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CATHODE RAY OSCILLOGRAPH CONTROL

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Fig. 1.

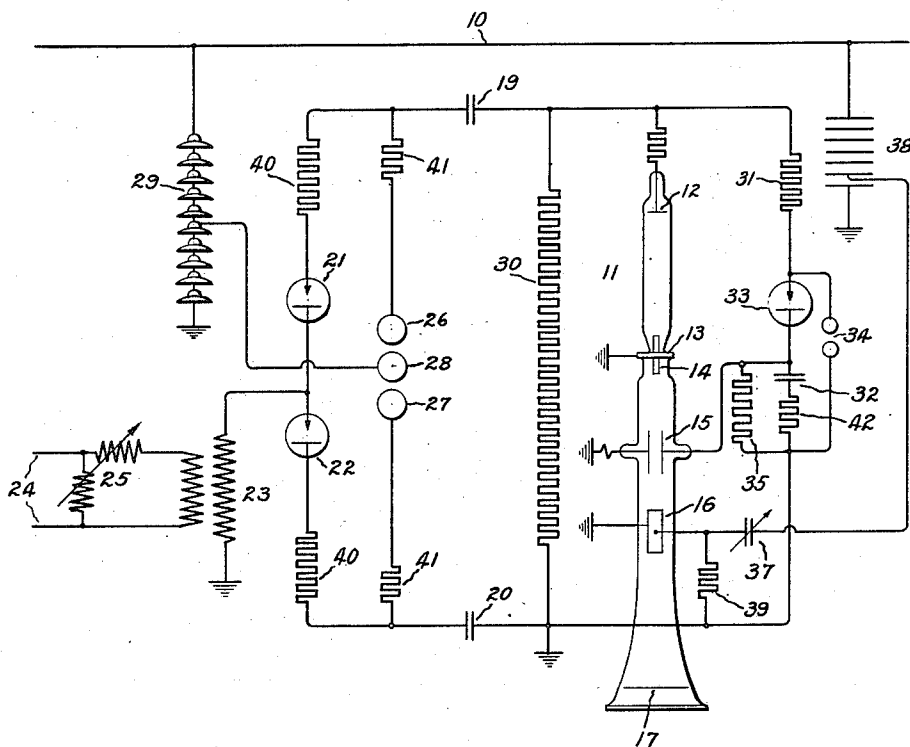


Fig. 2.



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UNITED STATES PATENT OFFICE

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CATHODE-RAY OSCILLOGRAPH CONTROL

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Our invention relates to control apparatus for cathode ray oscillographs and other voltage responsive devices and its primary object is to provide automatic means for setting into operation a cathode ray oscillograph on the occurrence of a transient condition such as a stroke of lightning in time for the oscillograph to record such condition. The invention may have other applications and may be used generally as a high speed relay device.

In the study of the effect of lightning on electric power lines it is desirable to obtain a record of the magnitude, duration and character of the surge resulting therefrom. The cathode ray oscillograph is an instrument capable of recording phenomena of lightning rapidity, once it is in operation. Generally, the transmission line on which the investigation is to be made is energized and the actuating circuits of the cathode ray oscillograph must be devised to prevent the normal line voltage from interfering with the measuring circuit. Also, the time lag of the measuring circuit must be reduced or the transient surge must be delayed in its influence on the oscillograph until the latter is in operating condition to record the surge. The surge may be positive, or negative, or oscillatory. These, and other considerations, make it somewhat difficult to successfully record lightning and other analogous surges occurring on live transmission lines and the controlling arrangement described below has been developed to provide self-actuating automatic apparatus capable of recording surges of steep wave front and short duration as they occur on live transmission lines. The apparatus can obviously be used on transmission lines which are not energized as well as for general surge testing purposes.

The features of our invention which are believed to be novel and patentable will be pointed out in the claims appended hereto.

For a better understanding of the invention reference is made in the following description to the accompanying drawing which shows in Fig. 1 one arrangement of the circuit and essential auxiliary apparatus embodying the invention as connected to control a cathode ray oscillograph in response to

surges on a live transmission line, and Fig. 2 is a reproduction of a lightning surge record obtained by this apparatus on a power line in the State of Pennsylvania.

