E. E. F. CREIGHTON.

LIGHTNING ARRESTER.

APPLICATION FILED FEB. 7, 1907.

992,744.

Patented May 16, 1911.

2 SHEETS—SHEET 1.

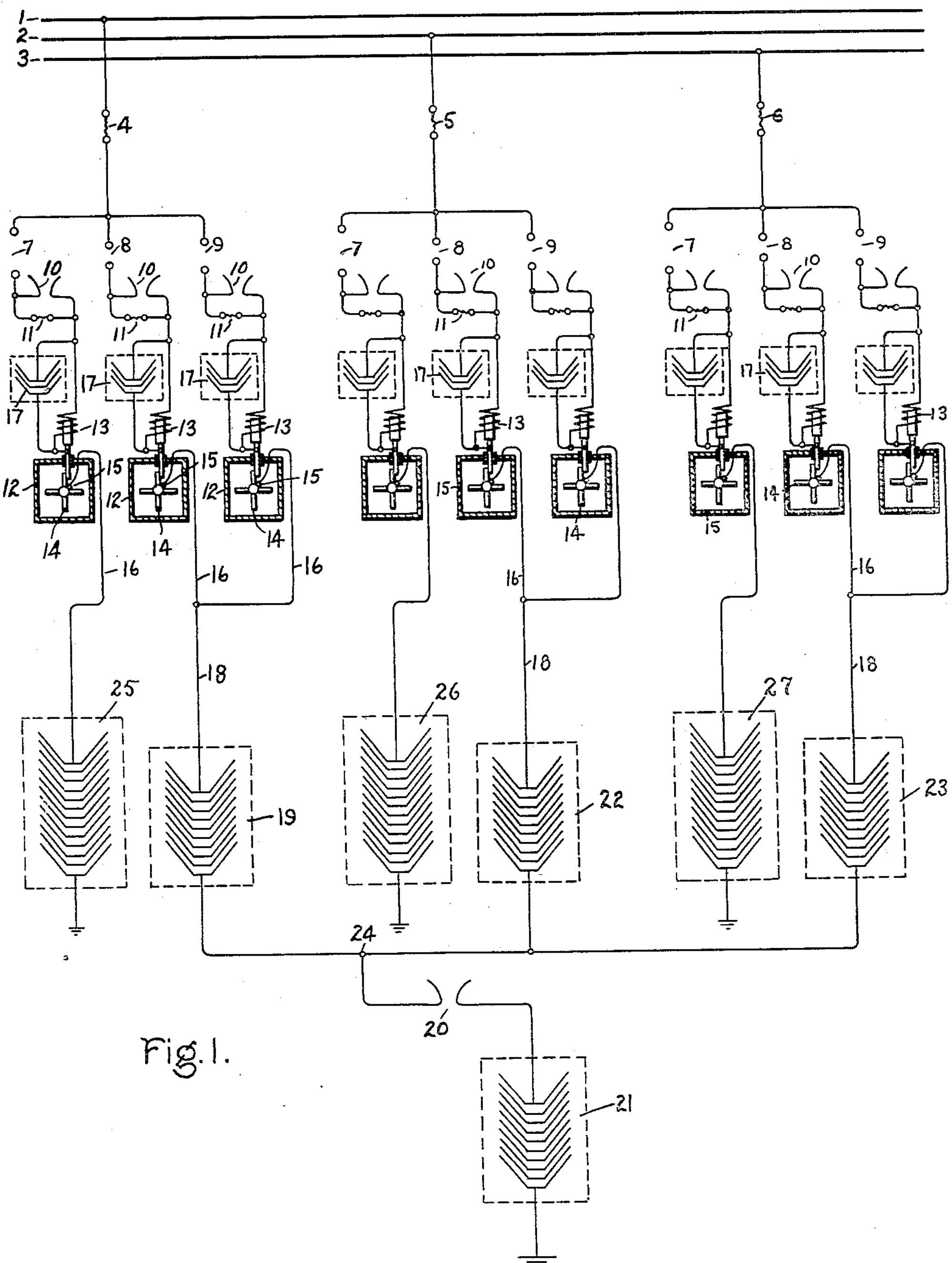

Fig. 1.

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2 SHEETS—SHEET 2.

Fig. 2.

