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[54] **CIRCUIT ARRANGEMENT FOR GENERATING A BEAM CURRENT IN A CATHODE-RAY TUBE**

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[52] **U.S. Cl.** **315/30**

[51] **Int. Cl.** **H01j 29/00**

[58] **Field of Search** 315/30, 31, 22, 20, 28, 315/29, 18, 19

[56] **References Cited**

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[57] **ABSTRACT**

A circuit arrangement in a cathode-ray tube for producing a cathode-ray beam current which is proportional to the deflection speed of the beam. The cathode-ray tube includes a cathode and a control grid along with circuitry for providing an intensity control voltage which is proportional to the deflection speed of a spot traveling across the face of the cathode-ray tube. A regulating circuit regulates the beam current such that the difference between a voltage proportional to the beam current and the intensity control voltage remains substantially at zero.

9 Claims, 3 Drawing Figures

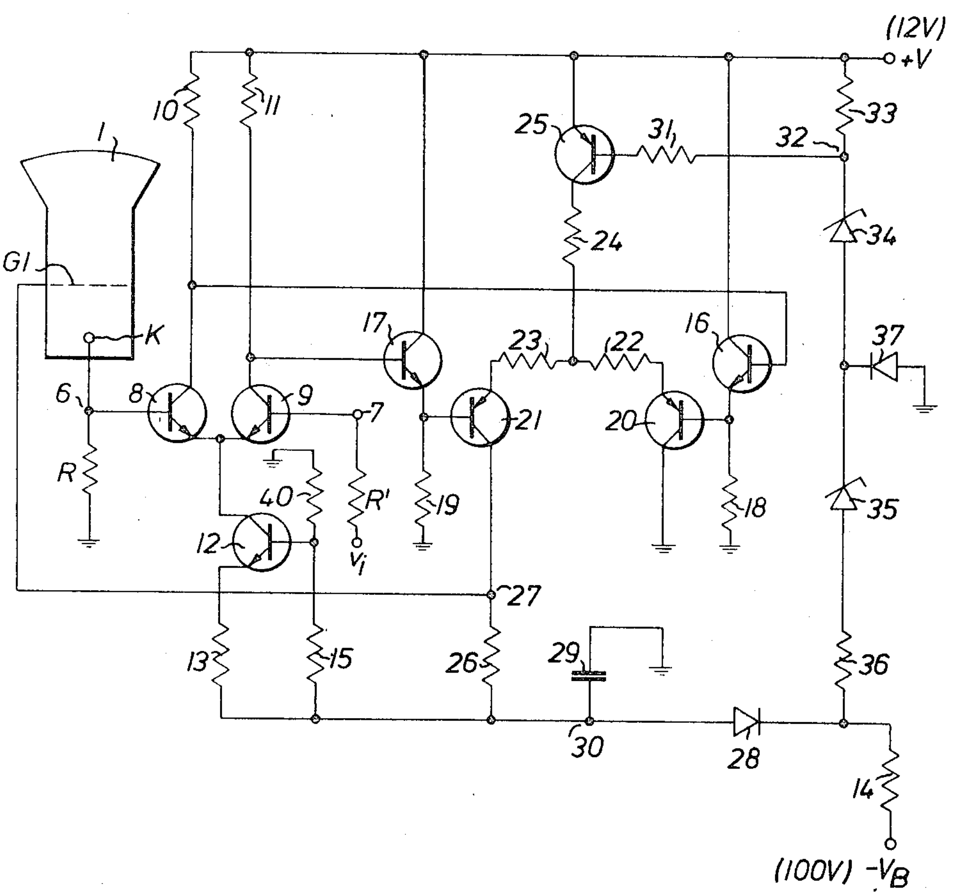


FIG. 1

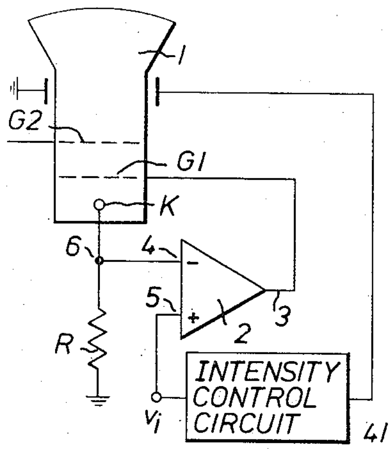


FIG. 2

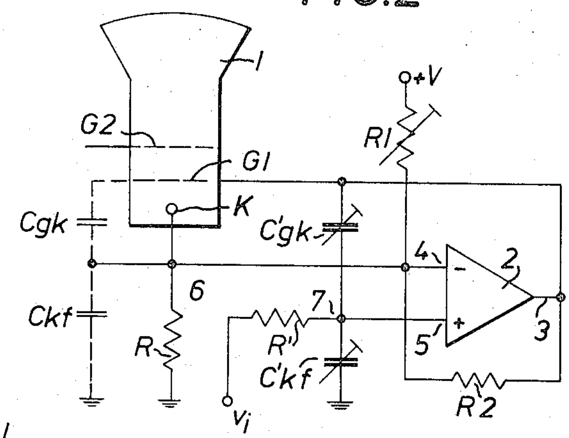
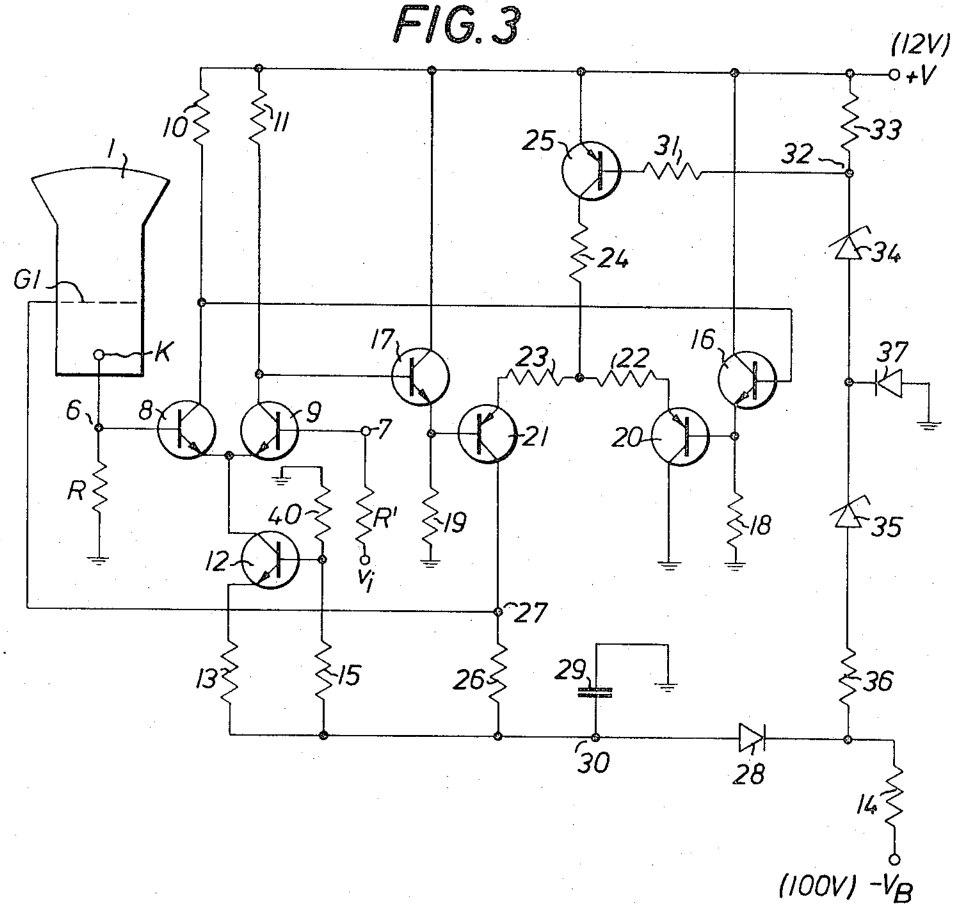


FIG. 3



CIRCUIT ARRANGEMENT FOR GENERATING A BEAM CURRENT IN A CATHODE-RAY TUBE

BACKGROUND OF THE INVENTION

The present invention relates to a circuit arrangement for a character writing cathode-ray picture tube for generating a beam current which is proportional to the deflection speed.