Referring to the drawing, 10 represents one phase of a high voltage transmission line. 11 designates a cathode ray oscillograph the cathode of which is represented at 12 and the anode at 13. 14 represents a tubular aperture through which a portion of the cathode rays pass downward between the sweep circuit plates 15 and the deflection plates 16 to the recording film represented at 17.

During the normal condition of line 10 it is generally desirable that no cathode rays shall be given off from the cathode 12. The essential problem involved is then to start the oscillograph into operation in response to an abnormal surge on the transmission line in time for the surge to be recorded on film 17. This requires an abrupt excitation of the cathode for initiating the cathode rays on the occurrence of a transient voltage, the simultaneous excitation of the sweeping plates 15 at a rate which will move the cathode ray across the film to give a satisfactory time axis and the energization of the deflection plates 16 in response to the voltage surge to be recorded so as to move the recording rays at right angles to the sweeping motion produced by plates 15. The explanation of how these functions are accomplished will be taken up and explained in the order mentioned above.

An auxiliary source of supply is provided for exciting the cathode, as follows: Connected across the cathode and anode or between cathode and ground through a high potential direct current source of supply are condensers 19 and 20. The direct current source comprises rectifying tubes or kenotrons 21 and 22 supplied through a transformer 23 from an alternating current source 24. The arrangement is such as to produce a predetermined negative voltage at the cathode 12 with respect to ground. Regulating means, such as an induction regulator 25, is preferably provided to regulate the charging voltage of the condensers 19 and 20. Connected in series with the direct current portion of the condenser discharging circuit

is a spark gap comprising spheres 26 and 27 between which is a third conductor or sphere 28 connected to the transmission line 10 through a capacitance potentiometer such as an insulator string 29. The condensers 19 and 20 are kept constantly energized by the kenotrons through a high resistance 30 so that there will exist across spheres 26 and 27 a high direct current potential, for example, from 50,000 to 100,000 volts. The sphere gap is adjusted so that this voltage is insufficient to break down the gap through the intermediate sphere 28 under normal conditions. Sphere 28 is normally energized through the grounded capacitance connection 29 at a potential gradient which is about midway between the potentials impressed upon spheres 26 and 27. The connection 29 may comprise an insulator string of sufficient length to withstand a lightning surge without arcing over and of sufficient capacitance to enable the sphere 28 to become charged by any potential on the transmission line.

Under the conditions specified, whenever a positive or a negative surge occurs on line 10, the potential of the intermediate sphere 28 will be raised or lowered sufficiently to initiate a breakdown between it and one of the spheres 26 or 27. This simultaneously starts a discharge of the condensers 19 and 20 between spheres 26 and 27 and immediately raises the voltage between cathode 12 and the grounded anode so that cathode rays are produced in the oscillograph tube. The charge on the condensers 19 and 20 which is released on the sphere gap side by the discharge across the sphere gap releases a corresponding charge on the oscillograph side of the condensers. The resistance 30 is too high to dissipate instantaneously this released charge and as a consequence it produces the required excitation of the cathode and cathode rays are produced in the oscillograph tube.

Resistances 40 are desirable to limit the charging rate of the condensers and thus prevent injury to the kenotrons during the initial charging period. Resistances 41 are desirable to prevent excessive oscillations in the condenser circuit when the breakdown of the sphere gap occurs. Otherwise we may have sufficient fluctuation of the cathode ray exciting voltage to prevent the desirable sharp focus of the recording ray. The value of the resistance 30 will depend somewhat on the capacitance of the condensers 19 and 20. The condensers should have sufficient capacity to maintain a steady discharge through the resistance 30 and the oscillograph tube long enough to record the transient under investigation; for example, a duration of 100 microseconds or longer. The resistor 30 may have from 30,000 to 100,000 ohms resistance and the capacitance of condensers 19 and 20 may be from one-fourth to one micro-

farad capacity each with satisfactory results.

The cathode ray is produced in less than one one-millionth of a second after the start of a surge which initiates a breakdown of the sphere gaps and continues to be produced long enough to record lightning surges of ordinary duration. As soon as the normal line voltage conditions are again established and the condensers 19 and 20 are discharged the arc across the sphere gap and the cathode ray cease and the condensers 19 and 20 are again recharged. As soon as the film is changed the apparatus is ready for another operation.

