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PROTECTIVE DEVICE FOR ELECTRICAL INSTRUMENTS

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FIG. 1

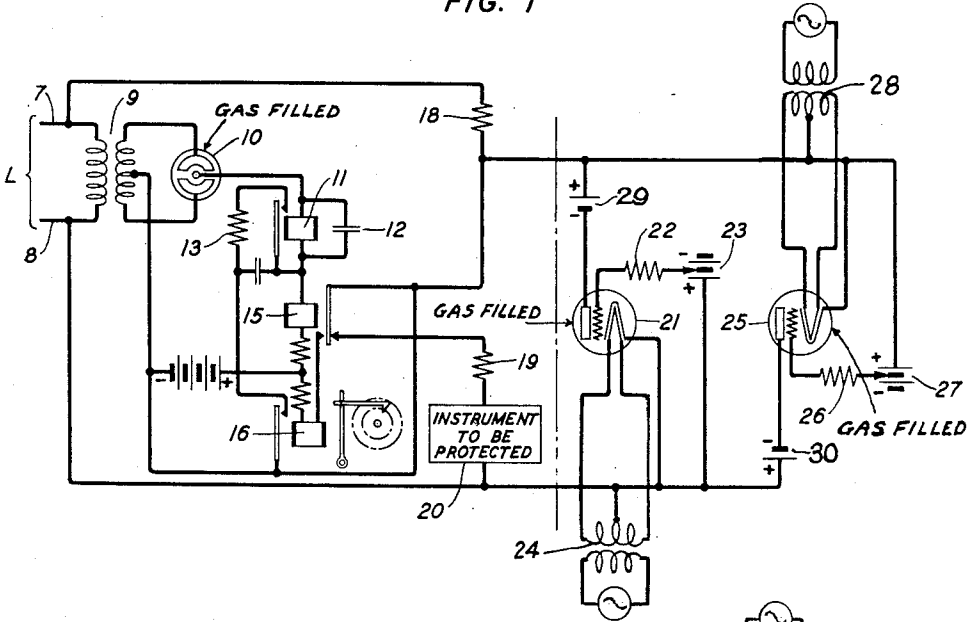
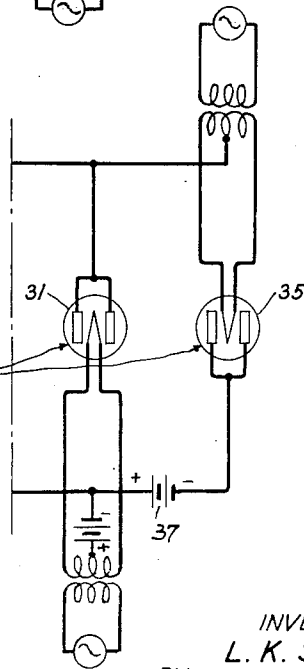


FIG. 2

MERCURY VAPOR-
TUBES



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PROTECTIVE DEVICE FOR ELECTRICAL INSTRUMENTS

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12 Claims. (Cl. 171-95)

This invention relates to protective systems and particularly to apparatus for protecting electrical measuring instruments from damage due to excessive and destructive voltages.

5 It is the object of the invention to improve the reliability and efficacy of protective devices used to protect electrical instruments from damage by potentials in excess of those which the instrument is designed to withstand.

10 This invention is a protective device comprising a three-element gas-filled tube for short-circuiting an electrical instrument upon and in response to the impression of an excessive voltage thereto, the grid of the tube being negatively biased to
15 render it non-responsive to the maximum voltage normally impressed upon the instrument. Features of the invention are the provision of current limiting means in series with the anode and cathode for limiting the current through the tube
20 and the provision of anode-cathode bias in addition to the grid bias for controlling the difference in potential necessary to render the tube conductive. The device may include two three-element
25 gas-filled tubes each connected in parallel with the instrument to be protected, both tubes being biased to prevent operation in response to normal voltages impressed thereon and so connected that one of the tubes responds to an excessive
30 voltage in one direction and the other tube responds to an excessive voltage in the other direction.

Another feature of the invention is a three-element ionic tube arranged to short-circuit an electrical instrument upon impression of an excessive voltage on the instrument, the grid of the
35 tube being negatively biased to render the tube non-responsive to the maximum voltage normally impressed on the instrument, a resistance being connected in series with the grid and the source
40 of biasing potential to reduce the bias when a high frequency voltage is impressed across the instrument.

