Nov. 26, 1963 P. THEISEN 3,112,425

PROTECTIVE CIRCUIT FOR CATHODE RAY TUBE

Filed Feb. 17, 1960 4 Sheets-Sheet 1

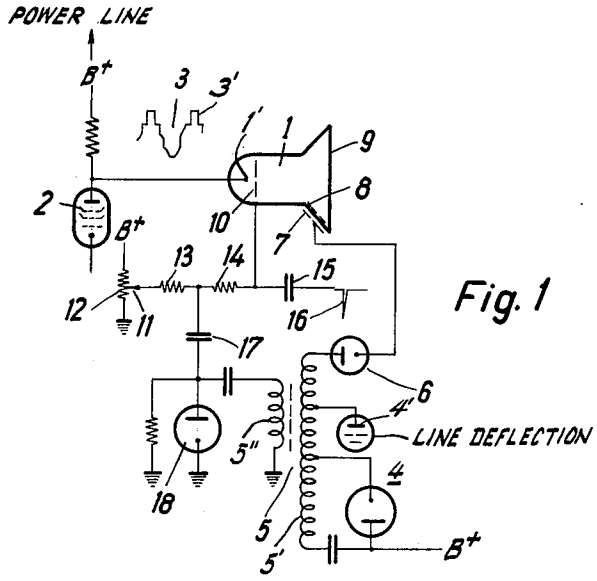


Fig. 1

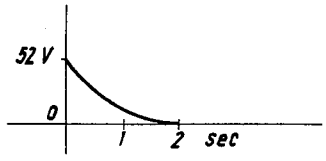


Fig. 2

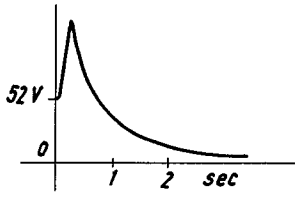


Fig. 3

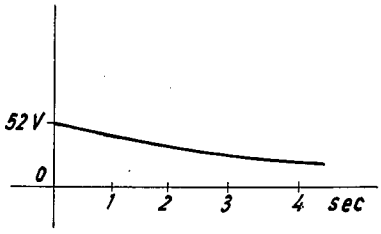


Fig. 4

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PROTECTIVE CIRCUIT FOR CATHODE RAY TUBE

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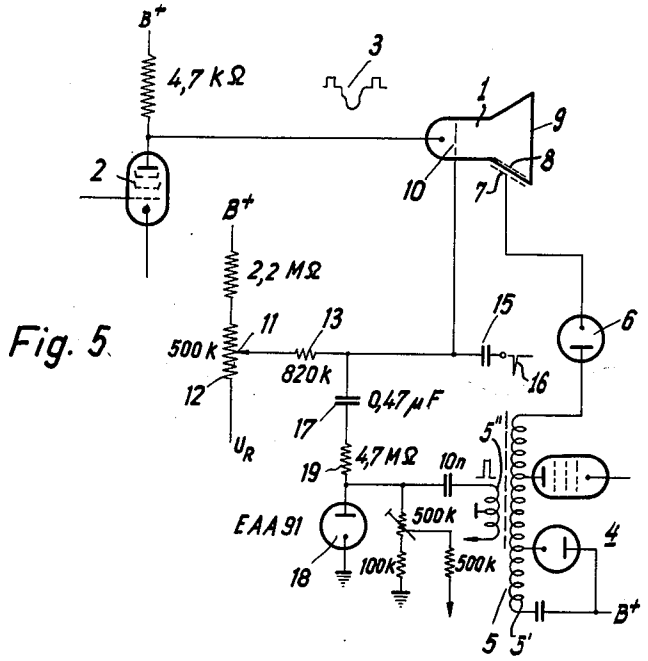


