Sept. 2, 1941. E. G. GAGE 2,254,214

SAFETY CIRCUIT FOR CATHODE RAY TUBES

Filed Sept. 1, 1939

Fig. 1.

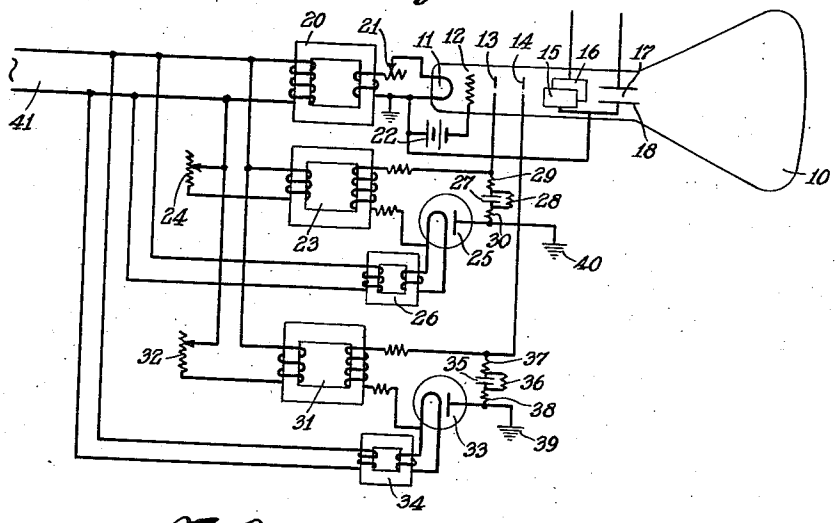


Fig. 2.

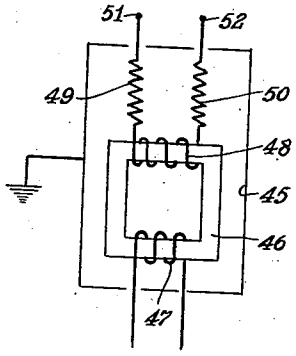


Fig. 3.

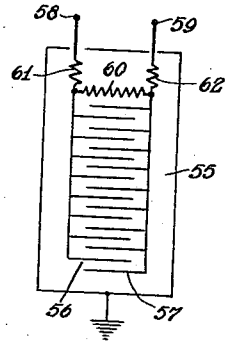
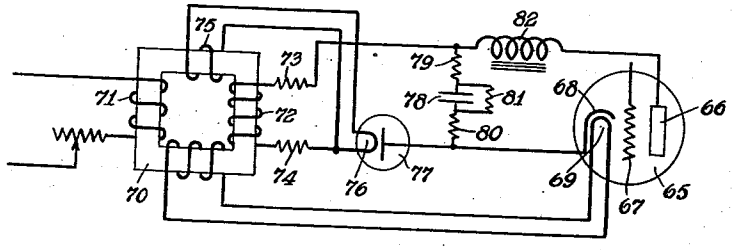


Fig. 4.



INVENTOR.
EDWARD G. GAGE

BY

ATTORNEY.

Patented Sept. 2, 1941

2,254,214

UNITED STATES PATENT OFFICE

2,254,214

SAFETY CIRCUIT FOR CATHODE RAY TUBES

Edward G. Gage, Brooklyn, N. Y., assignor, by direct and mesne assignments, of two-thirds to Leon Ottinger, New York, N. Y.

Application September 1, 1939, Serial No. 292,993

11 Claims. (Cl. 250—27)

The invention relates to a novel system of supplying a high voltage to the anodes of cathode ray tubes and other thermionic devices such as radio tubes; and more especially in a manner such that any exposed part of the wiring of the circuit may be contacted without personal injury.

An object of the invention is to allow the handling without injury of the circuits of a cathode ray or radio tube operating at dangerous voltages.

Another object is to provide a transformer so constructed that, regardless of the voltage in the secondary, it may be contacted at any external part without injury.

Still another object is to provide a filter condenser so constructed that it is impossible to obtain a dangerous shock either from a residual charge or from a charge in the condenser due to the impressed voltage.

Other and ancillary objects will hereinafter appear.

In the operation of cathode ray tubes, it is well known that the required voltages, especially those employed in television, are of such a high value as to be extremely dangerous and even deadly when the live circuits are contacted.

Voltages of this nature may range from 400 for the smaller cathode ray tubes to approximately 5,000 for the larger sizes, such as are used for television.

The ordinary methods of protection to the operator, as practiced heretofore, consist in providing interlocking switches so arranged that the cover of a cabinet containing the apparatus must be removed to get at the wiring; and when this is done, the primary current energizing the same is interrupted.

