

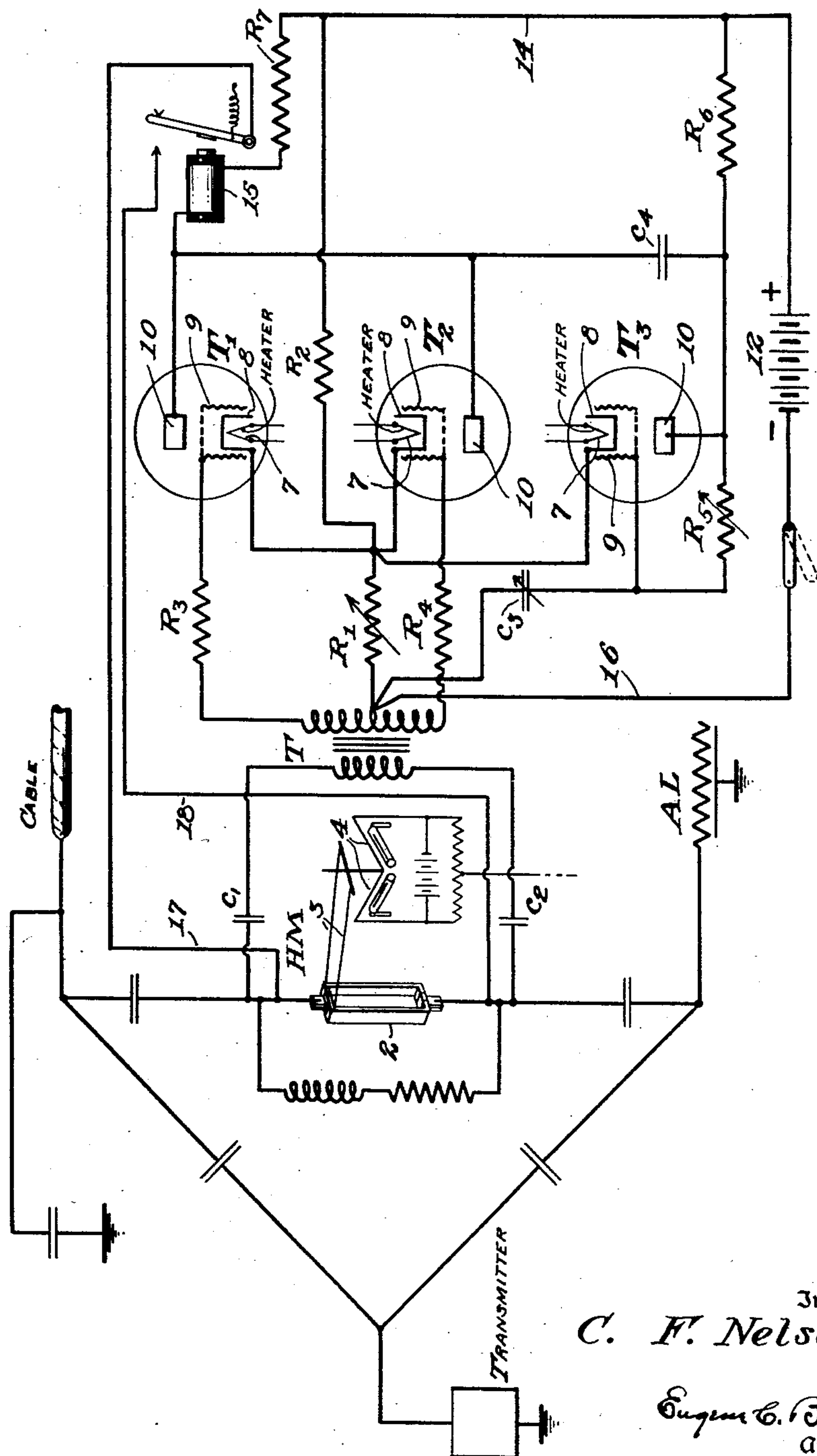
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PROTECTING ELECTRICAL INSTRUMENTS FROM EXCESSIVE ELECTRICAL SURGES

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PROTECTING ELECTRICAL INSTRUMENTS
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This invention relates to the protection of electrical instruments which are liable to be injured by excessive surges from lightning or other sources.