Fig. 5

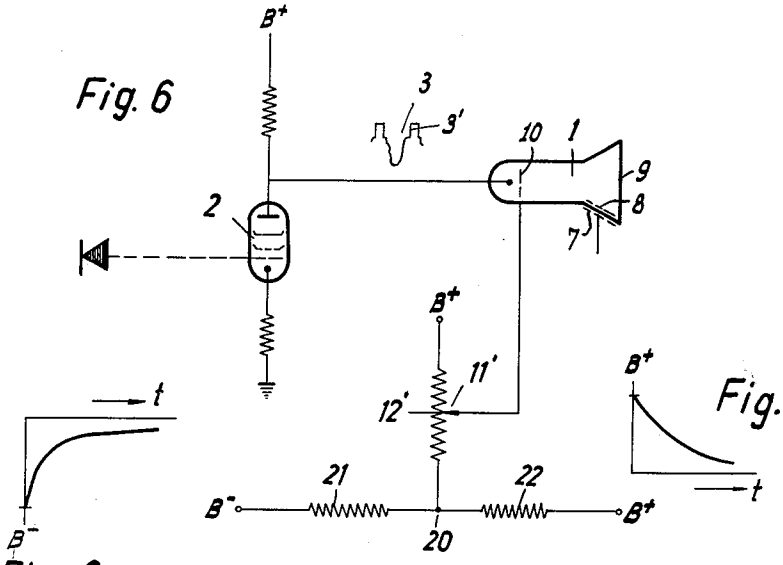


Fig. 6

Fig. 6a

Fig. 6b

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PROTECTIVE CIRCUIT FOR CATHODE RAY TUBE

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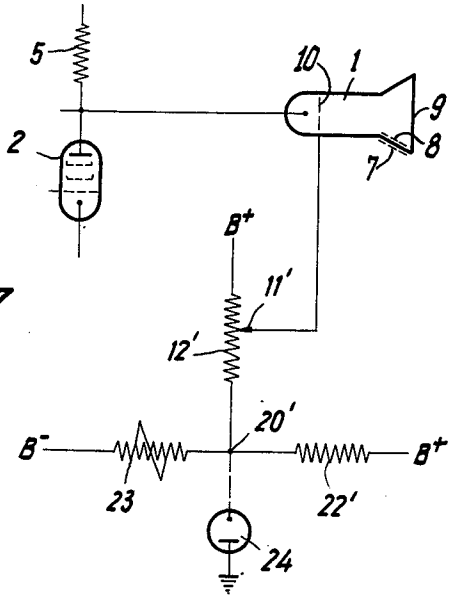


Fig. 7

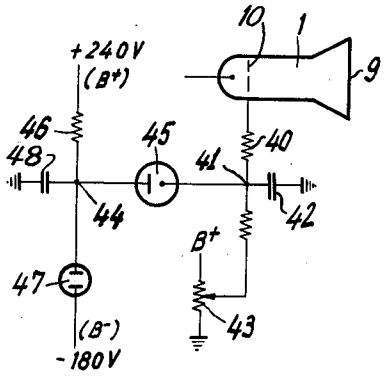


Fig. 8

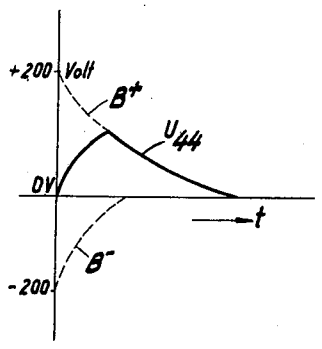


Fig. 9

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PROTECTIVE CIRCUIT FOR CATHODE RAY TUBE

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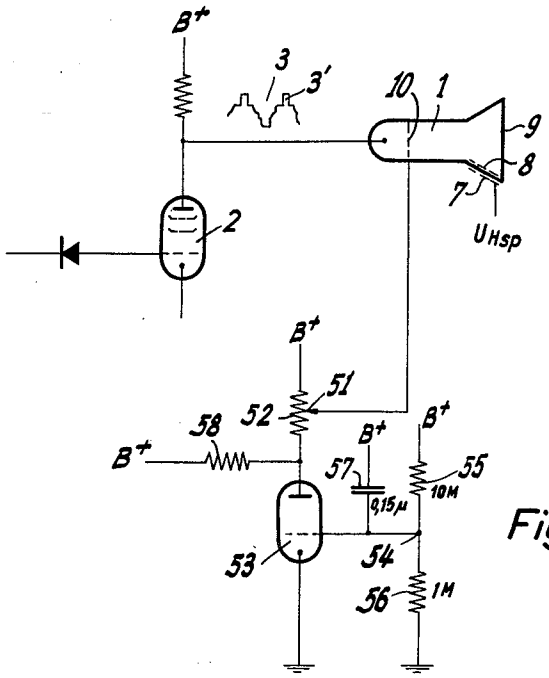