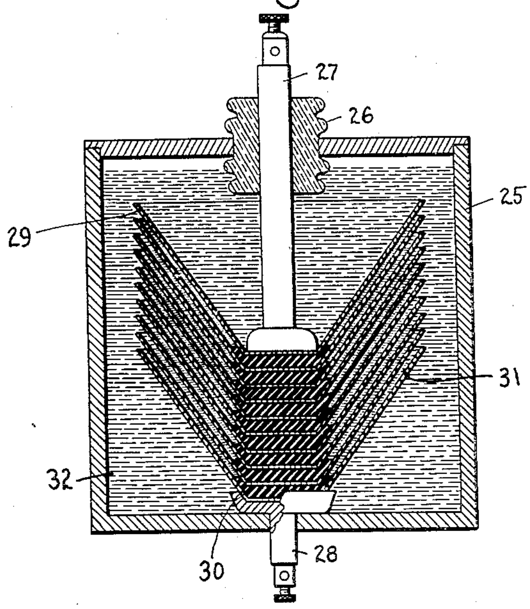


Fig. 4.

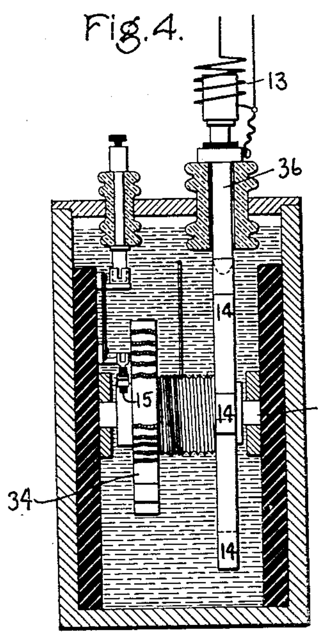
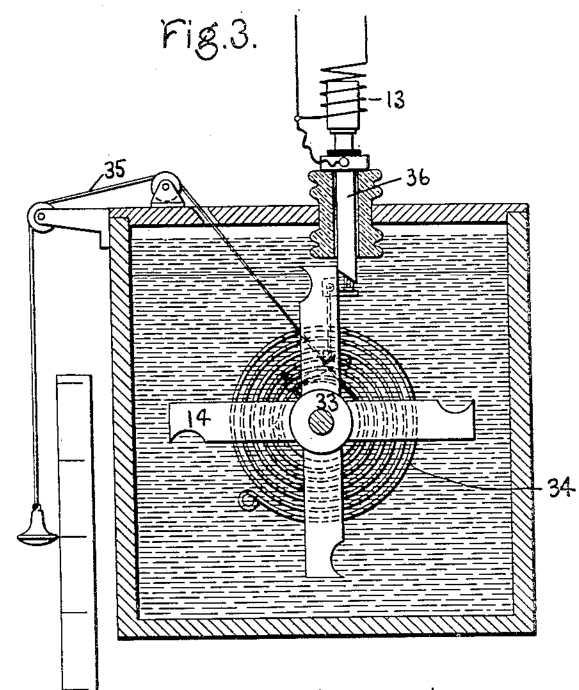


Fig. 3.



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UNITED STATES PATENT OFFICE.

ELMER E. F. CREIGHTON, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

LIGHTNING-ARRESTER.

992,744. Specification of Letters Patent. Patented May 16, 1911.

Application filed February 7, 1907. Serial No. 356,149.

To all whom it may concern:

Be it known that I, ELMER E. F. CREIGHTON, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Lightning-Arresters, of which the following is a specification.

This invention relates to protective devices for electrical transmission lines and more particularly to devices suitable for use on high potential circuits.

My invention includes several features which, though more or less distinct, coöperate to render the device reliable even under the trying conditions imposed by modern practice in long distance and high voltage transmission.

One feature of my invention resides in the use of duplicate devices connected to the same line-wire through spark gaps of different lengths and so arranged that if the charge to be conducted from the line is relatively small, it will be passed over the shortest gap and through only one of the duplicate devices. If, however, the charge is heavy, and could not be properly handled by a single device, it is permitted to break down a second spark gap and divide through a second device.

A second feature of my invention is an oil switch so arranged as to normally complete the circuit between spark gaps and other elements of the protective device. This switch is arranged to break the circuit after a heavy discharge has passed and to thereby disconnect the transmission line from ground and prevent the line current from following through on any arc formed by the escaping high potential energy. This switch automatically re-sets itself almost instantly, as hereinafter described more in detail.

A third feature of my invention consists in the use of aluminum electrolytic condensers or electrolytic cells of the aluminum type for absorbing and transmitting energy of very high potential, and at the same time opposing a practically prohibitive resistance to current of normal line potential.

