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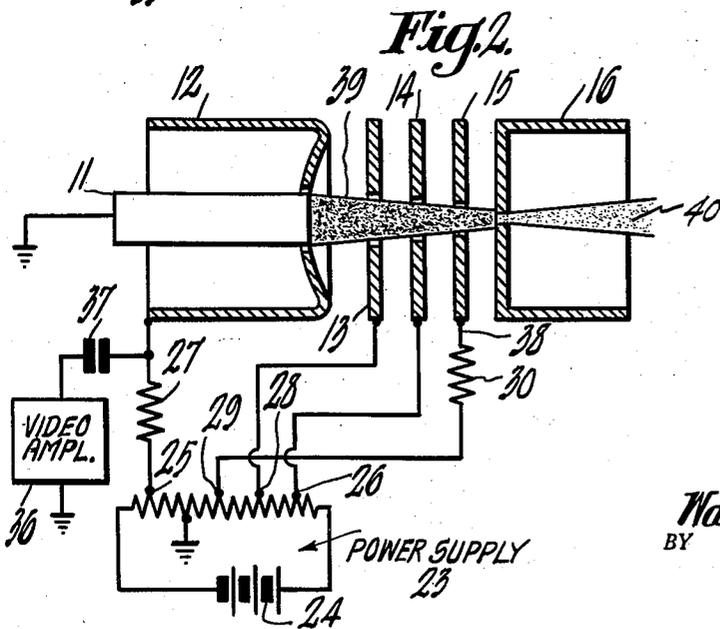
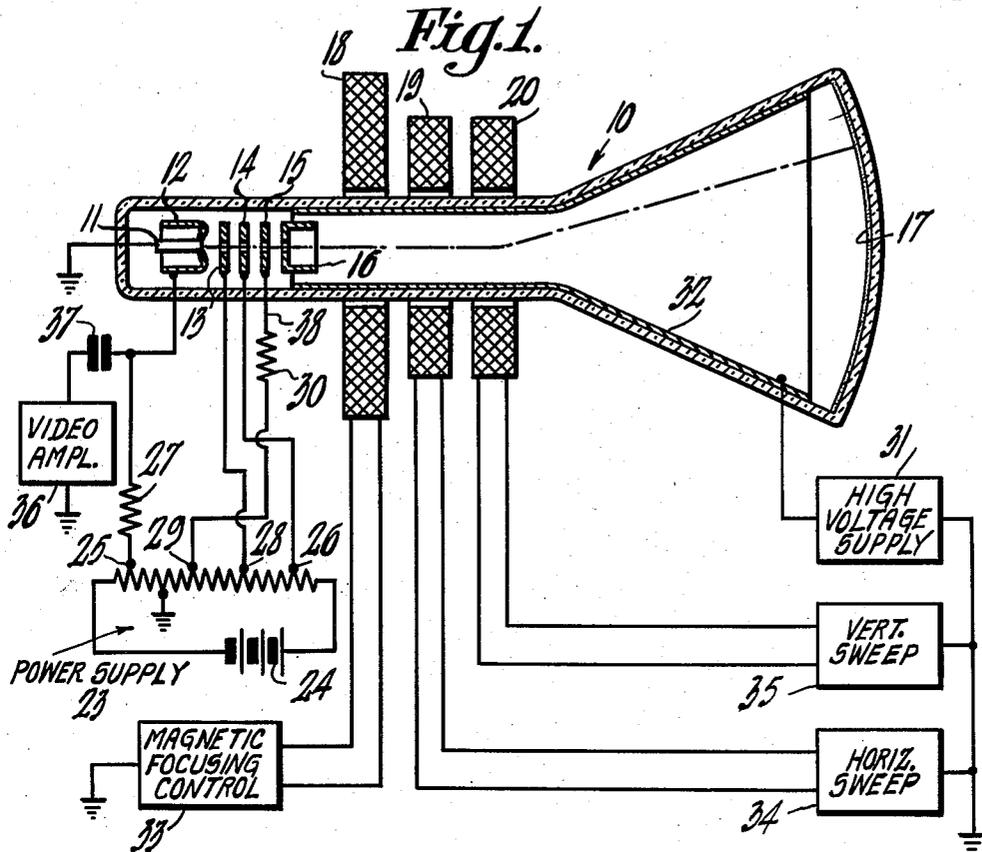
W. R. BEAM