Fig. 10

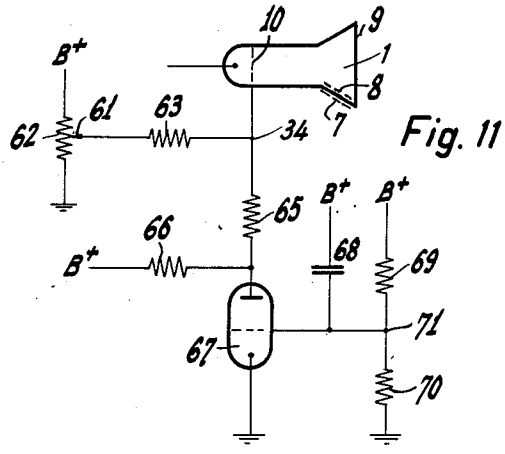


Fig. 11

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3,112,425

PROTECTIVE CIRCUIT FOR CATHODE RAY TUBE

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Filed Feb. 17, 1960, Ser. No. 9,327
Claims priority, application Germany Feb. 19, 1959
10 Claims. (Cl. 315—30)

The present invention relates to improvements in circuits for cathode ray tubes where the tube has a fluorescent screen over which an electron beam is deflected during operation, tubes of this type being used particularly in television receivers and oscilloscopes.

In general, the highly sensitive screen of a cathode ray tube must be protected from any continuous impingement of electrons onto the same spot or area; in other words, a cathode ray beam must be focused in such a tube only when the beam deflecting device is also in operation sweeping the beam over the screen. When an electron beam impinges upon the fluorescent layer of the video screen, such as the center thereof, even for only a short period of time, the fluorescent layer at the spot of impingement will be quickly burned.

It is known in the art to reduce automatically the intensity of a cathode ray beam when the deflecting device becomes inoperative for any reason.

Television receivers in which the line deflecting circuit is also used for producing the high accelerating voltage for the cathode ray tube, do not need such protection because when the line deflection circuit fails no high voltage will be produced for acceleration of the beam. However, it has been found that a protection device is necessary when the receiver is turned off. This is due to the fact that the picture tube accelerating anode has a sizeable capacitance constituted by the conductive layer deposited inside and outside of the envelope, which capacitance is used as a filter for the rectifier delivering high voltage peak pulses from the line deflection transformer during flyback. This capacitance usually amounts to 2,000 micromicrofarads. Upon cutoff of the receiver, the charge of this capacitance can be dissipated only through the remaining cathode ray beam. This discharge is visible until the remaining charge is insufficient to maintain further current flow of the cathode ray beam, i.e., until the anode cannot draw any electrons from the rapidly cooling cathode. In case of minimum picture brightness, i.e., a weak beam during the final instant of operation, almost no charge will flow from this picture tube capacitance after cutoff of the receiver because the electron beam will rapidly become too weak to maintain current flow. Only in case of maximum brightness during the final instant of operation will a considerable charge flow from the anode capacitance after cutoff of the receiver. Due to the fact that the glass wall of a picture tube has a high dielectric constant, the residual charge thereon may remain even for days. Particularly, long after the receiver has been turned off, there still is a high voltage of 10 kilovolts or more present in the tube. If the tube cathode is capable of emitting electrons relatively long even after its heater current has been turned off, and if furthermore the control voltage for the cathode ray beam is reduced to zero relatively fast, an electron beam may again begin to flow, discharging partially or completely the high potential charge on the tube. No deflection is present during this discharge and thus the electron beam impinges continuously for a considerable period of time on the video screen thus damaging the fluorescent layer in the center thereof.