The objection to this method is the fact that as the primary circuit is broken, it is not possible to properly investigate the circuits for trouble with the current on. The usual procedure, therefore, is to connect a jumper across the switches temporarily, thus defeating the purpose of the protective devices.

Grounding of the high potential anode is another method employed to protect the operator but the objection to this method is the fact that if the ground wire becomes disconnected, or one of the condensers separating the live side of the circuit from the mains becomes defective, the operator is likely to be fatally shocked either through the mains, or from some of the controls.

The novel method of protecting the operator from these dangerous voltages allows the filament of a cathode ray tube to be grounded in the ordinary manner, and the high potential anode to be left clear of the ground connection, and yet prevent dangerous shock. This is accomplished in the manner hereinafter set forth, bearing in mind that a cathode ray tube anode draws an extremely small current, a few mils only. The drop across the line supplying this voltage is ordinarily extremely small because of the extremely high resistance of the anode circuit compared to the resistance of the line circuit.

The conventional transformers supplying voltage to the line, through rectifiers, are wound with copper wire of small size. Even the smallest practical sizes, however, are capable of delivering a dangerous current, if sufficiently low resistance is placed across the secondary, such as the human body.

In addition, the ordinary condensers as used in filter circuits are capable of retaining a very heavy residual charge after the impressed voltage has been removed. While the impressed voltage is supplied, a much heavier current may be drawn from the filter condenser momentarily than from the charging circuit without the condenser. This is one of the reasons why the ordinary filter circuit is dangerous to contact.

To overcome these objections, and to make it impossible to draw a dangerous current from any part of the cathode ray and like high tension circuits, the novel arrangement contemplates winding the secondary of the transformer supplying the high voltages with fine resistance wire instead of the usual low resistance copper wire. Or, the usual copper winding may be utilized and additional series resistance included in the output connections to the terminals, the transformer or transformer and additional resistance being encased to prevent contact with portions of low resistance at high voltages.

This permits a flow of sufficient current to operate the beam of the tube, which current is of a harmless value, or, it may operate the plate circuit of a radio tube; but the introduced high resistance absolutely prevents a larger current from being drawn through the body if contacted, owing to the great voltage drop due to the high resistance of the secondary.

The principle of operation of the safety circuit depends upon the fact that it is the current and not the high voltage that is dangerous, and that at the moment of contact by the body, the apparatus voltage momentarily drops from 5,000 volts, as an example, to approximately 100. Upon removal of contact, the voltage again rises to 5,000.

The resistance of the human body varies great-

ly with individuals and with conditions, being as low as 5,000 ohms in some cases and as high as 50,000 ohms in others. The series resistance in the secondary of the transformer is therefore to be made sufficiently high to prevent a dangerous current from passing through the body if its resistance should be less than 5,000 ohms or even of negligible resistance.

A better understanding of the safety provision may be had by referring to the drawing, in which:

Fig. 1 represents a schematic drawing of the novel arrangement as applied to a cathode ray tube used, as an example, for television.

Fig. 2 shows a cross-section of a transformer protected in the novel manner; and Fig. 3 is a similar view of a protected filter condenser.

Fig. 4 shows a schematic drawing of the novel arrangement as applied to a radio tube.

Referring to the drawing, more especially Fig. 1, 10 designates the body of a cathode ray tube comprising the filament 11, the control anode 12, the first anode 13, the second anode 14, the vertical deflecting plates 15 and 16, and horizontal deflecting plates 17 and 18. A filament transformer 20 supplies current to the filament 11 through a filament control rheostat 21; and for the control electrode there is provided a bias battery 22. Reference character 23 designates the first anode transformer, 24 the first anode voltage primary control, and 25 the first anode rectifier, while the first anode rectifier filament transformer is designated by the reference character 26 and the first anode safety condenser by the reference character 27. Across this condenser is connected a shunt resistance 28, and two protective resistances 29 and 30 are connected in series with the condenser terminals in accordance with the invention. A second anode transformer 31 having the primary control 32 is connected to the second anode rectifier 33, while the second anode rectifier filament transformer 34 is connected to the filament thereof. A second anode safety condenser is designated by the reference character 35 and the same is provided with a shunt resistance 36 and the series protective resistances 37 and 38. A ground return connection 39 is also provided therefor and a ground return connection 40 for condenser 27. Power supply for all of the transformers is obtained from the mains 41; and all of the low resistance, high voltage portions of the apparatus are to be housed in a suitable casing to prevent contact therewith, only the high resistance terminals remaining exposed.