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MODULATION CONTROL FOR CATHODE RAY TUBES

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2 Sheets-Sheet 1



INVENTOR.
Walter R. Beam
BY
W. Gordon Dyke
ATTORNEY

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Fig. 3.

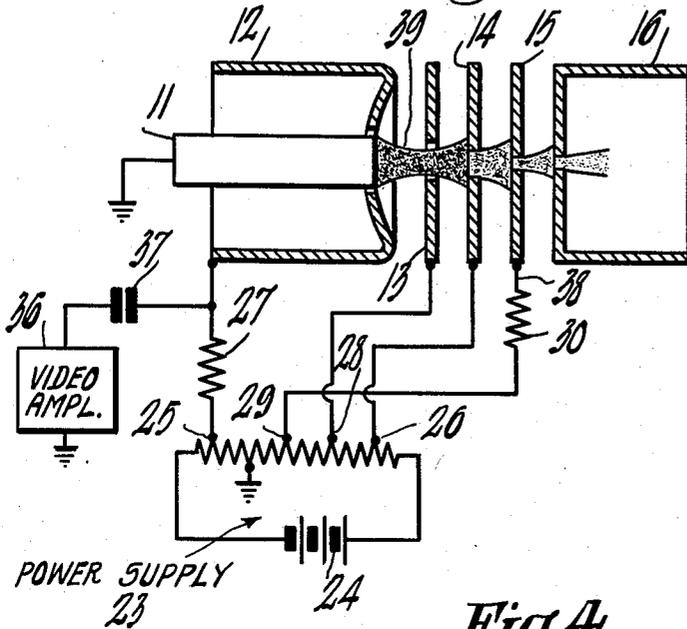
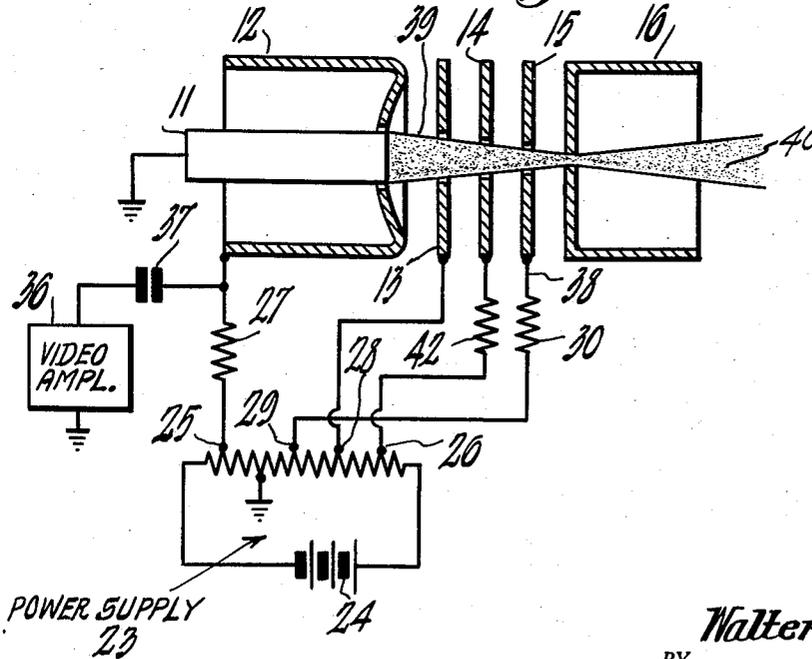


Fig. 4.