To avoid the last-mentioned effect, it is known to connect the grid of the cathode ray tube to a brightness control network having a long time constant, the remaining control voltage suppressing partially the flow of cathode current for some time after cutoff of the receiver. In the case of rapid decay of the cathode voltage, when the time constant, which is determined by the power supply to which the circuit is coupled, is low, there flows, after the cathode voltage has decayed, a current which eliminates the negative space charge at the cathode and thus prevents a ray electron beam despite the residual charge of the high voltage capacitance. However, this measure is no longer available if the cathode remains capable of electron emission for an appreciable time after receiver cutoff, and if in addition thereto, there is a straight electrode system involved as is the case, for example, in deflecting tubes of 110°. In that case, the time constant element would have to be so large as to result in a very slow-operating brightness adjustment during operation of the receiver, which is a highly undesirable feature. Thus, in this prior art arrangement having the usual highly emissive cathode and a reasonably fast acting brightness control, the discharge of the anode capacitance through an undeflected electron beam after receiver cutoff seems inevitable. It has been suggested to discharge the anode capacitance by means of an additional contact associated with the on-off switch of the receiver and adapted to shunt the picture tube layers during cutoff. This, however, would be ineffective if one turns the receiver off merely by unplugging it from the power line.

It is an object of the present invention to provide a new and improved circuit for the cathode ray tube system of a high-frequency video receiver which new circuit provides complete anode capacitance discharge immediately after receiver cutoff, i.e., during the time interval in which the associated deflecting circuit is still operative.

It is another object of the invention to provide a new and improved circuit for discharging the anode capacitance in a cathode ray picture tube after cutoff of the receiver power supply by which this tube is supplied without producing an undeflected cathode ray beam, whereby all the deficiencies of the systems mentioned above are avoided.

It is a further object of the invention to discharge the cathode ray tube capacitance through the electron beam during the time the positive plate voltage is decaying in the other control circuits of the cathod ray tube.

According to one aspect of the invention, in a preferred embodiment thereof, it is suggested to connect a control network to the control grid or other control element of a cathode ray tube, which control network maintains the brightness control substantially unchanged but automatically varies the grid voltage for a short period of time after receiver cutoff in such a way as to permit substantially maximum cathode beam electron flow. In particular, the network is triggered by the receiver cutoff and operates in dependence upon the decay of various D.C. supply voltages thereafter. This nework may, for example, comprise an electronic switching arrangement which changes substantially the time constant of the brightness control network upon decay of the positive power supply for this control network and the anode voltage. Alternatively, the operating point of the brightness control can be shifted in dependence upon the decaying positive power supply with the aid of either non-linear circuit elements or the faster decaying negative power supply or both.

Additional objects and advantages of the present invention will become apparent upon consideration of the following description when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a circuit diagram of the brightness control for a cathode ray tube having a video screen, and includes a network according to one embodiment of the invention.

FIGURE 2 is a plot of the cathode ray tube grid volt-

age against time if the network according to the invention were not used in the circuit of FIGURE 1.

FIGURE 3 is a similar plot if the inventive arrangement is used.

FIGURE 4 is a plot of the cathode ray tube grid voltage if a control network having a large time constant is used according to one prior art device discussed above.

FIGURE 5 illustrates a practical example of a circuit diagram designed according to the principle employed and explained in connection with FIGURE 1.

FIGURE 6 is a circuit diagram of another embodiment of the invention used in the brightness control network of a television receiver circuit.

FIGURES 6*a* and 6*b* are plots of decaying negative and positive power supply voltages, respectively, as they appear in FIGURE 6.

FIGURE 7 is a modified form of the circuit of FIGURE 6.

FIGURE 8 is a modification of the circuit diagram shown in FIGURE 7.

FIGURE 9 is a plot of the cathode ray tube grid control voltage as produced by the circuit shown in FIGURE 8 after receiver cutoff.

FIGURE 10 is a circuit diagram of another embodiment of the invention.

FIGURE 11 is a modification of the circuit shown in FIGURE 10.

FIGURE 1 shows a cathode ray tube such as is used in television receivers or oscilloscopes. The cathode **1'** of tube **1** receives video signals **3** including synch pulses **3'** from a video amplifier **2**. The video amplifier is shown only schematically because it is of conventional type.