It is known to provide the control signals for the electron beam of a character writing picture tube in a form representing the coordinates of the starting and ending point of straight lines which are to be written — i.e., vectors — at uniform pulsed time intervals. The point of impingement of the beam, therefore, must traverse these lines at a speed which is proportional to the respective vector length. In order to have vectors of different lengths appear with the same brightness on the screen of the cathode-ray tube, the beam intensity must be controlled in such a manner that it is also proportional to both the deflection speed and the vector length. It is also known to derive the intensity control voltage from the current fluctuations in the deflector coils.

An intensity control voltage, which is approximately proportional to the vector lengths, however, cannot be directly utilized. Since the input characteristic of the picture tube follows approximately the $V^{3/2}$ law, the intensity control voltage, therefore, would not vary linearly with the beam current. The input characteristic means the relation between the intensity control voltage and the beam current.

The intensity control voltage can be so predistorted that the relationship between the beam current and the intensity control signal will be as linear as possible in connection with the nonlinear characteristic of the picture tube. The brightness therefore, will largely depend on the voltage at the preacceleration grid. With the use of such an arrangement, the wide spread between the units of the picture tube system requires that the predistortion characteristic be individually set, which is associated with much matching work. This predistortion characteristic of the picture tube can be only approximately obtained if expenditures are to be maintained within a reasonable range. This intensity control voltage shifts with variations in the preacceleration voltage and also changes its curvature in response to such variations. In such known arrangements, an operating point instability of the video amplifiers as well as a slight drift of the preacceleration voltage will lead to a mutual shift of the equalizing characteristic with respect to the tube characteristic and thus to a nonuniform brightness over the intensity control range of the tube.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a circuit arrangement for regulating the beam current of a cathode-ray tube so as to avoid the above-mentioned drawbacks.

In accordance with the present invention, a circuit arrangement of the above-mentioned type is provided with a regulating circuit which regulates the beam current such that the difference between a voltage obtained from a beam current measuring resistor and an intensity control voltage, which is proportional to the deflection speed, is kept at zero.

The circuit arrangement of the present invention includes a differential amplifier which provides an output connected to the intensity control grid of the picture tube for varying the voltage on the control grid so as to regulate the beam current. This differential amplifier has two inputs, the first of which receives the voltage obtained from the measuring resistor through which the cathode current of the tube flows and the second of which receives the intensity control voltage.

In an advantageous modified embodiment of the present invention, the intensity control voltage is applied to the associated input of the differential amplifier via a resistor whose resistance is equal to that of the beam current measuring resistor. Both of these resistors have a voltage across them with respect to the same reference potential which preferably is ground. Furthermore, it is also advantageous to utilize variable capacitances which are connected to the second input of the differential amplifier, which is controlled by the intensity control voltage, so that the stray capacitances formed by components of the cathode-ray tube which become effective at the first input of the differential amplifier can be effectively matched.

In a further embodiment, the stray capacitances as well as the measuring resistor on the one hand and the variable capacitances as well as the resistor reproducing the measuring resistor on the other hand are respectively disposed in parallel branches of a bridge circuit in whose bridge lie the inputs of the differential amplifier.

Furthermore, in accordance with the present invention, the intensity control grid is connected in a direct current connection with the output of the differential amplifier. This output of the differential amplifier is connected with a negative operating voltage. Additionally, a first differential amplification stage of the differential amplifier as well as an end stage which is connected to the output, are connected both to the negative operating voltage source and also to a positive operating voltage source.

It is also desirable for a protective switch to be connected in the end stage of the differential amplifier, which switch interrupts the current flowing towards the output when either one or both of the operating voltages are reduced. In addition, a capacitor can be connected with the intensity control grid and charged to the potential of the negative operating voltage source by such source so that it at least initially maintains the potential in the circuit if the voltage of the operating voltage source is reduced.

In a further modified embodiment, an additional substitute circuit can be provided for applying a blocking voltage to the intensity control grid for effecting the dark control, i.e. blocking out, of the electron beam.

