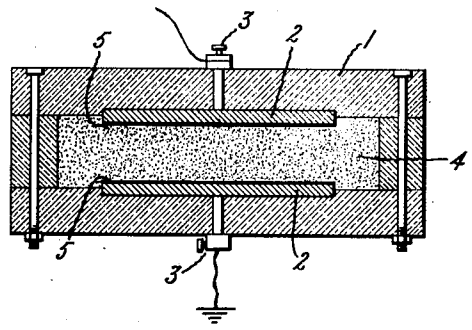


Fig. 4.

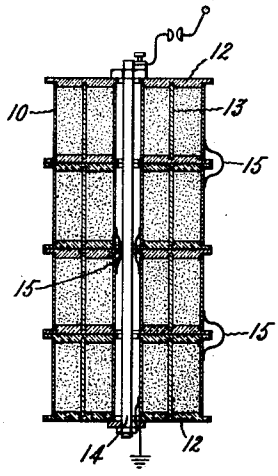


Fig. 2.

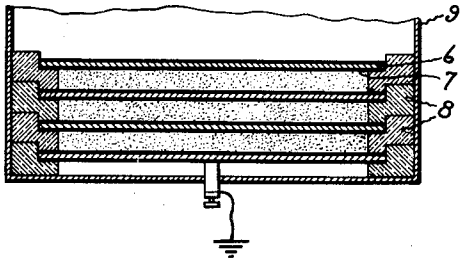


Fig. 5.

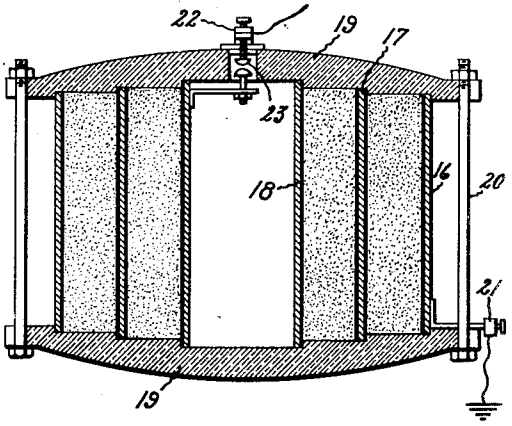
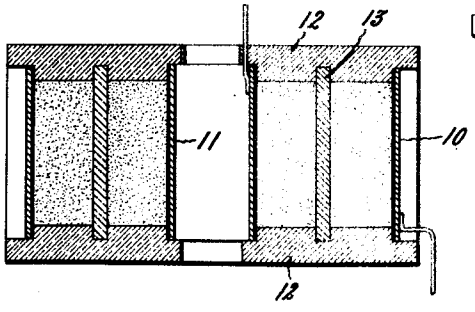


Fig. 3.



Inventor:
Crosby Field-Frank,
by Albert G. Davis
His Attorney.

UNITED STATES PATENT OFFICE.

CROSBY FIELD-FRANK, OF NEW YORK, N. Y., ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ELECTRIC DISCHARGE APPARATUS.

1,238,660. Specification of Letters Patent. Patented Aug. 28, 1917.

Application filed January 27, 1916. Serial No. 74,588.

To all whom it may concern:

Be it known that I, CROSBY FIELD-FRANK, a citizen of the United States, residing at New York, county of New York, State of New York, have invented certain new and useful Improvements in Electric Discharge Apparatus, of which the following is a specification.

My invention relates to apparatus which permits a free discharge through it only so long as the difference of potential between its terminals exceeds a predetermined amount. Such apparatus is particularly useful as a lightning arrester to remove abnormal potentials, surges and similar disturbances commonly designated as lightning from an electrical conductor without permitting escape of current at the normal potential of the conductor, and may also be utilized for many other purposes for which its characteristics render it available.

The object of my invention is to provide a simple and durable electric discharge device which will permit a very free discharge of electricity as long as the difference of potential between the terminals of the device is excessive, but will interrupt the discharge the instant the difference of potential becomes normal. A further object of my invention is to provide a device of this character in which the discharge is started and stopped more efficiently and quickly than in devices heretofore used. Another object is to provide a device of this character in which the ohmic resistance of the discharge path is low so that large amounts of energy can flow freely at abnormal potential and quickly relieve the conductor of dangerous voltages. A still further object is to provide an improved device of this character, as more particularly hereinafter pointed out.