The high voltage power for the cathode ray tube **1** is supplied from a line deflection transformer **5** having an oscillator **4** with electronic input control **4'** connected to its primary winding **5'**. The high voltage peaks during retrace are used for powering the tube **1**, and for this purpose these peaks are fed through a diode **6** to a capacitor which is formed by two conductive coatings **7** and **8** on the glass wall of the tube **1**. Coating **7** is deposited on the outside of tube **1** while coating **8** is deposited on the inside. Coating **8** is connected electrically to the anode of tube **1** (not shown). The thus-formed capacitor is the storage capacitor of the D.C. accelerating power supply for the tube **1**.

Grid **10** in tube **1** controls the brightness of the image produced by the cathode ray on the screen **9**. Grid **10** is connected to a tap **11** of a potentiometer **12** which is connected between ground and a positive D.C. voltage B+. The tap **11** is connected to grid **10** via two resistors **13** and **14**. The position of the sliding tap **11** determines the intensity of the beam and therefore the brightness of the image on screen **9**. Negative blanking pulses **16** are also supplied to grid **10** through a capacitor **15**. These pulses bias the grid sufficiently negative to block the cathode ray beam during retrace. The circuit as described thus far is conventional.

It has been found that with such a circuit, the screen **9** can be damaged when the receiver is turned off while the brightness control is in a relatively low position, i.e., when the cathode beam intensity was low during operation just before cutoff. In this case, the charge stored in capacitor **7—8** cannot be quickly discharged through the beam, as pointed out above. Thus, due to the fact that glass is a very good dielectric material, this high voltage can remain for a very long time. This in itself would not be a detriment if the cathode were not capable of emission even if the other electrode voltages are already reduced to zero. However, the cathode is in fact capable of emission long after receiver cutoff and thus the charge on the capacitor will discharge in the form of cathode ray beam current. This cathode ray beam will not be deflected and thus will damage the center of the fluorescent layer of the image screen **9**.

The following circuit arrangement according to the invention prevents such damage. A capacitor **17** is connected between the grid **10** and a negative voltage produced additionally in the receiver. One can obtain such negative auxiliary voltage, for example, by an additional secondary winding **5''** on the line deflection transformer **5**, which winding **5''** is connected to another diode **18** via a capacitor. The polarity of diode **18** is selected so as to produce a D.C. output voltage from the peak voltages appearing across winding **5''** during retrace. Diode **18** can be replaced by any known non-linear resistance element. The diode **18** and the transformer secondary **5''** may already be present in known television receivers, for example, to derive a control signal from the deflection transformer to be used in the deflection control circuit. However, it is not known to feed such a negative auxiliary voltage to the brightness control grid **10** of the video tube **1**.

During operation of the video tube **1** and its control device an equilibrium is established across capacitor **17**. The time constant of the brightness control remains substantially unaffected by the charged equilibrium of capacitor **17**, because this capacitor can be selected to be of relatively small value, for example, in the range of half a microfarad. Upon cutting off the receiver, the capacitor **17** discharges with the result that two different discharge currents flow through the capacitor **17** because capacitor **17** was charged on the upper plate by the B+ voltage and separately charged on the lower plate by the negative auxiliary voltage from diode **18**. In case the auxiliary voltage fed to capacitor **17** via diode **18** were positive, these discharge currents would have the same direction. However, due to the fact that this auxiliary voltage is negative, these discharge currents are in opposition. Upon proper selection of this auxiliary voltage one can in fact adjust the total discharge time of capacitor **17**. If the current produced by the auxiliary voltage has the same order of magnitude as the other discharge current, then the voltage at grid **10**, as compared with ground, decays with delay and the effective capacitance of capacitor **17** is increased. If the auxiliary discharge current exceeds the opposite discharge current, the grid voltage may even become positive for a short period. In other words, upon proper proportioning of the auxiliary voltage source the grid voltage can be elevated for a short period of time to a relatively high positive voltage without the use of a mechanical switch but by a similar electronic switching effect. The cutoff time constant of the decaying negative auxiliary voltage as shown in the drawing is given by the delay circuit elements associated with the transformer **5** producing the auxiliary voltage. The time constant of the transformer depends additionally on the decay time of the receiver power supply producing the B+. In a given receiver with a given power supply source, this time constant of the negative auxiliary voltage is fixed and predetermined. This is true also of the B+ power supply and the brightness control circuit.