The electrostatic field across plates 15 employed for sweeping the cathode ray across the film at a suitable rate to provide a satisfactory time axis is also supplied from the discharge of condensers 19 and 20. The discharge voltage is applied across a series resistance 31 and a condenser 32 so proportioned that the condenser voltage varies at a rate required to give the proper sweeping time to the cathode ray as it passes between plates 15. A kenetron tube 33 is preferably provided in series with the condenser 32 to prevent the return of the ray to the film after the transient has been recorded and while the condensers 19 and 20 are still discharging. A parallel sphere gap 34 is provided to limit the sweep plate voltage to a value below the plate flash-over voltage. A high resistance leak 35 is preferably connected across the condenser 32 to maintain the sweeping plates at ground potential prior to the occurrence of a surge. The resistance 42 is desirable to prevent oscillations of the sweep plate voltage.

The transmission line transient voltage is applied to the deflection plate 16 through the adjustable condenser 37 and capacitance potentiometer 38. The latter reduces the voltage across the deflection plates 16 to a value applicable to the oscillograph and the condenser 37 serves as adjustable means to give a satisfactory scale deflection of the cathode ray when the surge voltage is impressed. The capacitance potentiometer 38 is preferably grounded as shown to permit sufficient leakage therethrough to prevent a bound charge from accumulating. Resistance 39 is for the same purpose.

We may visualize what happens when a lightning surge occurs on the transmission line by reference to Fig. 2 which represents a record of a lightning surge obtained by means of the apparatus described. Prior to a lightning surge the apparatus is adjusted so that the recording ray, if it were produced, would be focused at a point represented at a point A. A stroke of lightning on line 10 sets the apparatus into operation, as previously described. The record at the beginning of the transient is not very distinct, it being somewhat blurred, as represented at B, owing

to the rising voltage at the cathode and the corresponding lack of sharpness in the focus of the recording ray. The plates at 15 sweep the ray to the right across the film and the plates at 16 move the ray at right angles in accordance with the variations in the transient voltage. At point C the transient has ceased and the straight line record to the right of this point corresponds to the normal line voltage and the path of the ray as it is swept off the film by the plates 15. By suitable calibration of the apparatus, the duration and magnitude of the transient may be determined. This particular lightning surge reaches its maximum value in about 5 micro-seconds and lasted about 40 micro-seconds.

In accordance with the provisions of the patent statutes we have described the principle of operation of our invention together with the apparatus which we now consider to represent the best embodiment thereof, but we desire to have it understood that the apparatus shown and described is only illustrative and that the invention may be carried out by other means.

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

1. Apparatus for producing a predetermined abrupt operating voltage for voltage responsive devices in response to a voltage surge comprising a pair of condensers, a high ohmic resistance connected between one set of terminals of said condensers, said terminals being the supply terminals of the voltage responsive device, a spark gap connected between the other set of terminals of said condensers, a direct current source connected across said spark gap for charging said condensers to a high voltage below the normal breakdown voltage of said spark gap, and means responsive to a voltage surge for initiating a voltage breakdown and a discharge of the condensers across said spark gap.

2. Apparatus for producing a predetermined abrupt operating voltage for voltage responsive devices in response to a voltage surge comprising a pair of condensers, a high ohmic resistance connected between one set of terminals of said condensers, said terminals being the supply terminals of the voltage responsive device, a sphere gap connected between the other set of terminals of said condensers, said sphere gap including an intermediate conductor member, a direct current source connected across said sphere gap for charging said condensers to a high voltage below the normal breakdown voltage of said sphere gap, means for normally exciting the intermediate conductor member of said sphere gap to give it a potential gradient approximately half way between the potential gradient of the spheres as determined by the normal voltage charge on the condensers, and means responsive to a voltage surge for altering the potential gradient of said inter-

mediate conductor member to initiate a voltage breakdown and a discharge of the condensers across the sphere gap.