The three more or less distinct elements above set forth are combined with each other and with the line circuits to be protected in such a way that abnormal charges of almost any size and nature may be successfully conducted to ground without danger of interrupting the service on the transmission line or of setting up dangerous oscillations, surges or fluctuations in the line potential.

In the drawings forming a part of this specification, I have illustrated the various elements of the device and have indicated diagrammatically one arrangement of the elements suitable for protecting a three-phase system.

Figure 1 is a diagrammatic illustration of my improved protective system; Fig. 2 is a sectional elevation of an aluminum condenser suitable for use according to this invention; Fig. 3 is a side elevation of the oil break switch; and Fig. 4 is a transverse section thereof.

According to the arrangement shown in Fig. 1, the line conductors 1, 2 and 3 are connected, respectively, through fused spark gaps 4, 5 and 6 to a plurality of spark gaps of varying sizes. Thus, conductor 1 is provided with a main spark gap 8 adjusted to such a length that the normal potential of the system will not send a discharge across the gap and must be augmented by say ten per cent., before a spark will pass. In parallel with this main gap 8 is a second circuit including a spark gap 9 intended as an adjunct to the main spark gap path and called into operation only when the oil switch or other safety device of the main path is in the open circuit position, as when rotating in the oil. Conductor 1 is also connected to a third spark gap 7 having a length considerably greater than spark gap 8 and communicating with ground through an oil switch and an electrolytic condenser. This path is intended as an emergency device for assisting the normal discharge path in carrying off charges of very great quantity. In series with each of the gaps 7, 8 and 9 is a horn gap 10 shunted by a fuse 11 and connected in series with an automatic oil switch 12. This switch comprises a tripping electromagnet 13 and a spring actuated rotary member 14 submerged in oil and connected by a sliding contact with a brush 15. By means of this brush, connection is made through a conductor 16 with other parts of the system. The tripping electromagnet 13, which is necessarily inductive and acts much like a reactance, is in parallel with an electrolytic condenser 17 of the type hereinafter described more in detail. This condenser provides a path for the high potential discharges, entirely free from coils or windings which might tend to act as reactances for a current of high frequency. The duplicate oil switches in series with spark gaps 8 and 9 are connected to conductor 18 leading to an electrolytic condenser 19 of the type shown in detail in Fig. 2. This condenser is connected to ground through a spark gap 20 and a second condenser 21.

I have above described the paths to ground from conductor 1 of the three-phase transmission line; conductors 2 and 3 are similarly equipped. They are provided respectively with condensers 22 and 23. These condensers are connected with electrolytic condenser 19 at the junction point 24 leading to spark gap 20 of the ground connection. The emergency paths through spark gaps 7 are provided with electrolytic condensers 25, 26 and 27 similar in design to that shown in Fig. 2 but having a greater number of aluminum plates.

In order that the operation of my improved protective means may be better understood, reference is now had to the remaining figures which illustrate details of the electrolytic condensers and of the rotary switches.

Fig. 2 shows an oil tight box 25 provided with a cover carrying an insulating bushing 26 through which passes a conductive standard 27 serving as one terminal for the electrolytic condenser contained in the box. The second terminal 28 passes through the bottom of the box and has a cup-shaped depression in its top. A plurality of aluminum cups 29 are arranged between these two terminals. These cups may be frusto-conical in shape and may be separated by saucer-like insulators 30. This particular shape of aluminum cup permits a ready discharge of the gases which sometimes form during the operation of an electrolytic condenser. A suitable electrolyte 31, such as an aqueous solution of citric acid, is placed between successive cups of the condenser or cell when the apparatus is set up, and the entire group of cups is then surrounded with an insulating body of oil 32. As the separate cups are insulated from each other except by the electrolyte placed therebetween, the cell as a whole may be regarded as a plurality of electrolytic condensers connected in series. The condenser action of the aluminum electrolytic cell is usually attributed to the formation of a thin film of aluminum oxid or hydroxid on the aluminum plate. This film is due to the oxidizing action of the electrolyte when the aluminum plate operates as anode. The film is of extreme thinness and seems to be partially absorbed or eaten away from the plate when the condenser is inactive. Possibly it still remains, and this apparent absence is due to the soaking up of the electrolyte by the film. The film does not appear to be present when current first flows between the electrodes but is developed only after the expenditure of considerable electrical energy. Thereafter it offers a high resistance to the flow of current from the aluminum plate. The film has, however, a break down voltage at which the film seems to puncture or fail in some way and lose its high resistance qualities. With an electrolyte of citric acid, the pressure between plates may be as high as 420 volts effective, before the film breaks down and permits an appreciable current to flow between the plates. Not only is the storage capacity of the aluminum condenser very high in proportion to its size and weight, but the condenser possesses certain other characteristics entirely lacking in condensers of ordinary type. The inductive capacity of the condenser bears a certain relation to the duration of the charging current; the capacity is, to a certain extent, dependent upon the time during which the condenser has been in operation. When the condenser is first thrown in circuit, the leakage therethrough is considerably higher than that found after the condenser has been in operation for some little time. This phenomenon is probably due to the gradual formation or development of the oxid or hydroxid coating by the oxidizing action of the leakage current. When the condenser is first thrown in circuit its low resistance or high leakage permits a relatively large quantity of energy to pass during the first instant of operation and then by oxidation interposes a sufficient resistance to prevent excessive current from flowing. In addition to the peculiar features of the aluminum condenser above set forth, it possesses the characteristic of transmitting high frequency energy with much greater ease than low frequency energy. This feature is all important in the use of these electrolytic condensers, for when the condensers are properly connected they act as selective devices to carry off the high frequency potential without permitting the normal current of the line to follow through on the high potential discharge.