INVENTOR.
Walter R. Beam

BY

W. Gordon Dyke
ATTORNEY

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MODULATION CONTROL FOR CATHODE
RAY TUBESWalter R. Beam, Hamilton Square, N.J., assignor to
Radio Corporation of America, a corporation of Dela-
ware

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4 Claims. (Cl. 315-16)

This invention is directed to circuitry which enables the extinguishing of the electron beam in a cathode ray tube by application of a much smaller negative signal than was possible in prior art arrangements. My invention is particularly applicable to a cathode ray tube in which the tube's electron beam is focused to pass through a series of small limiting apertures in a series of disk electrodes interspersed in the beam path. Such a tube is disclosed in U.S. Patent 2,266,773 issued to R. R. Law.

In operation of most cathode ray tubes it is sometimes desirable to cut off the electron beam completely, that is, to prevent all but a negligible number of electrons from striking the target of the tube. Since a tube of the type described above uses a high voltage and high intensity beam, it was necessary in prior art practices to apply a very high negative cut-off voltage to the control grid in order to cut off the beam completely. That high negative cut-off voltage was undesirable, as it meant large driver tubes, high power consumption, and circuitry which was involved and sometimes expensive. The object of this invention is to provide a simple means to achieve complete cut-off of the beam by a lower voltage than heretofore required, giving all the attendant advantages of the use of a lower modulating voltage. This objective is achieved through a circuit arrangement in which a signal of moderate magnitude sets up a self magnifying "bootstrapping" action.

It is a fact that a negative signal voltage of moderate magnitude can cause some beam defocusing when applied to a modulating electrode; and this defocusing will cause part of the beam to be intercepted by that electrode. Yet, such a signal can still be of insufficient magnitude to cause complete beam cut-off by its own direct action.

My invention makes use of this degree of defocusing to obtain the aforementioned bootstrapping action. If the electrons of such a defocused beam strike a positive electrode, they will be captured and conducted off. This action can be enhanced by having initial defocusing along with its attendant resultants (capturing and conduction) act to further increase the defocusing. This I achieve by connecting large resistances in series between one or more of the electrodes upon which electrons of the defocused beam impinge and the accompanying positive potential source. Substantially complete beam cut-off by bootstrapping is thus achieved in the following manner.

A negative signal of moderate magnitude is applied to a modulating electrode to cause the initial beam defocusing. Electrons then impinge upon a positive apertured electrode (which we shall hereinafter call the cut-off electrode) through which the focused beam ordinarily passes. These electrons are captured and conducted off through a large voltage dropping resistor. Current flow through this resistor causes an IR drop which serves to decrease the positive potential on the cut-off electrode. As a result of the change in potential on the cut-off electrode the beam is further defocused. This will in turn result in more of the electrons of the beam being in-

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terrupted by the cut-off electrode. This, of course, will cause a still greater IR drop. This bootstrapping action will continue to magnify itself until it results in substantially complete cut-off of the electron beam, and with but a fraction of the negative grid voltage that is necessary in the practices of the prior art. Though described above in terms of successive stages, the action is in practice essentially instantaneous.

In the drawings Fig. 1 shows a preferred embodiment of my invention as used with one type of cathode ray tube.

Figs. 2 and 3 show enlarged views of the electron gun unit of the cathode ray tube of Fig. 1.

Fig. 4 shows a modification of my invention as used with the same type tube illustrated in Fig. 1.