5 The object of the invention is to provide means for automatically short-circuiting the coil or part of an instrument connected to a line or cable with such rapidity that the main surge will be safely shunted around the instrument.

10 It has been the common practice to disconnect the line or cable from the apparatus and connect it to ground during the continuance of a lightning storm. This precaution is usually taken to protect the delicate receiving apparatus, such as
15 the Heurtley magnifiers which are generally used on long sections of unloaded telegraph cables. Inasmuch as lightning storms may occur at any time, it is often necessary to delay urgent traffic, rather than incur the risk of breaking the magnifier suspension which would necessitate the insertion and relining of a new one and require considerable time.

Protective devices of the electro-magnetic type do not act with sufficient rapidity and require an appreciable amount of energy to operate. Furthermore it is not feasible to operate an electro-magnetic device at the frequencies occurring in lightning surges. In order to overcome the difficulties which have heretofore prevented the success of a protective device for such purposes, I have provided a device which is voltage controlled and which operates unerringly at the frequencies occurring in lightning surges and yet is unresponsive to normal signaling impulses. To this
35 end I employ a protective apparatus which embodies electrostatically controlled arc discharge tubes having the characteristic of instantly causing the current in a local circuit to flow at the full value of the generator therein upon the application of a starting voltage applied to a grid member of the tube. The grid element thus acts as a "trigger" electrode which serves to instantly initiate a discharge across the arc included in the local operating circuit. The tubes are so arranged that the initial surge of either polarity
45 operates the device to apply the protection.

For the purpose of more adequately disclosing the invention I shall refer to the accompanying drawing, which is a circuit diagram illustrating in the usual conventional manner a duplex bridge arrangement at a terminal of a telegraph cable and showing my protective device adapted to apply a short circuit about a Heurtley magnifier instrument upon the occurrence of an excessive
55 electrical surge.

I have shown a Heurtley magnifier HM as an illustration of an instrument that may be protected by my invention. The line coil 2 of the instrument is inserted across the bridge between the cable terminal and the artificial line AL and is mechanically connected by the threads 3 with the suspension of the hot wires 4 of the instrument.

The actuating elements of the protector are connected through a transformer T to the bridge upon opposite sides of the coil 2. The transformer may have a step-up ratio of perhaps 1 to 10. The tubes T₁, T₂, T₃ are of the electrostatically controlled arc discharge type in which the current in the plate circuit continues to flow unaffected by the grid voltage after the arc has been established by the application of the critical voltage to the grid. For purposes of illustration I have shown tubes of the gaseous conduction type having a separate heater 7 for the electron emitting cathode 8 and a grid 9 of inverted cup shape composed of fine wire mesh. The action of the tube in continuing the discharge unaffected by the grid voltage and until the voltage of the plate 10 is reduced or stopped, is attributed to the formation of a sheath of positive ions around the grid, usually only a fraction of a millimeter in thickness, which contains the entire voltage drop between the grid and the surrounding space. Varying the potential of the grid merely changes the thickness of this sheath without affecting the potential of the remaining space. The action of the grid may, therefore, be likened to a trigger which is effective to initiate the discharge but which has no further influence on the discharge, being thus distinguished from the usual audion grid, which exerts a continuous influence on the discharge through the tube. The theory of operation is set forth in an article by Dr. Albert W. Hull entitled "Hot-Cathode Thyratrons" published in the General Electric Review Vol. 32, No. 4 April 1929.

The resistance R₁ is so adjusted that the negative bias on the grids of tubes T₁ and T₂ prevents the operation of the tubes during the reception of normal signals. Resistance R₂ is employed to limit the steady biasing current through the resistance R₁. R₃ and R₄ are appropriate grid resistors, their value depending upon the particular tubes employed.