The intensity control voltage is preferably generated by the above-mentioned known technique according to which the intensity control voltage is derived from the current fluctuations in the deflector coils.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block circuit diagram of a basic embodiment of the present invention.

FIG. 2 is a circuit diagram of the circuit of FIG. 1 with the inclusion of a bridge circuit and a blocking circuit.

FIG. 3 is a circuit diagram similar to that of FIG. 2 showing the details of the differential amplifier and the inclusion of a protective switching circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 there is illustrated a character writing cathode-ray picture tube 1 in which only the cathode K, the intensity control grid G1 and the preacceleration grid G2 following thereafter are shown. The cathode K is connected to ground via a resistor R. A differential amplifier, or operational amplifier, 2 is provided whose output 3 is connected with the intensity control grid G1. The negative input 4 of the differential amplifier 2 is connected to the cathode end of resistor R at the junction point 6. The other input 5 of the differential amplifier is provided with the intensity control voltage v_i with reference to ground, by an intensity control circuit 41. The intensity control circuit 41 is shown as being coupled to the deflection coil, which coils are illustrated by a general representation. This intensity control voltage is proportional to the respective writing, or beam deflection, speed. In this circuit arrangement, the picture tube has been connected as a cathode follower and the beam current is regulated such that the voltage drop produced by the beam current at the resistor R serving as the measuring resistor is made equal to the intensity control voltage. This equalization of the voltages is accomplished in that the amplified difference voltages produced at the output 3 of the differential amplifier act on the intensity control grid G1 so as to maintain the equality of the two input voltages of the differential amplifier. The accuracy of this control depends only on the ring amplification of the control circuit. Consequently, the desired accurate linearity between the intensity control voltage and the beam luminance is provided and the shape of the tube characteristic no longer has any influence on the brightness.

As shown in FIG. 2, the intensity control grid G1 has a capacitance *Cgk* with respect to the cathode K, and the cathode K has a capacitance *Ckf* with respect to the heating filament (not shown) which is connected to ground. A change in voltage at the intensity control grid G1 produces, via these stray capacitances, in the measuring resistor R, a dynamic voltage component which is determined by changes in the charge of the capacitances *Cgk* and *Ckf* and the measuring resistor R. The differential amplifier 2 cannot distinguish this component of the total current through measuring resistor R from the pure beam current.

A suppression of the above-mentioned dynamic voltage components is accomplished by connecting the input 5 of the differential amplifier 2 with the same RC combination as input 4, i.e. the matchable capacitances as shown in FIG. 2. In this circuit arrangement the following circuit elements are connected to the input 5 of the differential amplifier 2 via junction point 7: a resistor R′ to whose other end the intensity control voltage v_i is fed with respect to ground and which has the same dimensions as resistor R, a variable capacitance *C′gk* whose other end is connected with the intensity control grid G1 and finally a variable capacitance *C′kf* whose other end is connected to ground.

The capacitance *Cgk* of the tube lies between the cathode K and the intensity control grid G1 and the capacitance *Ckf* lies between cathode K and ground. A bridge circuit is thereby constructed which has two parallel branches connected between the intensity control grid G1 and ground; the first branch contains, between junction point 6 and G1, the capacitance *Cgk* and between junction point 6 and ground the capacitance *Ckf* in parallel with the resistor R and the second branch contains, between junction point 7 and G1, the variable capacitance *C′gk* and between junction point 7 and ground the variable capacitance *C′kf* in parallel with the resistor R′. The inputs 4, 5 of the differential amplifier 2 are connected in the bridge between the junction points 6 and 7. With sufficient common mode rejection and a sufficiently large common mode range of the differential amplifier 2, the beam current alone can now produce a signal at the output 3 of the amplifier with the dynamic noise signal being highly suppressed as an common mode signal.

It is very easy to reproduce the RC combination at the cathode at the second input of the amplifier since the steepness of the picture tube is negligible for all possible operating points of the picture tube with respect to the measuring resistor R due to the connection of the tube as a cathode follower. Since the cathode heating filament capacitance Ckf varies with heating of the cathode, the capacitive matching must be effected with a hot tube.