FIGURE 2 shows the discharge characteristics, i.e., the decaying voltage of grid **10** if the capacitor **17** were directly connected to ground, and not to diode **18**.

FIGURE 3 shows the voltage characteristics if the same capacitor **17** is connected to the negative potential, which is the salient feature of one embodiment of the invention. As can be seen from the plot in FIGURE 3, the grid voltage increases positively to such a value, which in fact is sufficiently high to discharge completely the anode capacitance of the picture tube in less than one second even if the brightness control was adjusted for its lowest position corresponding to minimum brightness. During this time, the deflection electrodes in tube **1** are still operative and sweep the cathode ray over the screen **9**. It will be observed that the elements **4**, **5** and **18** serve as a non-linear transmission network for the decaying B+ which powers the oscillator **4**. This non-linear network causes a reduction in the time constant of the decay;

i.e., the negative voltage at the anode of diode 18 decays further than the B+ at the input of oscillator 4.

It has been found that a similar complete discharge could also be obtained if the capacitor 17 were connected directly to ground, as known in the art, but this would require a capacitor whose capacitance is about 2.5 microfarads. Even then, there would still be no positive voltage peak at the grid 10 but the grid voltage would remain positive sufficiently long to discharge the anode capacitance. However, the time constant of such capacitor would be 2.5 seconds, which is undesirable because it renders the brightness control too slow, and the deflection will not operate long enough after receiver cutoff. This is shown in FIGURE 4, while when the curves of FIGURES 2 and 3 were measured and plotted, the capacitor 17 was selected to have a capacitance of 0.47 microfarad.

While FIGURE 1 illustrates only the principal circuit elements required to carry out the invention, FIGURE 5 is a complete schematic diagram thereof. Similar circuit elements are denoted with like reference numerals, and the elements are further provided with circuit values which have been found suitable when tested and used. To avoid brightness jumps in case of power supply voltage variations in FIGURE 5, a resistor 19 is connected in series with capacitor 17, which resistor 19 additionally serves as a substitute for resistor 14 of FIGURE 1 which is omitted in FIGURE 5. The peak of the voltage at grid 10 will be somewhat reduced but this has no effect as far as the fast discharge of the anode is concerned.

In FIGURE 6 the grid 10 of tube 1 is connected directly to a tap 11' of a brigthness control potentiometer 12'. This potentiometer is connected between a positive voltage source B+ and the junction 20 of two ohmic resistors 21 and 22 which are connected between a positive voltage B+ which may be equal to the B+ feeding potentiometer 12' and a negative voltage B— produced by the line deflection transformer during retrace. When the receiver is turned off, the positive supply voltage B+ decays with a time constant determined by the power supply filter network of the receiver. The negative voltage B— also decays but with a different time constant which is determined by the deflection transformer and its input and output circuits. In general, the negative voltage decays faster than the positive voltages from the power supply with its comparatively large filter capacitors, etc. Thus, the potential at junction 20 having a fixed value during operation, for example zero, now shifts suddenly to a positive value after cutoff of the receiver. This in turn causes the voltage of tap 11' and of grid 10 to increase to a positive value whereby the cathode ray current of tube 1 is increased and remains so until the high voltage of the anode capacitance is bled off. The deflection circuits are still in operation and the increased cathode ray sweeps over a substantial part of the video screen 9.

FIGURES 6*a* and 6*b* illustrate the decay time of the negative and of the positive voltages, respectively, between which the resistors 21 and 22 are connected.

