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CONTROL FOR PLAN POSITION INDICATOR

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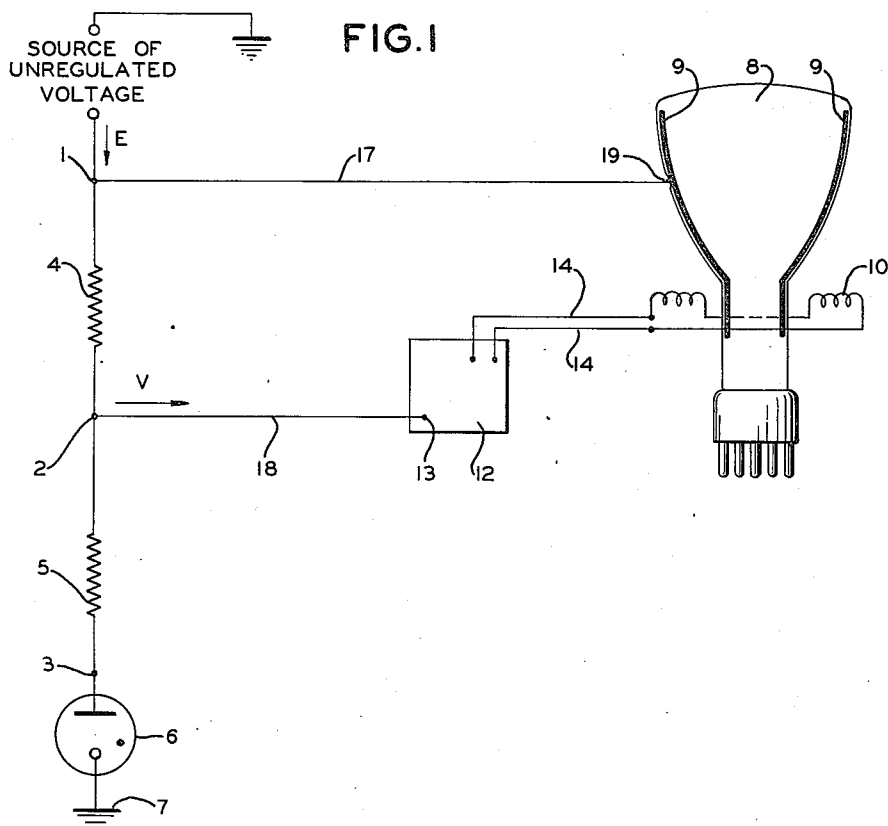
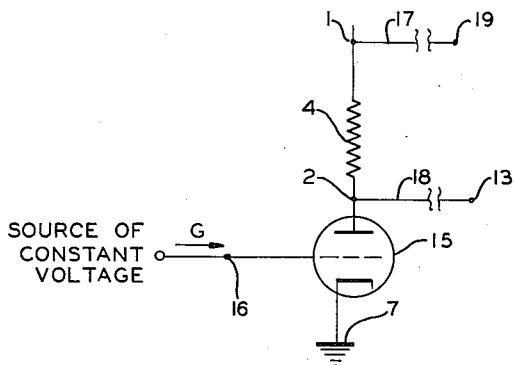


FIG.2



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CONTROL FOR PLAN POSITION INDICATOR

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10 Claims. (Cl. 315-19)

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This invention relates to cathode ray tubes, and more particularly to means for stabilizing the sweep of such a tube in the presence of line voltage fluctuations.