In accordance with my invention a large number of independent discharges may take place, each passing through a discharge path which is initally of low ohmic resistance but quickly increases in resistance, due to a permanent chemical change brought about in the material of the discharge path by the effect of the discharge, until further flow of current through that particular path is prevented, whereupon the discharge is diverted to another similar path and so on until the abnormal potential is relieved. In order to secure this action I so construct the apparatus that the discharges take place through a mass consisting wholly or in part of some material such as lead peroxid, which is a good conductor of electricity but is very quickly converted into some non-conducting salt or material if subjected to an electrical discharge under certain conditions of limiting conducting path. To permit free discharge and also to render the action of the device practically instantaneous, I prefer to use lead peroxid, which has a low ohmic resistance and which changes into a very high resistance lower oxid almost instantaneously when subjected to the discharge. The lead peroxid or similar material is preferably used in the form of powder and placed adjacent a terminal which is provided with some means, such as a thin insulating film, for restricting each individual discharge to a very small part of the mass of lead peroxid, with the result that each successive discharge affects a different part of the mass.

The novel features of my invention are pointed out with particularity in the appended claims, but the invention itself will best be understood in connection with the accompanying drawing in which simply for purposes of illustration I have shown embodiments of my invention and in which Figure 1 is a longitudinal section of a simple form of low voltage arrester; Fig. 2 is a longitudinal section of a portion of a high voltage arrester; Fig. 3 is a longitudinal section of a novel form of high voltage arrester having an arc shield to prevent short circuiting of the arrester; Fig. 4 is a longitudinal section of another form of high voltage arrester composed of a number of units constructed as shown in Fig. 3; and Fig. 5 is a longitudinal section of one form of arrester suitable for use on circuits of about 600 volts.

The form of my invention shown in Fig. 1 comprises a casing 1 of insulation and containing conducting plates or electrodes 2 forming part of the terminal 3. Interposed between the electrodes 2 is a filler or mass 4 composed wholly or in part of powdered lead peroxid and constituting the discharge path between the electrodes. While I do not wish to be restricted to any particular theory of the action of this device, it seems certain that since lead peroxid is a very poor conductor of heat, a discharge occurring from one of the electrodes causes at the point of discharge a very local and very

intense heating which instantly changes a very small amount of the lead peroxid into some lower oxid having a very high electrical resistance. For example, a cubic centimeter of lead peroxid, BbO_2, having an electrical resistance of 1/2 ohm can easily be converted by heat into the lower oxid Pb_3O_4 having an electrical resistance of 24,000,000 ohms, or into another lower oxid, PbO, having a still higher resistance. As a result of this great and permanent change in the electrical resistance of that part of the filler 4 affected by the discharge, a mass of substantially non-conducting material instantly forms in the path of discharge and what may be called a reseal action takes place; that is, further flow of current at that point is prevented. Lead peroxid is a very good electrical conductor and provides a very low resistance path for discharges, so that when the discharge rate of the device is very high a large current can flow as long as the material in the path of discharge is unchanged, and the time lag or delay in starting the discharge after the applied voltage exceeds normal is very slight. Each discharge requires energy and in many cases one or two discharges will relieve a line of the abnormal potential on it. If for any reason the abnormal potential is still present after the first discharge has converted the lead peroxid at the point of that discharge into a lower oxid, a second discharge occurs at some other point on the electrode and converts some of the lead peroxid at that other point into a lower oxid, thereby stopping the current flow at the point of second discharge, and so on, until finally when the potential across the terminals of the device becomes normal, no further current will flow. As each discharge is confined to a very small area, the current density in that area is so great that the heat developed instantly converts the lead peroxid in that area into a lower oxid or oxids having very much greater electrical resistance. The electrode 2 has sufficient area to permit a great many discharges to take place at different points on it before all the lead peroxid adjoining the electrode is converted into the non-conducting lower oxids.