The operation of my protector device will be evident to engineers and those familiar with circuits of this character. If a surge occurs, due to lightning or other cause, impressing a potential upon the primary of the transformer T through

the condensers c_1 , c_2 which impresses a voltage upon the secondary coil sufficient to raise the voltage on the grid of one of the tubes to the critical value, it will instantly cause that tube to discharge through its plate circuit, thus starting the flow of current from the plate battery 12 which will thereafter continue to flow until stopped by external means. If the initial potential of the surge is positive, the tube T_1 will start and a current will flow from battery 12 through conductor 14, resistance R_7 , relay 15, through tube T_1 , resistance R_1 and conductor 16 to negative pole of the battery. The armature of the relay closes a short circuit through the conductors 17 and 18 around the line coil 2 of the instrument. This short circuit occurs so quickly (micro-seconds) that the movement of the coil 2, if any, is so slight that no violent motion can be transmitted to the hot wires 4 or their suspension. In other words, before the inertia of the coil is overcome, it becomes short circuited and consequently any tendency to move is immediately damped. If the initial potential of the surge is in the opposite direction, it is evident that the current would flow through the relay and the tube T_2 instead of through the tube T_1 , the plates of these tubes being connected in parallel to the relay.

As previously stated, the tubes employed have the characteristic of operating at full value the instant the discharge takes place and hence the relay is actuated with great rapidity. Inasmuch as the grid operates with a trigger action to start the tube and thereafter has no control over the operation of the tube, provision must be made for stopping the tube. For this purpose I have shown a third tube T_3 with circuit arrangements which cause it to start a predetermined interval after one of the other tubes and its operation immediately extinguishes said other tube. This feature is the invention of H. F. Wilder and is covered in another application Serial No. 615,211 filed June 3, 1932.

When neither of the tubes T_1 , T_2 is operating, their plates 10 will assume the full voltage of battery 12 (assume 115 volts). The instant the tube T_1 is started, the voltage of its plate will drop from 115 volts to perhaps 15 volts, a drop of 100 volts. Inasmuch as the plate of tube T_3 is connected to the plate of Tube T_1 through the condenser c_4 , it is subjected to a corresponding drop. The voltage on the grid of tube T_3 builds up during a predetermined period, depending upon the constants in its grid circuit determined by the condenser c_3 and resistance R_5 . When the potential on the grid reaches its critical value and the tube is started into operation, the voltage on its plate instantly drops from 115 to 15 volts and as the plates of the tubes T_3 and T_1 are connected through the condenser c_4 , the plate of tube T_1 must also instantaneously decrease by the same amount, which lowers it to minus 85 volts which momentarily stops the current and the production of ions. If the condenser is large enough so that the ions in the space between the grid and the anode have time to diffuse to the walls of the tube before the anode voltage again becomes positive, the grid, now negative, prevents the current from restarting. In this manner the auxiliary tube T_3 stops the flow of current in whichever tube the current is started and is itself stopped upon the starting of either of said tubes T_1 or T_2 . The current in the auxiliary or stopping tube T_3 may be several times smaller than that through the operating tubes T_1 and T_2 , the amount of current being controlled by the limiting resistance

R_6 . The manner in which one tube operates to stop another tube as above described is set forth in the "Proceedings of the National Academy of Science, Vol. 15, No. 3, page 218" and also in an article by Dr. Hull entitled Hot-Cathode Thyratrons, published in the General Electric Review Vol. 32 No. 7, July 1929.

It is not necessary, of course, to keep the protective device in service at all times as lightning storms are not liable to occur during certain seasons and weeks or months may elapse without the necessity for using the device. When disturbances indicate that excessive surges are liable to occur, the attendant in charge will connect the protective circuits, adjusting the biasing resistance R_1 , if necessary, so that the tubes T_1 and T_2 are not affected by the normal signals being received. Business may therefore be transacted over the cable without the interruption which has heretofore occurred upon the approach of a storm. If a surge occurs, one or the other of the tubes T_1 or T_2 will be started and for the very brief interval during which they are in operation, the siphon of the recording instrument will move to zero position. This informs the receiving operator that a surge has occurred and it will be necessary to have that particular part of the message repeated. In other words, during lightning storms, instead of discontinuing the operation of the cable altogether, it will only be necessary to handle a few extra RQ's (service repeat messages).

I have illustrated one embodiment of this invention but it will be obvious to engineers that various modifications can be made to adapt it to different conditions. Instead of employing the tube T_3 to extinguish the arc in the other tubes after a predetermined interval, I may accomplish this purpose by means of a slow acting relay, connecting the relay winding and its contact in series with the common anode circuit of the tubes T_1 and T_2 . The contact must be arranged to open at the end of the stroke of the armature. Instead of shunting the instrument to be protected it may be preferable under certain conditions to open its circuit during the predetermined protecting interval.