In a cathode ray tube that has electrostatic acceleration of the electron beam, and magnetic deflection of that beam to produce a sweep on the face of the tube, the deflection of the electron beam is directly proportional to the flux density of the deflecting magnetic field and inversely proportional to the square root of the voltage on the electron accelerating anode. The accelerating anode voltage is highly positive with respect to the cathode of the cathode ray tube, and is often furnished by an unregulated source. As a consequence, the accelerating anode voltage may fluctuate and introduce instability in the deflection of the cathode ray beam, or the sweep. Instability in the sweep renders the information presented by the cathode ray tube inaccurate and difficult to read or measure. In cases where such a cathode ray tube and circuit are used in radio object detecting or television equipment, the presentation is of reduced value. Such instability may be reduced greatly by introducing a compensating voltage of the proper magnitude into the magnetic deflection coils. As will be explained hereinbelow, this compensating voltage should be proportional to the square root of the accelerating anode voltage and should be arranged to control the magnetic deflecting field strength in a linear fashion. It will be proved hereinbelow that this relationship between the accelerating anode and compensating voltages will be had if the percentage variation of the compensating voltage is made to be substantially one-half the percentage variation of the accelerating anode voltage. It is accordingly, an object of our invention to provide a sweep stabilizing circuit for a cathode ray tube that will furnish two voltages that fluctuate in such a manner that one of the two voltages has a percentage variation which is always substantially equal to one-half the percentage variation of the other of the two voltages.

It is another object of our invention to provide such a circuit that will maintain the sweep of the cathode ray tube stable when the accelerating anode of the cathode ray tube is electrically connected to a source of unregulated voltage.

It is a further object of our invention to provide such a circuit that will maintain the flux density of the deflecting field of the cathode ray tube proportional to the square root of the electron accelerating voltage of that tube as the electron accelerating voltage fluctuates,

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It is a still further object of our invention to provide such a circuit that consists of a small number of parts, and is small, light, and simple and inexpensive to construct.

Other objects and features of our invention will become apparent upon a careful consideration of the following detailed description when taken together with the accompanying drawing, the figures of which, illustrate typical embodiments of the invention.

Fig. 1 illustrates one embodiment of our invention, and

Fig. 2 illustrates the differences in a second embodiment of our invention.

In a simplified discussion of magnetic deflection, the electron beam is assumed when being deflected to travel in the arc of a circle of radius r , given by the mathematical relation:

$$r = \frac{K\sqrt{E}}{H}$$

where:

K =a constant,

E =the electron accelerating voltage, and

H =the magnetic field strength or flux density of the deflection field.

The electron beam is constrained to follow a section of arc of this circle during the time the beam is in the deflecting magnetic field, and is thereby bent in its path, or deflected. The larger the radius, r , is, the smaller will be the amount of deflection of the electron beam, and conversely, the smaller the radius r is, the greater will be the amount of deflection of the electron beam.

Therefore, the amount of deflection is inversely proportional to the radius, r , and we can express the deflection by the equation:

$$d = K' \frac{H}{\sqrt{E}}$$

where:

d =the deflection of the electron beam, and

K' =another constant.

Variations in line voltage cause a proportional variation in the electron accelerating voltage, E . In order to prevent unstable deflection of the electron beam, or instability in the sweep, which is caused by variations in either quantity, r or d , it is necessary to cause the flux density of the deflecting field, H , to vary in proportion to the square root of the electron accelerating voltage, E . This is accomplished by causing the current I through the deflection coils to vary in the desired proportion. Since the current I varies in direct

proportion to the voltage V applied across the deflection coils, it is necessary to cause the voltage V to vary in direct proportion to the square root of the voltage E . If this is done, radius r will remain constant as voltage E fluctuates with line voltage variations, and the deflection, and hence the sweep will remain stable.

It is apparent, then, that the relation V is proportional to $\sqrt{E}$ is the condition required for stability of the cathode ray tube sweep. In the case where variations in the voltage E are small, the relation

$$\frac{\Delta V}{V} = \frac{1}{2} \frac{\Delta E}{E}$$

is approximately true, where:

ΔE = a small variation in the voltage E , and
 ΔV = a small variation in the voltage V .

This is a close approximation, established as follows:

If:

V is proportional to $\sqrt{E}$

then:

$V = k\sqrt{E}$, where k = a constant of proportionality

If we now have a small increase in the voltage E , there will also be a small increase in the voltage V and we will have: $V + \Delta V = k\sqrt{E + \Delta E}$. Squaring both sides of this equation, we have: $V^2 + 2V\Delta V + (\Delta V)^2 = k^2(E + \Delta E)$. Since ΔV is small, $(\Delta V)^2$ is insignificant, and can be omitted, leaving:

$$V^2 + 2V\Delta V = k^2(E + \Delta E)$$

Now square $V = k\sqrt{E}$, and have:

$$V^2 = k^2 E$$

from which we obtain:

$$k^2 = \frac{V^2}{E}$$

Perform the following subtraction:

$$\begin{array}{r} V^2 + 2V\Delta V = k^2 E + k^2 \Delta E \\ V^2 = k^2 E \\ \hline 2V\Delta V = k^2 \Delta E \end{array}$$