Thus, as indicated in Fig. 2, 45 indicates the grounded casing of the safety transformer with core 46, primary winding 47, and secondary winding 48 housed therein, together with internal protective resistances 49 and 50 which are connected to the respective external binding posts 51 and 52.

In Fig. 3, 55 represents the grounded case of the safety filter condenser having the electrodes or coatings 56 and 57 connected to the respective terminals 58 and 59. A shunt resistance 60 is connected across the terminal leads within the casing, and there is included in the respective leads the series safety resistances 61 and 62.

In Fig. 4 there is indicated an ordinary three-element radio tube 65, which may also be a multi-element tube, the same comprising the plate 66, the grid 67, cathode 68, and the heater 69. A high voltage safety transformer 70 therefor, with primary 71 and secondary 72, is arranged with the internal safety resistances 73 and 74, while a winding 75 is provided for heating the filament 76 of a rectifier 77. The filter condenser 70 is made safe by the series introduction of the protective resistances 79 and 80, and a shunt resistance 81 is bridged across the same. The usual choke coil or impedance is indicated at 82.

In the practical application of my invention to medium-sized cathode ray tubes, it is preferred to employ resistances of the order of 20,000 ohms in the secondary of the safety transformer, or sufficient internal resistance may be added in series to that value to allow a maximum of 10 mils to pass through the secondary when short-circuited.

It is apparent that the higher the voltage required to operate the tube, the higher must be the resistance of the secondary. No. 36 Nichrome resistance wire is a practical size wire with which to wind the secondary to obtain the above results. If copper wire is used for the secondary, then the internal resistances 49 and 50, Fig. 2, should be increased until the total resistance is sufficient to pass but 10 mils on short-circuit.

The internal resistances 61 and 62, Fig. 3, of the safety filter condenser may be of the order of 10,000 ohms each, while the shunt resistance 60, Fig. 3, may be of the order of 1 megohm. This shunt resistance allows a residual discharge to leak slowly from the condenser, thus preventing shock from a later contact.

The resistances 61 and 62 prevent a heavy surge of current from passing from the condenser through contact of the body with its terminals.

In the application of the invention to ordinary radio tubes, where the plate voltage is comparatively low, of the order of 500 volts only, the resistances of the secondary of the transformer may be of the order of 2,500 ohms each, or of sufficiently high resistance to permit the tube to operate with sufficient plate current, and yet prevent a dangerous (over 50 mils) current to flow. The same circuit may also be applied to vacuum tube transmitters having high impedance tubes.

While I have shown specific adaptations of my invention, it is apparent that many variations of the safety circuits described herewith may be made without departing from the scope of the appended claims.

I claim:

1. In the art of safeguarding the human body with respect to exposed parts of a dangerously high potential electrical circuit connected with a high potential source to render such parts harmless upon bodily contact with the same: an electrical circuit including a transformer secondary winding affording a dangerously high potential, a cathode ray tube connected therewith, a high potential filter condenser in the connection, and a rectifier interposed between the transformer and the condenser, a casing enclosing the said transformer and a casing enclosing the said condenser, resistors located within the respective casings and of a value sufficiently low to permit operation of the said tube but of a value sufficiently high to effect a drop, when bodily contact is made with the said circuit externally of the respective casings, of voltage in the circuit to a degree sufficient to limit the passage of current through said circuit and body to a harmless value.

2. In the art of safeguarding the human body with respect to exposed parts of a dangerously high potential electrical circuit connected with a high potential source to render such parts

harmless upon bodily contact with the same: an electrical circuit including a transformer secondary winding affording a dangerously high potential, a cathode ray tube connected therewith, a high potential filter condenser in the connection, and a rectifier interposed between the transformer and the condenser, a casing enclosing the said transformer and a casing enclosing the said condenser, resistors located within the transformer casing in series in the respective output leads from its secondary and resistors located within the casing for the condenser in series in the respective output leads from its electrodes, and a further resistor connected across the condenser output leads within the casing of a value sufficiently high to prevent an appreciable drop of voltage across the condenser leads and sufficiently low to prevent accumulation of a residual charge, said series connected resistors being respectively of a value sufficiently low to permit operation of the said tube but of a value sufficiently high to effect a drop, when bodily contact is made with the said circuit externally of the respective casings, of voltage in the circuit to a degree sufficient to limit the passage of current through said circuit and body to a harmless value.