I claim:

1. In a signaling system including an instrument responsive to signaling impulses, means for protecting the instrument from excessive voltages such as lightning discharges, comprising a shunting device and electrostatically controlled thermionic means non-responsive to signaling impulses but responsive to excessive voltages and operatively connected to actuate said shunting device.

2. In a signaling system including an instrument responsive to signaling impulses, means for protecting the instrument from excessive voltages such as lightning discharges, comprising a shunting device and electrostatically controlled means non-responsive to signaling impulses but responsive to excessive voltages of either polarity operatively connected to actuate said shunting device, and electrostatically controlled means operating to deenergize said shunting device after a predetermined interval.

3. In a signaling system including an instrument responsive to signaling impulses, means for protecting the instrument from excessive voltages such as lightning discharges, an electrostatically controlled actuating device for said protecting means responsive only to voltages greater than the signaling impulses and electrostatically con-

trolled means for deenergizing said actuating device after a predetermined interval.

4. In a signaling system including an instrument responsive to signaling impulses, means for protecting the instrument from excessive voltages such as lightning discharges, comprising a relay controlling a shunt around said instrument, a local circuit including a generator and said relay, and electrostatically controlled trigger means non-responsive to signaling impulses but responsive instantaneously to excessive voltages to close said local circuit.

5. In a signaling system including an instrument responsive to signaling impulses, means for protecting the instrument from excessive voltages such as lightning discharges, comprising a relay controlling a shunt around said instrument, a local circuit including a generator and said relay, and electrostatically controlled trigger means non-responsive to signaling impulses but responsive instantaneously to excessive voltages to start the operation of said local circuit, and electrostatically controlled means associated with said circuit to stop its operation after a predetermined interval.

6. In a signaling system including an instrument responsive to signaling impulses, the combination of electrostatically controlled means for protecting the instrument from excessive voltages such as lightning discharges, of a relay to actuate said protective means, a local circuit including said relay, a current source, and a gaseous conduction device and electrostatically controlled means responsive to an excessive voltage in the system for initiating a discharge through said device.

7. In combination with apparatus for the reception and utilization of electric impulses from a transmission line or cable, a protective device for shielding said apparatus from excessive voltage conditions, comprising a local circuit including a current source and an ionizable medium, actuating means for said device in said circuit and electrostatically controlled means responsive to an excessive voltage on said line or cable for initiating a discharge through said ionizable medium.

8. In combination with apparatus for the reception and utilization of electric impulses from a transmission line or cable, a protective device for shielding said apparatus from excessive voltage

conditions, comprising a local circuit including a current source and an ionizable medium, actuating means for said device in said circuit, electrostatically controlled means responsive to an excessive voltage on said line or cable for initiating a discharge through said ionizable medium, said initiating means being ineffective to further control the discharge, and means for automatically interrupting said discharge after a predetermined interval.

9. In a communication system, receiving apparatus responsive to signaling impulses from a transmission line or cable, a protective device operating to shield said apparatus from excessive voltage conditions, a local circuit including a current source, an actuator for said protective device and an electrostatically controlled gas discharge tube in said local circuit, said tube being responsive to excessive voltage conditions but unaffected by signaling impulses, a starting element or grid in said tube connected to be subjected to voltages on said line or cable, said tube operating irrespective of grid potential after being started, and electrostatically controlled means associated with said local circuit for stopping the operation of said tube after a predetermined interval.

10. In a signaling system including an instrument responsive to signaling impulses, means for protecting the instrument from excessive voltages such as lightning discharges, comprising a local circuit including a current source and an actuating element for said protecting means, a pair of electrostatically controlled gas discharge tubes connected to said circuit and responsive respectively to positive and negative impulses of excessive voltage but unresponsive to signaling impulses, the grid elements of said tubes being subjected to the voltages of the system, and means operating to automatically stop either tube after a predetermined interval.

11. In a signaling system as defined in claim 10, said stopping means comprising a third electrostatically controlled gas discharge tube connected to said local circuit and so arranged that it operates a predetermined interval after the starting of either of the other tubes, its operation serving to extinguish the operating tube and being itself stopped upon the starting of either of said tubes.

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