Yielding ----- $2V\Delta V = k^2 \Delta E$

it being good mathematical practice to subtract one equality from another, and have as a result another equality. Then substitute in this last equality the value of k^2 obtained above, and have:

$$2V\Delta V = \frac{V^2 \Delta E}{E}$$

or

$$\frac{V\Delta V}{V^2} = \frac{\Delta E}{2E}$$

or

$$\frac{\Delta V}{V} = \frac{1}{2} \frac{\Delta E}{E}$$

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It will be noted that the expression

$$\frac{\Delta V}{V}$$

is a percentage variation in the voltage V , and the expression

$$\frac{\Delta E}{E}$$

is likewise a percentage variation in the voltage E . It is established then that if we are to have the voltage V vary in proportion to the square root of the voltage E , we must cause the per-

centage variation of the voltage V to be very close to one-half the percentage variation of the voltage E .

In Fig. 1, a resistor 4 is connected at point 1 to a source of unregulated D. C. voltage E , which voltage may also be applied at a connector 19 to the accelerating anode 9 of a cathode ray tube 8 by means of a suitable wire 17. When so connected to anode 9, voltage E controls the potential on anode 9 linearly. Resistor 4 is further connected at point 2 to a second resistor 5 and to a wire 18. Resistor 5 is connected at point 3 to the anode of a gaseous voltage regulator tube 6. The cathode of tube 6 is connected to electrical ground at 7. Resistors 4 and 5, and tube 6 may be said to form a voltage divider network between the accelerating anode voltage E and ground 7. Voltage E may be positive, and have its negative side grounded, as shown. In such a case, the voltage divider network made up of resistors 4 and 5, and tube 6 may be said to be connected across the source of voltage E . Resistor 5 and tube 6 together may be said to constitute a non-linear resistance element. Electromagnetic deflection coils 10 are driven by a sweep voltage generator 12 through wires 14. A voltage V taken from the voltage divider at 2 is furnished to sweep generator 12 at a connection point 13 through wire 18, and is so connected to generator 12, in a known fashion but not shown, as to exert linear control over the current that flows in coils 10.

The operation of the embodiment of our invention illustrated in Fig. 1 will now be explained. Voltages E and V on Fig. 1 are the voltages E and V mentioned in the theoretical discussion hereinabove. Since voltage E is furnished by an unregulated source, this voltage will fluctuate as the line voltage fluctuates. In the simple case where voltage E is equal to voltage V , each having, let us say a value of 300 volts, resistors 4 and 5 should have equal values, preferably of the order of one megohm each. The voltages at point 1 and point 2 will then be initially 300 volts each. The voltage at point 3 will be of a constant value, and tube 6 is preferably so chosen that this voltage is also 300 volts. If the voltage E be now increased to 305 volts, the voltage V will increase to 302.5 volts. The reason for this is that the voltage at point 3 remains constant, and, resistors 4 and 5 having equal values, the difference of 5 volts between points 1 and 3 is evenly divided between them so that there is a difference of 2.5 volts between points 2 and 3.

The percentage variation of the voltage E is then

$$\frac{5}{300} \times 100 = 1.67\%$$

and the percentage variation of voltage V is

$$\frac{2.5}{300} \times 100 = 0.83\%$$

From this we see that the percentage variation of voltage V is one-half the percentage variation of voltage E . As hereinabove stated, voltage V is applied to the sweep generator 12 in such a manner that the current in coils 10 varies linearly with voltage V . In turn the field strength of the magnetic field generated by coils 10 varies linearly with the current in coils 10, and therefore with voltage V . Thus, the flux density of the deflecting field varies in such a manner that the percentage variation of flux density of the deflecting field is one-half the percentage varia-

tion of the accelerating anode voltage E, and the flux density of the deflecting field will vary in proportion to the square root of the electron accelerating voltage. Deflection of the electron beam, and hence the sweep of the cathode ray tube, is thus maintained stable during fluctuations of the accelerative anode voltage.