Another feature of the invention is the provision of an ionic device for short-circuiting an
45 electrical instrument upon impression of an excessive voltage thereon and other circuit means responsive to the excessive voltage for disconnecting the instrument if the excessive voltage endures after the short-circuiting of the instrument.
50 Such an arrangement is of particular utility where the instrument to be protected is of the recording type in which case the instrument is protected from injury by excessive voltages by the break-down of the ionic device thereby immediately
55 reducing the potential across the instru-

ment; and, if the excessive voltage continues after the break-down of the ionic device, the additional circuit means responds to the excessive voltage to open the circuit through the instrument and thereby prevent the instrument from recording
5 the reduced voltage.

The drawing which forms a part of this specification shows, schematically, circuit arrangements embodying the features of this invention. The invention is, of course, not limited in its application to the particular arrangements shown.
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Referring to the drawing:

Fig. 1 shows a line L and electrical instrument 20 and a protective circuit arrangement comprising an input transformer 9, gas-filled tube 10,
15 relays 11 and 15, and gas-filled rectifier tubes 21 and 25;

Fig. 2 shows gas-filled tubes 31 and 35 connected for use in place of tubes 21 and 25 in Fig. 1. The electrical instrument 20, which may be a thermocouple, a recording oscillograph, or other
20 electrical instrument, is connected in series with resistor 18, the back contact of relay 15 and resistor 19, across the conductors 7 and 8 of line L for operation by the differences in potential normally impressed across these conductors. The transformer 9 has a high impedance; and the potential induced in its right winding by normal potentials impressed on line L is not sufficient to cause ionization of the gas in tube 10, which tube
25 is of the three-element cold-cathode type. Each of the gas-filled tubes 21 and 25 is connected to the line L in parallel with the instrument 20. These tubes, 21 and 25, are of the three-element hot-cathode type. The cathode of tube 21 is
30 heated by current through its heater winding and the secondary winding 24 of a power transformer; and the cathode of tube 25 is heated by current through its heater winding and the secondary winding 28 of another power transformer. The plate or anode of tube 21 is connected through an
35 impedance element, resistor 18, to conductor 7 of line L, the cathode is connected directly to conductor 8, and the grid or control element of tube 21 is connected through impedance 22 and biasing battery 23 to conductor 8. The plate of tube 25
40 is connected directly to conductor 8, the cathode is connected through resistor 18 to conductor 7, and the control element of tube 25 is connected through impedance 26, biasing battery 27, and resistor 18 to conductor 7. The biasing batteries
45 23 and 27 are poled to make the grid of each of tubes 21 and 25 negative with respect to the cathode and are of such a voltage as to permit break-down of the tubes only when the voltage
50
55

impressed on the instrument exceeds that which may be safely applied to the instrument. The line voltage at which break-down of the tubes will occur may be further controlled by inserting biasing batteries 29 and 30 in the conductors which connect to the plate or anode elements. The amount and character of the anode bias required depends upon the character and constants of the tubes and the minimum voltage at which protection of the instrument is required. For instance, if the voltage required for operation of tubes 21 and 25 with no anode bias is 23 volts, and the maximum difference in potential to which the instrument 20 is normally subjected is 16 volts, the provision of a 7-volt positive anode bias will enable break-down when the voltage impressed on the instrument exceeds 16 volts. If, however, the maximum difference in potential to which instrument 20 is normally subjected is greater than 23 volts, for instance 30 volts, the provision of a 7-volt negative anode bias will prevent break-down until the voltage impressed on the instrument exceeds 30 volts. In the latter case the desired control can be secured by a small negative grid bias instead of the 7-volt negative anode bias. Or, if desired, a combination of anode bias and grid bias may be used. The batteries 29 and 30 are poled in the drawing to illustrate the provision of a negative anode bias. When a difference in potential of constant polarity and equal to or in excess of the break-down value is impressed across conductors 7 and 8, tube 21 breaks down if the difference in potential is in one direction and tube 25 breaks down if the difference in potential is in the other direction. If the excessive difference in potential is alternating in character, tube 21 breaks down on one-half cycle, and tube 25 breaks down on the other half cycle. When the voltage across conductors 7 and 8 reaches the tripping point and break-down of one or both of the tubes 21 and 25 occurs, the voltage across the tubes and therefore across the instrument is reduced to a constant value, for instance 16 volts; the strength of current through the tube varies with the line voltage and the drop in potential through resistor 18 is equal to the difference between this line voltage and the constant drop in potential through the tube or tubes. As soon as the line voltage drops below the sustaining voltage of 16 volts, the tube restores and is nonconductive until the next occurrence of a potential difference sufficient to cause break down.