Figs. 3 and 4 illustrate the rotary oil switch indicated diagrammatically in Fig. 1. This switch comprises an oil tight box within which is mounted a spring actuated rotary member 14 consisting of four radial arms mounted on a hub 33. A coiled spring 34 is secured to the hub and may be put under tension by means of a string 35 wound in a spiral groove of the hub and passing upward through the cover of the box. When the spring is under tension it tends to rotate the hub in a clockwise direction and holds the radial arms in electrical contact with a tripping plunger 36. This plunger not only holds the rotating member 14 against rotation by the spring but also serves to conduct current to one of the radial arms as shown diagrammatically in Fig. 1. The radial arms are electrically connected through the hub with a slip ring on which the brush 15 makes a sliding contact. The tripping plunger is controlled by an electromagnet 13 and may be lifted to release one of the rotary arms and open the circuit under the oil.

When the above described oil switch and electrolytic condenser are assembled as shown in Fig. 1, they constitute protective means of good efficiency. When the quantity of energy to be discharged from the line is not too large it is absorbed in the electrochemical action which takes place in the condenser. The voltage across the condenser under these conditions does not reach the maximum or break down voltage of the condenser and the line is relieved of its high potential without any disturbance of the normal line current. If the plate surface of the cell is not sufficient to absorb all the discharge, the voltage rises above the critical film voltage and the film breaks and the film resistance drops to a small fraction of its maximum value; current then flows freely through the cell. As soon, however, as the voltage drops below the critical or break down voltage the film resistance reappears and chokes down the current to a low value. The oil switches in series with the electrolytic condensers serve to interrupt the condenser current which flows in the electrolytic cell after the main line discharge has passed.

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

1. The combination with a line conductor to be protected from high potential charges, a plurality of paths to ground therefor, spark gaps of different lengths for said paths, an oil switch in each of said paths, an electrolytic condenser common to a plurality of said paths, electromagnetic means for tripping said switches and condensers in shunt with said electromagnetic means.

2. In a protective device for electrical systems, a ground connection, a plurality of electrolytic condensers connected therewith, a plurality of automatic switches in series with said condensers, a line conductor, and a plurality of spark gaps of different lengths interposed between said conductor and said automatic switches.

3. In an electrical protective device, a switch comprising a rotary member submerged in oil, a tripping means therefor actuated by an electromagnet, a condenser in shunt with said electromagnet, and an electrolytic cell in series with said switch.

4. The combination with a line conductor to be protected from high potential charges, a path to ground therefor including a spark gap and an automatic switch, and an electrolytic condenser, and a second path to ground therefor having a larger spark gap.

5. In an electrical protective device, a spark gap, an aluminum electrolytic condenser in series with said spark gap, and an automatic switch for rupturing the condenser current after a discharge has passed therethrough.

6. Protective means for an electrical system, comprising a ground connection, an electrolytic condenser connected therewith and parallel paths between said condenser and a line conductor, each of said paths including a rotary oil switch.

7. The combination of a plurality of line conductors, a path to ground for each of said conductors including a relatively large spark gap and an electrolytic condenser, and a second path to ground for each of said conductors, said second path including an electrolytic condenser in series with a plurality of automatic switches.

In witness whereof, I have hereunto set my hand this 5th day of February, 1907.

ELMER E. F. CREIGHTON.

Witnesses:
BENJAMIN B. HULL,
HELEN ORFORD.