Although the lead peroxid is preferably used in the form of a fine powder, it may be made into a cake or solid body by subjecting it to pressure or by mixing it with a suitable binder such as coal tar. By varying the pressure to which it is subjected its electrical resistance can be varied. It may be made into a paste with any suitable vehicle such as water, and is then quite suitable for use with an aluminum electrode, on which an insulating film may, if desired, be previously formed electrolytically in a suitable electrolyte.

The electrode 2 may be made of practically any of the metals or other conducting materials, and may be made in the form of a plate, a brush, a wire network, or of a plurality of metal rods mounted adjacent one another. In some cases it may be desirable to knurl or otherwise roughen the surface of the electrodes, to coat them with filings or fine granules, or otherwise provide the surface with numerous discharge points.

The energy of any discharge from the electrode to the filler 4 should be concentrated on a restricted area of the filler by some suitable means, as for example, by an insulating film or layer 5 between one or both of the electrodes and the surface of the filler 4. Such a film may be formed by impressing normal voltage upon a bare electrode in contact with the lead peroxid, whereupon enough of the lead peroxid immediately adjoining the electrode is converted into a layer or film of non-conducting lower oxid to prevent flow of current at normal voltage. During this operation the current is kept within such limits that there will be no danger of converting all of the lead peroxid into the lower insulating oxids. The best method is to provide one or both of the electrodes 2 with an insulating film of uniform and proper thickness before the arrester is assembled. The thickness of this film may vary within wide limits and depends upon the normal voltage, the characteristics of the film material, and the extent to which the impressed voltage is permitted to rise above normal before discharging through the film to the filler. For protecting a line of which the normal potential is about 300 volts, I find that an arrester having a filler of lead peroxid and two electrodes each with a film of insulating varnish about 1/1000 of an inch thick gives good results and permits discharge at somewhat less than double the normal line voltage.

The insulating film on the electrode may be produced by applying a thin uniform layer of insulating varnish or lacquer to a well cleaned or burnished surface of the electrode in any suitable way, as by painting, dipping, spraying, or in any other suitable manner. By dipping the electrodes into a solution of the proper consistency, and baking, if necessary, at a uniform temperature, all of them may be provided with insulating films of substantially the same thickness. Films of different degrees of toughness, resilience and dielectric strength may be obtained by varying the composition or consistency of the varnish, by baking at different temperatures, or by baking at fixed temperatures for different periods.

Instead of a varnish, I may use for the insulating film, a paste of some salt of lead, such as monoxid or other insulating salt

mixed in a suitable vehicle, such as glycerin, oil, or water; or I may apply lead peroxid mixed with a suitable vehicle to the electrode and then turn the lead peroxid into an insulating layer by passing current through it, heating it, or in some other suitable manner bringing about a permanent conversion to a lower oxid. I may also spray upon the electrode a glass, or an enamel glaze, or a metal which will readily form a film of non-conducting oxid. For example, metallic lead sprayed upon a copper electrode may be oxidized to a non-conducting lead oxid.

Insulating films may also be produced electrolytically. If the electrode is of aluminum, it may be immersed in any of the well known electrolytes; if of lead, in an electrolyte containing orthoplumbates of the alkaline earths, such as calcium orthoplumbate. The electrode may also be electrolytically coated with a thin layer of lead or of lead peroxid in an electrolyte of caustic potash and litharge, the coating then being converted into non-conducting lead salts, such as the lower oxids, sulfids, or sulfates.

The insulating film may be formed chemically by heating a lead electrode in air or oxygen; or by sprinkling an oxidizing powder, such as lead peroxid, over the metal electrode while the electrode is hot. By dipping or treating the electrodes in a suitable solution, they may be coated with thin layers of non-conducting salts such as are sometimes known as oxidizing finishes but which in reality are insulating sulfids and sulfates.