There is, of course, some electrostatic capacity between the anode and grid of each of tubes 21 and 25 but the impedance is so high that the current therethrough at normal voltages is negligible. If, however, an excessive alternating current potential occurs and the frequency is high, the drop in potential through impedance 22 or 26, due to the plate-grid current, decreases the negative bias on the grid and the break-down of the tube is thereby accelerated. The tubes will, of course, operate to protect the instrument 20 if the impedances 22 and 26 are omitted.

Upon the occurrence of a voltage equal to or greater than that which is effective to break down tube 21 or tube 25, the difference in potential induced in the secondary winding of transformer 9 between the anode element of tube 10 and the one or the other of the cathode elements is sufficient to ionize the gas in tube 10 and the resulting current through the windings of relays 11 and 15 is effective to operate these relays. The operation of relay 11 is delayed slightly during the charging of condenser 12. Relay 15 opens the circuit

through instrument 20 and closes a circuit through register 16. The opening of the circuit through instrument 20 occurs a very short interval of time, for instance four-thousandths of a second, after tube 10 breaks down, but the instrument 20 might be damaged during this interval except for the shunting of the instrument by the break-down of tube 21 or tube 25. When relay 11 operates and with register 16 operated, the winding of relay 11 and the current path through tube 10 are shunted by a circuit path through resistor 13 and the contacts of relay 11 and register 16. This shunt is effective to cause the release of relay 11 and to deionize tube 10. If an excessive potential still exists across conductors 7 and 8 the tube is immediately reenergized and after the charging of condenser 12, relay 11 reoperates. Relay 11 continues to operate the release as long as an excessive voltage exists across conductors 7 and 8 but relay 15 and register 16 remain operated; but when the voltage across these conductors drops below that necessary for break-down of tube 10, the tube is deenergized and the release of relay 11 causes the release of relay 15 and register 16. The register 16 records the number of times that an excessive potential occurs across the line L; and relay 15, by opening the circuit through instrument 20, prevents this instrument from falsely recording the voltage across tube 21 or tube 25 after break down and during the continued energization of these tubes as being the voltage then existing across the line L.

The tubes 31 and 35 shown in Fig. 2 are of the mercury-vapor type each having a filament-cathode connected to a winding of a power transformer. While each of these tubes has two anodes and is adapted for use as a full wave rectifier, the two anodes of each tube are connected together and each of the tubes is operated as a half-wave rectifier. The electrostatic capacity between the elements acts as a shunt on the line but is so small as to be negligible. The biasing battery 33 connected between conductor 8 and the cathode of tube 31 and the biasing battery 37 connected between this conductor and the anodes of tube 35 are of such a polarity as to oppose break-down and of such a voltage as to permit break-down of the tubes at the minimum difference in potential across line L against which it is necessary to protect instrument 20. For instance, if the normal line voltage is two volts, two-volt biasing batteries are provided and break-down of the tubes occurs when the voltage applied to the tubes exceeds two volts. The current through the tubes does not become very large until the applied voltage reaches about 18 volts at which time the drop in potential through the tube is 16 volts and this drop in potential does not increase if the applied voltage is further increased, the resistor 18 being effective to limit the current to prevent damage to the tubes. With this arrangement the apparatus to be protected must be able to withstand a 16-volt peak in excess of the normal working voltage.

What is claimed is:

1. In combination, an electrical circuit, an electrical recording instrument connected to said circuit, a rectifier connected in parallel with said instrument, said rectifier being effective to shunt said instrument upon the occurrence of an excessive voltage in said circuit, and circuit means responsive to said excessive voltage for opening the circuit path through the instrument.

2. In an electrical system, a line, an electrical

recording instrument connected to said line, an ionic tube connected in parallel with said instrument, means for biasing said tube to render it non-conductive while the impressed difference in potential across said instrument is less than a certain value, and circuit means responsive to an impressed difference in potential of said certain value for opening the circuit path through the instrument.