The voltages at points 1, 2, and 3 need not have initially equal value, nor must resistors 4 and 5 have equal values. If the ratio of the values of resistors 4 and 5 be so chosen that the value of resistor 4 divided by the value of resistor 5 is substantially equal to the ratio found by dividing the initial value of voltage E by the value of the voltage at point 3, the percentage variation of voltage V will be substantially equal to one-half the percentage variation of the voltage E, for small variations in the line voltage. Since the voltage at point 3 may be any convenient value, and will always be constant, the ratio of resistor 4 to resistor 5 will determine the value of voltage V, and also the fraction of the variation of voltage E that will appear as a variation of voltage V.

In Fig. 2 there is illustrated an embodiment of our invention having a triode electron tube 15 in place of resistor 5 and tube 6 of the embodiment shown in Fig. 1. The grid of tube 15 is electrically connected at point 16 to a source of constant voltage G, which may have a value of minus 9 volts or another voltage in the region where the grid controls the current in tube 15. This is a voltage that is easily obtainable, as from a small battery. Resistor 4 is a plate resistor in this circuit. The plate circuit resistance of tube 15 as computed by the formula

$$R = \frac{\text{Plate voltage}}{\text{Plate current}}$$

is analogous in the circuit of Fig. 2 to resistor 5 and tube 6 together in Fig. 1. By proper adjustment of the voltage G, it is possible to adjust the relative values of resistor 4 and the plate circuit resistance of tube 15 so that as voltage E fluctuates, the percentage variation of voltage V will be one-half the percentage variation of voltage E. It should be noted that undesirable effects of using a large unregulated voltage E may be eliminated with this circuit by providing a source of small constant voltage G. The circuit of Fig. 2 is connected to a cathode ray tube and sweep voltage generator at points 19 and 13 in like fashion to the circuit of Fig. 1.

We have shown two circuits with which the deflection of the electron beam, and hence the sweep, of a cathode ray tube may be maintained stable when a source of unregulated voltage is used to provide an accelerating anode potential. Although we have shown and described only these two specific embodiments of our invention, we are fully aware of the many modifications possible thereof. We are further aware that, by virtue of the scientific and mathematical discussion hereinabove set forth, our invention may be used with any arrangement of electromagnetic devices which control the beam of an electrostatically accelerated cathode ray tube, when such a device acts in combination with an electrostatic accelerating element to control the motion of electrons. Therefore this invention is not to be limited except insofar as is necessitated by the prior art and the spirit of the appended claims.

We claim:

1. An electrical circuit comprising in combination a linear and non-linear resistor connected together at a common point and adapted to be

connected at the free ends thereof across a source of voltage, a cathode ray tube having an electron accelerating anode and magnetic electron beam deflecting coils, and means for producing a sweep current in said coils, said anode being connected to said source, and said coils being so connected through said means to said common point that said current responds linearly to variations in the voltage at said point, said resistors being so proportioned that when the voltage of said source varies the percentage variation of said voltage at said point is substantially half the percentage variation of said source voltage.

2. In an electrical circuit, a cathode ray tube having an electron accelerating anode and a magnetic electron beam deflecting coil, a generator providing a sweep voltage to said coil, a source of voltage connected to said anode and controlling the potential thereof linearly, a first resistor connecting said source to said generator, a voltage regulator tube having an anode and a cathode effectively connected at its cathode to the negative side of said source, and a second resistor connected from the generator end of said first resistor to the anode of said voltage regulator tube, said coil being so connected through said generator to the junction point of said resistors that the current in said coil responds linearly to variations in the voltage at said point, said voltage regulator tube being adapted when conducting current to maintain the voltage at its anode constant in value, and said resistors being so proportioned that as the voltage of said source varies the percentage variation of said voltage at said point is substantially half the percentage variation of said source voltage, whereby the deflection of the electron beam of said cathode ray tube is stabilized.