3. Apparatus for producing a predetermined abrupt operating voltage for voltage responsive devices in response to abnormal surges on live high voltage transmission lines comprising a pair of condensers, a high ohmic resistance connected between one set of terminals of said condensers, said terminals being the supply terminals of the voltage responsive device, a three electrode spark gap having two electrodes connected between the other set of terminals of said condensers and an intermediate electrode connected to the high voltage transmission line through a capacitance potentiometer, a direct current source connected in parallel to the condenser terminals with the spark gap electrodes for charging said condensers to a high direct current voltage below the normal breakdown voltage across the spark gap, the capacitance potentiometer connection to the transmission line being such as to normally impress a voltage on the intermediate electrode intermediate the voltages on the other two electrodes such that an abnormal voltage surge on the transmission line will initiate a voltage breakdown and a discharge of said condensers across said spark gap.

4. In combination with a cathode ray oscillograph having a cathode, an anode and cathode ray sweep plates, means for energizing the same by abrupt operating voltages in response to a phenomenon to be recorded comprising a capacitance having charging and discharging circuits, the charging circuit including a high voltage direct current source and a high ohmic resistance and the discharging circuit including said high ohmic resistance and a spark gap adjusted for a breakdown voltage higher than the voltage of said source, means responsive to the phenomenon to be recorded for initiating a voltage breakdown and a discharge of the capacitance across said spark gap, and connections for energizing the previously mentioned electrodes and plates of the oscillograph from the voltage impressed across said resistance when said breakdown occurs.

5. In combination with a cathode ray oscillograph having a cathode, an anode, and cathode ray sweep plates, capacitance, means for normally charging said capacitance to a high direct current potential, means responsive to a phenomenon to be recorded for discharging said capacitance, circuits for impressing the voltage charge of said capacitance between the cathode and anode of the oscillograph when the discharge occurs, a sweep voltage circuit including a resistance and a condenser connected in parallel with the cathode and anode, said resistance and condenser being proportioned to charge the condenser at a suitable rate to provide a satis-

factory time axis when said discharge occurs, and circuits for impressing the voltage of said condenser across the sweep plates.

6. In combination with a cathode ray oscillograph having a cathode, an anode, and cathode ray sweep plates, means for energizing said electrodes and plates in response to a phenomenon to be recorded comprising capacitance normally charged to a high direct current potential means for abruptly discharging said capacitance in response to a phenomenon to be recorded, a high ohmic resistance through which the discharge current of the capacitance is caused to flow, connections for impressing the voltage across said resistance between the anode and cathode of said oscillograph, a sweep voltage circuit including a resistance and a condenser connected across said high ohmic resistance, the cathode ray sweep plates being connected between one terminal of said high ohmic resistance and a point in said sweep voltage circuit between the resistance and condenser therein such as to obtain an increasing voltage across the sweep plates.

7. In combination with a cathode ray oscillograph having a cathode, an anode, and cathode ray sweep plates, a sweep voltage circuit connected in parallel with the cathode and anode, said circuit containing a resistance and a condenser proportioned to gradually charge the condenser when a high direct current voltage is impressed between cathode and anode, said sweep voltage circuit including means for preventing the discharge of said condenser through said resistance, and circuits for impressing the voltage of said condenser across the sweeping plates.

8. In combination with a cathode ray oscillograph having a cathode, a capacitance with means provided for charging it to a suitable potential, a discharge circuit for the capacitance including a three-electrode gap which normally has a higher breakdown potential than the potential impressed on the capacitance, means for unbalancing the three-electrode gap so that it is caused to spark in response to a voltage surge, and circuits for impressing the discharge potential of the condenser on the cathode of the oscillograph.

9. In combination with a cathode ray oscillograph having a cathode and anode electrodes, apparatus for producing an abrupt operating voltage between said electrodes comprising a capacitance, means for normally maintaining a charge upon said capacitance of sufficient magnitude to operate said oscillograph, a three-electrode spark gap associated with the capacitance through which said capacitance is adapted to be discharged but which is normally adjusted to prevent such discharge, and means for disturbing such adjustment to produce a discharge in

response to some phenomenon to be recorded, and circuits for impressing the discharge voltage across said electrodes when the discharge occurs.

In witness whereof, we have hereunto set our hands, this 22nd day of Jan., 1929.

ELMER J. WADE.

WILLIAM J. RUDGE, JR.

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