3. In an electrical system, a line, an electrical instrument connected to said line for response to normal operating voltages impressed on said line, and means for protecting said instrument against excessive voltages, said means comprising a three-element gas-filled tube, the anode and cathode of said tube being connected in parallel with said instrument, means for negatively biasing the grid element of said tube to render it non-conductive to normal operating voltages, and a resistor connected in series with the anode and cathode for limiting the current through said tube.

4. In an electrical system, a line, an electrical recording instrument connected to said line, a rectifier connected in parallel with said instrument, said rectifier being effective to shunt said instrument upon the occurrence of a voltage across said line in excess of the maximum normal operating voltage, a resistor connected in series with the rectifier for limiting the current through said rectifier, and circuit means responsive to an excessive voltage being impressed on said line for opening the circuit path through said instrument.

5. In an electrical system, a line, an electrical instrument connected to said line, and means for protecting said instrument against excessive voltages impressed upon said line, said means comprising a three-element gas-filled tube, the anode and cathode of said tube being connected in parallel with said instrument, and a source of potential for negatively biasing the grid of said tube to render it non-conductive to normal operating voltages impressed upon said line, and a resistor connected in series with said source of potential.

6. In an electrical system, a line, an electrical instrument connected to said line for response to voltages normally impressed upon said line, and means for protecting said instrument against excessive voltages impressed upon said line, said means comprising a three-element gas-filled tube, the anode and cathode of said tube being connected in parallel with said instrument, a source of potential for negatively biasing the grid of said tube to render it non-conductive to normal operating voltages impressed upon said line, and a source of potential connected in the anode-cathode circuit path for controlling the difference in potential necessary to render the tube conductive.

7. In combination, an electrical circuit, an electrical recording instrument connected to said circuit, means for shunting said instrument, said means being operatively responsive to the impression of a voltage in excess of a certain value on said circuit, and means responsive to the impression of a voltage in excess of said certain value for opening the circuit through the instrument to prevent the making of a false record after the instrument is shunted.

8. In combination, an electrical circuit, an electrical recording instrument connected to said circuit, means comprising a three-element rectifier connected in parallel with said instrument for shunting said instrument responsive to the impression of a voltage in excess of a certain value on said circuit, and means comprising a three-element gas-filled tube coupled to said circuit and a relay controlled by said tube for opening the circuit path through said instrument in response to the impression of a voltage on said circuit in excess of said certain value.

9. In combination, an electrical circuit, a recording instrument connected to said circuit, means comprising two three-element rectifiers connected to said circuit in opposite relation and each in parallel with said instrument for shunting said instrument responsive to the application of a voltage in excess of a certain value to said circuit, and means comprising a three-element gas-filled tube coupled to said circuit and a relay controlled by said tube for opening the circuit path through said instrument in response to the application of a voltage to said circuit in excess of said certain value.

10. In combination, an electrical circuit, an electrical instrument connected to said circuit, means comprising a three-element rectifier for shunting said instrument in response to the application of a voltage in excess of a certain value to said circuit, means for negatively biasing the grid of said rectifier, a resistor connected in series with the grid element of said rectifier, said resistor being effective upon application of high frequency surges to said circuit to decrease the grid bias, and means comprising a gas-filled triode for opening the circuit path through said instrument in response to the application of a voltage in excess of said certain value to said circuit.

11. In combination, a circuit, a recording instrument connected to said circuit for recording the voltage impressed thereon, a gas-filled triode connected to said circuit in parallel with said instrument, said triode being effective only upon impression of an excessive voltage on said circuit to shunt said instrument to protect it from injury, a resistance in series with the instrument and the triode for reducing the voltage across the instrument while said triode is shunting the instrument, and means for preventing the instrument from recording the voltage while the instrument is shunted by said triode, said means comprising a three-element gas-filled tube coupled to said circuit and a relay controlled by said tube for opening the circuit through the instrument, said tube and relay being operatively responsive to said excessive voltage.

12. In an electrical system, a line, an electrical recording instrument connected to said line, means comprising a gas-filled tube operatively responsive to the application of an excessive voltage to said line for opening the connection between said line and instrument, and means comprising a gas-filled tube instantaneously responsive to the application of an excessive voltage to said line for shunting said instrument to protect the instrument against damage prior to the opening of the connection between said line and instrument.

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