The action of the insulating film 5 in concentrating the discharge on a restricted area of the filler 4 may be facilitated by weakening the film at predetermined points, as, for example, by perforating the film or distributing conducting particles through it. The lead peroxid for the filler should preferably be pure, although the conductivity of the filler does not appreciably change until the lead peroxid content is reduced to about 50%. For the best results, the lead peroxid should be finely powdered, but not very dense. I prepare it by stirring red lead into an alkaline solution and passing in chlorin, keeping the solution concentrated, the temperature about 80 degrees centrigrade, and afterward carefully removing all alkali, thereby obtaining a product which is fluffy and does not settle readily when suspended in water.

The properties of the filler may be modified by varying the pressure upon it and also by mixing suitable materials with it. For example, the resistance of a lead peroxid filler may be increased by mixing with it barium peroxid, alumina, ammonium tetraborate, galena, carborundum or similar materials, preferably granular or powdered; or the resistance may be decreased by distributing through the filler some metallic filings or conducting granules, which may be made to facilitate the break down by a multigap action due to their electrostatic capacity. I may also mix with the lead peroxid a catalytic agent, such as manganese dioxid to take up oxygen from the air and replace that lost by the reduction of the lead peroxid.

If the arrester increases in resistance with use, it may be restored to approximately its initial condition and resistance by treating the filler in some suitable manner as by pressing or compacting it, or by subjecting the arrester to pounding, tapping, or other vibration applied from the outside.

The filler may consist of or contain various other materials which act in the same way as lead peroxid, and all such materials I consider to be within my invention and to be equivalents of lead peroxid. In some cases and for some purposes I have obtained results with bismuth dioxid, Bi_2O_4, sodium bismuthate, BiO_3NaBiO_3H, and barium nitrite, $Ba(No_2)_2$, but these materials are not as good as lead peroxid.

Arresters for high voltage may be made by connecting a number of filmed electrodes in series with suitable filling, such as lead peroxid, between them. For example, as indicated in Fig. 2, electrodes 6 with insulating films 7 may be held side by side by means of spacers 8 and some suitable retainer or holder 9. The voltage required to initiate a discharge through such an arrester depends upon the number of the electrodes 6 and the thickness of the insulating films 7.

I may interpose between the electrodes a refractory body embedded in the filler or having a layer of filler between it and the electrode. For example, as shown in Fig. 3, two concentric electrodes 10 and 11 held in place by heads 12 of some suitable insulating material, such as porcelain, have interposed between them a refractory body 13 made of carbon or similar refractory material. The refractory body 13 lessens the amount of filler required and acts as an arc shield to prevent impurities in the filler causing an arc to hold from one electrode to another. An arc in the filler can extend only from one electrode to one side of the arc shield, as the other side of the shield would act as another electrode on which an insulating film would quickly build up and stop the current flow. The probability that impurities would be so segregated on both sides of the arc shield as to form a conducting bridge between it and both electrodes is very slight.

The form of arrester shown in Fig. 3 is a unitary structure suitable to line voltages of between 200 and 300 volts. An arrester suitable for much higher voltages such as 30,000 volts can be made by connecting the requisite number of these units in series. This may be done as shown in Fig. 4, where

units are assembled upon a central rod 14 and are connected in series through connectors 15.

A form of arrester suitable for distribution circuits of about 600 volts, such as street car circuits, is illustrated in Fig. 5, in which concentric electrodes 16, 17 and 18 are held in place by insulating heads 19 suitably recessed to engage the ends of the electrodes. The heads are held against the ends of the electrodes by bolts 20. The outer electrode is provided with a ground terminal 21 and the inner electrode is connected to a line terminal 22. A spark gap comprising electrodes 23 preferably made of brass and mounted in a recess in one of the heads 19, may be interposed between the arrester and the line to prevent a continuous potential strain on the arrester. The spark gap spacing depends on the line voltage, and may be as small as fifteen one thousandths of an inch for direct current circuits of 600 volts. In many cases the spark gap may be omitted and the arrester connected directly to the line, especially if the circuit carries alternating current.

An arrester embodying my invention and made with aluminum electrodes previously formed or coated with an insulating film, and with a filler of lead peroxid containing ammonium tetraborate, has some electrostatic capacity. In cases where the capacity or condenser effect is important, I use a mixture of glycerin and lead peroxid for the filler 4. The power factor may be reduced by mixing with the filler 4 some suitable substance, such as a hydrate, like hydrate of alumina.