As shown in Fig. 1, the tube 10 includes a cathode 11 which protrudes through an opening in the end wall of a cup-shaped focusing and modulating electrode 12. A suitable number, for example three, of centrally apertured focusing, disk electrodes 13, 14, and 15 are aligned with the cathode on one end and with an aperture anode 16 on the other end. In addition to its beam focusing function, electrode 15 serves as the cutoff electrode, as will be hereinafter explained in greater detail. Further out the neck of the tube from the anode 16 toward the screen 17 is a magnetic focusing coil 18, and deflection coils 19 and 20. Suitable potentials are supplied to electrodes 12, 13, 14, and 15 from a power supply 23 shown schematically by a battery 24 and a potential divider 25-26. Modulating electrode 12 is connected through a resistor 27 to the negative end of the divider at terminal 25, electrode 14 to the positive end of the divider at terminal 26, and electrodes 13 and 15 to intermediate taps 28 and 29 respectively, a large voltage dropping resistor 30 being included in the circuit of cut-off electrode 15. The high voltage supply 31 supplies a high positive potential to the apertured anode 16 and to a second anode 32 which is in the form of a conductive coating on a part of the inner surface of the tube 10. According to one mode of typical operation the voltages at terminal 25, taps 29 and 28, and terminal 26 might be -10, 500, 1000, and 1500 volts respectively; the voltage output from the power supply 31 might be 10,000 volts; and the resistor 30 might be 200,000 ohms. Magnetic focusing control 33 serves to energize the focusing coil 18 while the deflection coils 19 and 20 are energized respectively by the horizontal sweep 34 and the vertical sweep 35. Modulating signals are fed to modulating electrode 12 from a video amplifier 36 through coupling capacitor 37.

Figs. 2 and 3 illustrate the effects of my invention upon tube operation. Fig. 2 shows the operational condition of the electrons when maximum beam current is being drawn. Fig. 3 shows the operational condition of the electrons after a negative signal cut-off voltage of a moderate magnitude has been applied to the modulating electrode. The operational condition of Fig. 2 might exist during that time when a peak brightness signal is being applied to the modulating electrode 12 by the video amplifier 36. At such time the modulating electrode bears a voltage which is only slightly negative with respect to the cathode 11. The free electrons 39 remain focused through the aligned central apertures of the focusing electrodes 13, 14, and 15, and the anode 16, so that very few of them strike the cut-off electrode 15. As a result there is no current flow in the line 38 and through the dropping resistor 30, or at most only negligible current. With negligible current to cut-off electrode 15, there is little or no IR drop across resistor 30, thus the positive voltage at the cut-off electrode 15 is maintained at or near the voltage level at the tap 29 of the power supply 23. As a result of the maintenance of this normally high positive voltage, virtually no defocusing is effected in the

region of the cut-off electrode 15. Thus, under these conditions the electrons 39 are focused into a concentrated beam 40 which impinges upon the screen 17 farther out in the tube.

Fig. 3 will illustrate the manner in which the addition of dropping resistor 30 to circuits of the prior art results in an electronic action which greatly enhances beam cut-off control by the modulating electrode 12. Fig. 3 shows the operational condition of the free electrons 39 in the region of the focusing electrodes 13, 14, and 15 when a negative cut-off voltage is applied to the modulating electrode 12 by the video amplifier 36. This cut-off voltage does not need to be sufficiently large to completely cut off the electron beam by its own direct action. On the contrary it need be only large enough to cause an unbalance of beam focusing to the extent that some of the electrons 39 strike the cut-off electrode 15. Actually, in the type tube described focusing is so critical that alteration of electrode voltage by about 50 percent of the normal cut-off voltage of prior art arrangements will defocus the beam appreciably, reducing current passing through the aperture to a very small value.

Upon application of such a negative signal voltage to modulating electrode 12, the electrons 39 are defocused in the region of the focusing electrodes 14 and 15, causing some of them to impinge upon these electrodes. Those electrons which impinge upon the electrode 14 will be conducted to the power supply terminal 26. Since the conduction path of these electrons is of negligible resistance, the D.C. level potential on the electrode 14 will remain substantially equal to the potential at terminal 26. On the other hand, those electrons which impinge upon the cut-off electrode 15 will be conducted along line 38, through the dropping resistor 30 and to the positive tap 29 of the power supply 23. This electron flow, or current, through dropping resistor 30 will cause a potential difference to exist across the resistor such that the end of the resistor connected to the electrode 15 will be negative with respect to the end connected to the power supply tap 29.