3. In an electrical circuit, a cathode ray tube having an electron accelerating anode and a magnetic electron beam deflecting coil, a generator providing a sweep voltage to said coil, a source of voltage connected to said anode and controlling the potential thereof linearly, a resistor connecting said source to said generator, an electron tube having an anode, a cathode, and a grid connected at its anode to the generator end of said resistor and effectively connected at its cathode to the negative side of said source, a source of constant voltage connected to said grid of said electron tube, said coil being so connected through said generator to the junction point of said resistor and electron tube anode that the current in said coil responds linearly to variations in the voltage at said point, said constant voltages and said resistor being of such magnitudes that as the voltage of said source varies the percentage variation of said voltage at said point is substantially half the percentage variation of said source voltage, whereby the deflection of the electron beam of said cathode ray tube is stabilized.

4. An electrical circuit comprising, in combination, a resistor and an electron tube having a grid, a plate, and a cathode, the plate of said tube and one end of said resistor being connected together at a common point, the cathode of said tube and the free end of said resistor being adapted to be connected across a first source of voltage, a second source of constant voltage connected to the grid of said tube, a cathode ray tube having an anode and beam deflecting coils, and means for producing a sweep current in said coils, said anode being connected to said source, and said coils being so connected through said means to said common point that said current responds

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linearly to variations in the voltage at said point, the magnitude of said resistor with respect to said constant voltage being such that when the voltage of said first source varies the percentage variation of the voltage at said point is substantially half the percentage variation of said voltage of said source, whereby the deflection of the beam of said cathode ray tube is stabilized.

5. An electrical circuit comprising, in combination, two resistors connected together at a common point and a voltage regulating electron tube having an anode and a cathode connected at its anode to the free end of one of said resistors, the cathode of said tube and the free end of the other of said resistor being adapted to be connected across a source of voltage, said tube being adapted when current flows in said circuit to provide a constant voltage at said anode, a cathode ray tube having an accelerating anode and beam deflecting coils, and means for producing a sweep current in said coils, said accelerating anode being connected to said source, and said coils being so connected through said means to said common point that said current responds linearly to variations in the voltage at said point, said resistors being so proportioned that when the voltage of said source varies the percentage variation of the voltage at said point is substantially half the percentage variation of the voltage of said source.

6. An electrical circuit comprising, in combination, a voltage dividing means adapted to be connected across a source of voltage, a cathode ray tube having an accelerating anode and electron beam deflecting coils, and means for producing a sweep current in said coils, said accelerating anode being connected to said source, and said coils being so connected to a point on said voltage divider that said current responds linearly to variations in the voltage at said point, said point being so located on said voltage divider that when the voltage of said source varies the percentage variation of the voltage at said point is substantially half the percentage variation of said source voltage, whereby the deflection of the electron beam of said cathode ray tube is stabilized.

7. An electrical circuit comprising, in combination, a voltage dividing means adapted to be connected across a source of voltage, and a cathode

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ray tube having an accelerating anode and beam deflecting coils, said accelerating anode being connected to said source and said coils being connected to a point on said voltage divider such that when the voltage of said source varies the percentage variation of the voltage at said point is substantially one-half the percentage variation of said source voltage.

8. In combination with a cathode ray tube having an accelerating anode and beam deflecting coils, a source of voltage, said accelerating anode being connected to said source, and voltage divider means connected across said voltage source, said deflecting coils being connected to a point on said voltage dividing means which has a percentage voltage variation which is substantially one-half the percentage voltage variation of said source, whereby the deflection of the electron beam of said cathode ray tube is stabilized.

9. In combination with a cathode ray tube having an accelerating anode and beam deflecting coils, voltage dividing means connected across a source of voltage, said anode and said deflecting coils being respectively connected to said source and a point on said voltage divider, the percentage voltage variation at said point being substantially equal to one-half the percentage voltage variation of said source.

10. In combination with a cathode ray tube having an accelerating anode and beam deflecting coils, a source of voltage, and means connected across said source of voltage and coupled to said anode and said deflecting coils for maintaining the flux density of the deflecting field produced by current in said deflecting coils proportional to the square root of said voltage as said voltage fluctuates.

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