3. In combination, a transformer having a low voltage input winding, an enclosing casing for said transformer, together with terminals carried by said casing externally thereof, an intermediate output high voltage circuit portion of a resistance value sufficiently low to permit operation of electrical devices from the terminals but of sufficiently high value to prevent passage of current of dangerous value, a high resistance electrical device connected with the respective terminals, and a filter condenser, together with a rectifier therefor, said condenser comprising a casing for said condenser, terminals carried by said casing externally thereof and connected with the terminals of said transformer through the said rectifier, and resistance inserted between the condenser electrodes and said external condenser terminals within said casing, and being of sufficiently low value to allow the operation of the electrical device from said condenser terminals, but of sufficiently high value to prevent the passage of current of a dangerous value.

4. The combination with an electrical condenser and an enclosing casing therefor having external terminals connected with the condenser electrodes; of resistance located within the casing and connected intermediate the electrodes and terminals and of a value sufficiently low to afford the required potential at the said terminals but of a value sufficiently high to effect a drop of voltage, when bodily contact is made with the circuit at or beyond the said terminals, to a degree sufficient to limit the passage of current through the body to a harmless value.

5. The combination with an electrical filter condenser, a rectifier connected therewith, and an enclosing casing for the condenser having external terminals connected with the condenser electrodes; of resistance located within the casing and connected intermediate the electrodes and terminals and of a value sufficiently low to afford the required potential at the said terminals but of a value sufficiently high to effect a drop of voltage, when bodily contact is made with the circuit at or beyond the said terminals to a degree sufficient to limit the passage of current through the body to a harmless value.

6. The combination with an electrical condenser and an enclosing casing therefor having external terminals connected with the condenser electrodes, and a resistor connected across the condenser terminals within the casing of a value sufficiently high to prevent an appreciable drop across the condenser leads and sufficiently low to prevent accumulation of a residual charge; of resistance located within the casing and connected intermediate the electrodes and terminals and of a value sufficiently low to afford the required potential at the said terminals but of a value sufficiently high to effect a drop of voltage, when bodily contact is made with the circuit at or beyond the said terminals, to a degree sufficient to limit the passage of current through the body to a harmless value.

7. An electrical circuit having a source of dangerously high potential, a high-resistance device operating at a dangerously high potential, conductors between the source of high potential and the said device affording a permanently continuous connection therebetween, and resistance permanently included in said conductors so close to said source of high potential that all exposed parts of the circuit lie between the resistance and said device, said resistance being of such high magnitude that upon establishment of a closed circuit through said exposed parts and the human body the current in such closed circuit is reduced by said resistance to a safe value.

8. An electrical circuit having a transformer affording a dangerously high potential, a cathode ray tube operating at a dangerously high potential, conductors between the former and the latter affording a permanently continuous connection therebetween, and resistance permanently included in said conductors so close to said transformer that all exposed parts of the circuit lie between the resistance and said cathode ray tube, said resistance being of such high magnitude that upon establishment of a closed circuit through said exposed parts and the human body the current in such closed circuit is reduced by said resistance to a safe value.

9. An electrical circuit having a source of dangerously high potential, a device having a resistance of the order of magnitude approximating that of the human body and operating at such dangerously high potential, conductors between the source of high potential and said device affording a permanently continuous connection therebetween, and resistance permanently included in said conductors and the said circuit having all of its exposed parts lying between said resistance and said device, the resistance of the circuit between said source and any of said parts being of a magnitude sufficiently low to enable said device to be operated at the required voltage but so high in comparison to the resistance of the human body that upon establishment of a closed circuit through said exposed parts and the human body the current in such closed circuit is reduced by the included resistance to a safe value.

10. An electrical circuit having a source of alternating current supply embodying a plurality of transformer secondary windings, each affording a dangerously high potential, a high resistance device operating at dangerously high potential, conductors affording a permanently continuous connection between the windings and said device, a filter condenser with rectifier interposed between each of said transformer secondary windings and said device in said conductors, and resistance included permanently in at

least one conductor from each of said transformer secondary windings so close to a said winding that all exposed parts of the circuit lie between the resistance and said device, said resistance being of such high magnitude that upon establishment of a closed circuit through said exposed parts and the human body the current in such closed circuit is reduced by said resistance to a safe value.

11. In the art of safeguarding the human body with respect to exposed parts of a dangerously high potential electrical circuit connected with a high potential source to render such parts harmless upon bodily contact with the same: an electrical circuit including a source of dangerously high potential, a high resistance device having a permanently continuous connection therewith, resistance permanently connected with the parts of highest voltage, said resistance being of such high magnitude that upon establishment of a closed circuit through said exposed parts and the human body the current in such closed circuit is reduced by said resistance to a safe value, and means to encase the said source and said resistance.

EDWARD G. GAGE.