My invention may be embodied in many other forms, and is not limited to those shown and described, as I intend to cover all changes and modifications which are within the spirit of my invention and the scope of the appended claims.

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

1. The combination with a dry powdered metallic salt having low heat conductivity and high electrical conductively and permanently converted by heat into a salt of different chemical composition and of very low electrical conductivity, of two coöperating electrodes mounted to direct an electrical discharge between said electrodes through said salt to produce localized heating of said salt and bring about a local conversion of sufficient salt in the path of discharge to interrupt the discharge.

2. An electrical device of the character described having a terminal, a mass of dry powdered conductive oxid permanently converted by heat into a different oxid of higher electrical resistance and positioned to carry current from said terminal, and a coöperating terminal comprising an electrode with an extended surface mounted adjacent said oxid to direct an electrical discharge between terminals into said oxid and thereby produce local heating in the path of discharge.

3. An electrical device comprising two electrodes and a filling of dry powdered lead peroxid between and adjacent said electrodes to receive discharges between them.

4. An electrical device comprising two terminals, an electrode connected to one terminal, and a mass of dry lead peroxid adjoining said electrode and forming a normally conductive part of a path for discharges between said electrode and said other terminal.

5. An electrical device comprising a mass of dry powdered lead peroxid which is free from alkali, is fluffy, and when suspended in water settles more slowly than the powdered lead peroxid prepared by acting upon red lead with nitric acid, and two electrodes adjoining said mass to direct a discharge between said electrodes through said mass.

6. An electric device having a terminal, a mass of powdered metallic salt of low heat conductivity and low electrical resistance, and permanently converted by heat into a salt of different chemical composition and high electrical resistance, said mass being in position to carry current from said terminal, a coöperating terminal comprising an electrode having an extended discharge surface in proximity to said mass of metallic salt, and a layer of insulation between said surface and said salt.

7. A device comprising two separated electrodes having one of their opposed faces provided with an insulating coating, and a filling between said electrodes of a metallic salt of low electrical resistance and convertible by heat into a salt of high resistance.

8. A device of the character described comprising separated electrodes, one of which is coated with an insulating film, and a filling of lead peroxid between said electrodes and adjacent said film.

9. A device of the character described comprising separated electrodes, one of which is coated with an insulating film and a conductive filling between said electrodes and adjoining said film and comprising a metallic salt which in response to a discharge through said film into said filling is instantly and permanently converted into a non-conductive salt at the point of discharge only.

10. A device comprising metallic plates insulated from one another, and a filling between said plates containing lead peroxid and insulated from said plates at normal voltage on said circuit.

11. A protective device having two electrodes, a filler comprising lead peroxid between said electrodes and a refractory con-

ductive member interposed between said electrodes and embedded in said filler.

12. A protective device having two parallel conductive plates, a filler of lead peroxid between said plates, and a refractory conductive arc shield substantially coextensive with said electrodes embedded in said filler between said electrodes.

13. A device of the character described comprising a plurality of conducting plates each coated with an insulating film, an insulating spacer for positioning and holding said plates separated, and a filler comprising lead peroxid in the space between said plates.

14. A device of the character described comprising two conducting plates, solid insulation engaging the edges of said plates to hold them substantially parallel and to form with said electrodes a closed receptacle, and a lead peroxid filling in said receptacle.

15. A unit of the character described consisting of a receptacle having two parallel portions of its wall of metal and the remainder of insulation and a filling of lead peroxid between said metal portions.

16. A unitary structure comprising concentric tubular electrodes, insulating heads for closing the ends of said electrodes, and a filling comprising lead peroxid in the space between said electrodes.

17. A unitary structure comprising a plurality of concentric conducting members, insulating heads in engagement with the ends of said members to position them and form a closed receptacle, and a filling of lead peroxid in said receptacle and in contact with said members.

In witness whereof, I have hereunto set my hand this seventeenth day of January, 1916.

CROSBY FIELD-FRANK.