FIGURE 7 is another embodiment of the invention. Here, the time constants of the positive and of the negative supply voltages are not especially important any more. The positive voltage of B+ is fed to junction 20' via a resistor 22', the negative voltage from negative auxiliary voltage B— supply source is also fed to the junction 20' via a non-linear resistor 23 which has an approximately constant value at higher currents. Junction 20' is connected to the potentiometer 12' as was junction 20 in FIGURE 6. The decaying positive voltage B+ is transmitted to junction 20' in an undistorted configuration while the non-linear resistor 23 changes the decaying negative voltage to such an extent that the potential of junction 20' shifts to positive values. Here one can use positive and negative supply voltages of similar decay time constants but still will obtain a positive shift of the grid voltage of the cathode ray tube after receiver cutoff. If the supply voltages are of unequal decay time constants, with the negative supply decaying faster as shown in FIGURES 6*a* and 6*b*, the non-linear resistor 23 increases the effect and produces a higher positive grid voltage after cutoff whereby the anode capacitance of the cathode ray tube is discharged even faster. The connection of junction 20' to the cathode of a diode 24 having its anode connected to ground is optional and serves to stabilize variations in the power supply for the receiver which must not affect the brightness of the television picture. Alternatively, diode 24 may be connected to a positive or a negative voltage of such magnitude that diode 24 is conductive during operation of the receiver.

FIGURE 8 illustrates a modification of the circuit shown in FIGURE 7. The grid 10 of tube 1 is connected via a resistor 40 to a first junction 41, which junction is connected to ground via a capacitor 42. Junction 41 is further connected to a brightness control potentiometer 43, as well as to a second junction 44 with a diode 45. Junction 44 interconnects an ohmic resistor 46 and a glow discharge tube 47. Resistor 46 and glow discharge tube 47 are connected as a voltage divider between a positive and a negative supply voltage. Junction 44 is furthermore connected to ground via a capacitor 48.

During operation, diode 45 is blocked. Upon cutoff of the receiver, the negative voltage decays faster than the positive voltage and with the additional effect of the nonlinear resistance of the glow discharge tube 47 the potential of junction 44 follows a curve plotted in FIGURE 9. In this embodiment, the adjustment of the network producing the positive grid voltage after cutoff does not affect the brightness control 43 which thus can be dimensioned within greater scope.

In FIGURE 10, the control grid 10 of cathode ray tube 1 is connected to the tap 51 of a brightness control potentiometer 52. One terminal of potentiometer 52 is connected to a positive voltage, the other terminal is connected to the anode of a triode 53, the control grid of which is connected to a junction 54 of a voltage divider 55, 56, which in turn is connected between a positive voltage supply source and ground. The junction 54 is further connected to the positive voltage via a capacitor 57.

The circuit as described thus far produces a control voltage at grid 10 of cathode ray tube 1 which is determined by the voltage taken from the potentiometer 52 and by the grid bias of triode 53 which has low ohmic resistance during operation of the receiver. Upon cutoff of the receiver the decay of the positive voltage is transmitted to the grid of triode 53 via the capacitor 57, whereby the triode immediately becomes a high resistance. The time constant for blocking triode 53 is very small as compared with the time constants of the power supply decay. This control action in turn immediately renders the tap 51 positive as compared with its potential at the same position but prior to cutoff of the receiver. This potential increase at tap 51 even exceeds any voltage charge produced across potentiometer 52 and thus a very high positive voltage peak appears at grid 10 of cathode ray tube 1.

For a further increase of this effect it can be of advantage additionally to connect the anode of triode 53 to the positive voltage supply via a high ohmic resistor 58. This increases the speed of the voltage increase at tap 51 upon cutoff of triode 53.

FIGURE 11 illustrates a modification of the circuit shown in FIGURE 10. Elements 66, 67, 68, 69, and 70 and their mode of interconnection correspond to elements 58, 53, 57, 55, and 56, respectively, in FIGURE 10. The brightness control potentiometer 62 is connected between a positive voltage and ground and thereby it is partially connected in parallel to triode 67 which has a grounded cathode. Grid 10 of cathode ray tube 1 is connected to a tap 61 of potentiometer 62 via a resistor 63. The junction 34 of the grid lead-in and resistor

63 is connected to the anode of triode 67 via a resistor 65. The anode circuit of triode 67 thus includes a voltage divider formed by resistors 63 and 65.