This potential difference, which is commonly referred to as IR drop, will serve to make the potential at the cut-off electrode 15 less positive than it was prior to the initial defocusing of the electron beam. As a result of this decreased positive potential on the cut-off electrode 15, the beam will be further defocused in the region of that electrode. Since focus is affected mostly in that region as opposed to the regions of the focusing electrodes 13 and 14 a still greater percentage of the defocused electrons 39 will be intercepted by that electrode. This greater electron interception will, in turn, cause a greater electron flow in lead 38 and through resistor 30, and consequently a greater IR drop across the resistor 30. The greater IR drop results in an even lower positive potential being available on the cut-off electrode 15. Thus it can be seen that a self-magnifying cut-off action is achieved which can continue to function until virtually all of the emitted electrons 39 are being intercepted by the electrodes 14, and 15, with practically none of the electrons passing beyond the cut-off electrode 15 and through the aperture in the anode 16. In this manner substantially complete cut-off of the electron beam can be achieved with only a minimum of negative signal voltage being applied to the modulating electrode 12.

Fig. 4 shows a modification of my invention to illustrate that more than one of the focusing electrode circuits may have voltage dropping resistors. The embodiment of Fig. 4 is identical to the embodiment of Fig. 3 except that a resistor 42 is included in the circuit connection between focusing electrode 14 and power supply terminal 26. Such a modification permits focusing electrode 14, as well as focusing electrode 15, to act as a cut-off electrode. As a result, the bootstrapping action of electron

defocusing and capturing as provided by the circuit of cut-off electrode 15 in the embodiment of Fig. 3, is further enhanced by the addition of a second bootstrapping unit.

I claim:

1. In combination with a cathode ray tube having, in the order named, a cathode, a modulating electrode for providing normal operating beam modulation, at least one apertured beam cut-off focusing electrode, an anode, and a screen; an electron beam cut-off circuit comprising a source of positive direct current potential, a dropping resistor having two terminals with one terminal connected to said positive source and the other terminal connected to said focusing electrode, and means for applying to said modulating electrode a negative voltage pulse sufficient to cause electron interception by said focusing electrode which will result in a current flow through said resistor causing a drop in the positive potential on said focusing electrode which will in turn cause defocusing of the electron beam in the region of said focusing electrode.

2. An electron beam cut-off circuit for a cathode ray tube, said tube having a modulating electrode for providing normal beam modulation and at least one apertured, positive potential bearing, beam cut-off focusing electrode on which electrons from a defocused beam will impinge and through which a focused electron beam will pass, said circuit comprising a source of positive direct current potential, a connection between said source and said focusing electrode including a large dropping resistor, and means for applying to said modulating electrode a negative voltage pulse.

3. An electron beam cut-off circuit for a cathode ray tube which has in the order named a cathode, an apertured control grid for providing normal operating beam modulation, and an apertured beam cut-off focusing electrode coaxially arranged to provide passage through said control grid and said cut-off electrode of a focused beam of electrons, said circuit comprising a source of D.C. potential, a large dropping resistance connected between said cut-off electrode and said source of potential, and means for applying to said control grid a negative voltage pulse to cause electron impingement on said cut-off electrode which will result in defocus of said electron beam.

4. An electron beam cut-off circuit comprising: a cathode ray tube having in the order named, a cathode, a modulating electrode for providing normal operating beam modulation, a plurality of apertured beam cut-off focusing electrodes, an anode, and a screen; a source of positive direct current potential; a plurality of dropping resistors, each of said resistors connected between said source of potential and a different one of said plurality of apertured focusing electrodes; and means for applying to said modulating electrode a negative voltage pulse sufficient to cause electron interception by said ones of said plurality of apertured electrodes to which said resistors are connected which is occasioned by normal initial defocusing of said beam, and which will result in current flow through said resistors causing a drop in the positive potential on said ones of said plurality of apertured electrodes which will in turn cause further defocusing of the electron beam in the regions of said ones of said plurality of apertured electrodes.

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