During operation, the grid 10 of tube 1 receives a stable bias voltage which is determined by the dimensioning of resistors 62, 63 and 65 and the internal resistance of triode 67 at the given grid control voltage thereof. A variation of the position of tap 61 varies this bias voltage for grid 10. Upon cutoff of the receiver, the positive supply voltage decays according to a given function and a given time constant. The variation of this varying supply voltage is transmitted to the control grid of triode 67 via the capacitor 68. Thereby the triode 67 immediately becomes substantially blocked and forms a high resistance. This in turn shifts the potential of junction 34 by a predetermined amount which is larger than the positive voltage at any time after cutoff of the receiver. Thus, the control grid 10 receives a high positive control voltage increasing the cathode ray current for a short period of time.

Triode 67 can, if desired, be replaced by a multigrid tube or any other controllable device which can be varied between high and low internal resistance.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

I claim:

1. In a control circuit for a cathode ray tube having a screen and at least one control element for controlling the intensity of the cathode ray beam and having an accelerating anode capacitance charged to a high voltage by a power source during operation, an improved circuit for discharging said capacitance through the beam when the source is cut off, said circuit comprising: control means connected to said control element for adjusting the operating bias level thereon, and voltage translating network means connected between said control element and said power source for producing a positive transient voltage on said element at a level increasing above said bias level during decay of the power source when the latter is cut off, said network means including a second power source having a decay function different from that of the first-mentioned power source and said transient voltage being derived from the superposition of decay transients obtained from said power sources and serving as the control voltage.

2. In a control circuit for a cathode ray tube having a screen and at least one control element for controlling the intensity of the cathode ray beam and having an accelerating anode capacitance charged during operation to a high voltage by a power source having a predetermined decay function when cut off, an improved circuit for discharging said capacitance through the beam when the source is cut off, said circuit comprising: control means connected to said control element for adjusting the operating bias level thereon, and non-linear network means connected between said control element and said power source for translating said decay function to a positive transient voltage and applying it on said element to raise the voltage thereon above said bias level during decay of the power source when the latter is cut off, said network means including a second power source having a decay function different from that of the first-mentioned power source and said transient voltage being derived from the superposition of decay transients obtained from said power sources and serving as the control voltage.

3. In a control circuit for a cathode ray tube having a screen and at least one control element for controlling the intensity of the cathode ray beam and having an accelerating anode capacitance charged during operation to a high positive voltage by a power source having, upon cut-off, a certain decay rate, an improved circuit for discharging said capacitance through the beam when the source is cut off, said circuit comprising: potentiometer means having a tap connected to said control element for adjusting the operating bias level therein, an auxiliary negative power source having, upon cut-off, a decay rate which is faster than that of the positive power source, and means, connected between said control element and said auxiliary negative power source for producing a positive transient control voltage on said element at a level increasing above said bias level during decay of the positive power source when the sources are cut off.

4. In a circuit as set forth in claim 3, beam deflection means including a deflection transformer, and said auxiliary source comprising a winding on said transformer, and rectifier means connected with said winding and delivering negative pulses during sweep return traces.

5. A control circuit for a cathode ray tube having a video screen, a control grid and an anode capacitance connected with a high voltage power supply, said control circuit comprising: bias control means connected to said grid, a resistance voltage divider having a junction between resistors, a positive voltage supply source having a predetermined decay time-constant when cut off, a negative voltage supply source having a cutoff time constant smaller than said first mentioned time constant, said voltage divider being connected in series between said two voltage supply sources, and resistance means connected between said junction and said grid.

6. In a control circuit as set forth in claim 5, said bias control means comprising a potentiometer connected to a positive source of voltage at one end and having a tap connected to said grid, said potentiometer comprising said resistance means and having its other end connected to said junction.

7. In a control circuit as set forth in claim 5, said voltage divider including a non-linear resistance connected between said junction and said negative voltage source.

8. A control circuit as set forth in claim 7, said non-linear resistor being a glow discharge tube.

9. In a control circuit as set forth in claim 5, said last mentioned means including a unidirectional conductor element having a cathode and an anode, said anode being connected to said junction, said cathode being connected to the grid circuit.

10. In a control network as set forth in claim 5, a diode having a cathode and an anode, said cathode being connected to said junction and said anode being connected to a constant potential biasing the diode conductive to drive a current therethrough until said sources are cut off.

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