FIG. 3 show details of the differential amplifier of FIG. 2 and a switching circuit connected to the differential amplifier for protecting the screen of the picture tube 1.

In the circuit shown in FIG. 3, the differential amplifier includes a first differential amplifier stage formed by two npn transistors 8 and 9 whose collector is connected to a positive operating voltage +V of, for example, 12 V via a resistor 10 or 11, respectively. The connected emitters of these two transistors are connected to a negative operating voltage source V_B of, for example, 100 V via the collector-emitter path of an npn transistor 12 and a resistor 13 as well as a bias resistor 14. The base of the transistor 8 is connected to the measuring resistor R at the junction point 6 and the base of the transistor 9 to the resistor R′ at the junction 7. The base of the transistor 12, which forms a current stage for the current through the transistors 8, 9, is connected between resistors 40 and 15 of a voltage divider which is disposed between the negative operating voltage V_B and ground. With a large voltage drop at the emitter resistor 13 of the current stage transistor 12, the first differential amplifier stage obtains a very good stability for the operating point.

The collector of the transistor 8 is connected with the base of an npn transistor 16 which operates as an emitter follower and constitutes a separating stage, the collector of the transistor 9 is correspondingly connected with an npn transistor 17. The emitter of transistor 16 and the emitter of transistor 17 are connected to ground, each via a resistor 18 or 19, respectively; the positive operating voltage +V is applied to the collectors of the transistors 16 and 17. The emitter of the transistor 16 is connected with the base of a pnp transistor 20 and the emitter of transistor 17 with the base of a pnp transistor 21. The emitters of the transistors 20 and 21 are connected, each via a resistor 22 or 23, respectively, as well as a common resistor 24 and a pnp transistor 25 operating as a switch, with the operating voltage +V. The collector of the transistor 20 is connected to ground, the collector of the transistor 21, however, from which the output signal of the differential amplifier is obtained is connected with the strongly negative operating voltage $-V_B$ via a collector resistor **26.** Furthermore, the collector of the transistor **21** is connected, via a connecting point **27** with the intensity control grid G1 with respect to the direct current. Thus the intensity control grid G1 receives a sufficiently negative voltage to control it in the desired permissible range with respect to the beam current intensity.

A diode **28** whose cathode is connected with $-V_B$ is connected between the resistor **26** and the bias resistor **14.** A capacitor **29** has one end connected to ground and its other end to a junction point **30** between the resistor **26** and the anode of the diode **28.** The diode **28** operates in the forward direction when an operating voltage $-V_B$ is present, the capacitor **29** is then charged to this operating voltage. If, however, the operating voltage $-V_B$ drops because it is switched off or because there is a malfunction, diode **28** becomes blocking and the negative operating voltage at the collector resistor **26** is maintained for some time by the charged capacitor **29** at least until the cathode K of the picture tube **1** has sufficiently cooled. In this way it is prevented that a reduction in the negative voltage at the intensity control grid G1 temporarily produces too strong a beam current.

When the operating voltage $-V_B$ or the operating voltage +V or both of them drop due to a malfunction or because they are switched off, the transistor **25** and, consequently, the current through the end stage of the differential amplifier are blocked. For this purpose the base of the transistor **25** is connected, via a resistor **31** at point **32,** with a shunt path lying between the operating voltages +V and $-V_B$. This shunt path includes in a series connection a resistor **33,** a first Zener diode **34,** a second Zener diode **35** and a resistor **36.** Between the Zener diodes **34** and **35** the cathode of a diode **37** is connected whose anode is connected to ground. The connection point **32** lies between the resistor **33** and the first Zener diode **34.** The Zener voltage of the Zener diode **34** is approximately 11 V, the Zener voltage of the Zener diode **35** is approximately 90 V. If the voltage +V is reduced by a certain amount, for example approximately 10 percent, the current supply from Zener diode **34** is blocked because its Zener voltage has dropped below its threshold, so that the base of the transistor **25** no longer receives current and the transistor opens. The diode **37** becomes conductive from the current from the diode **35.** If the amount of the voltage $-V_B$ is reduced, for example also by about 10 percent, no current will any longer flow through both of the Zener diodes **34** and **35** because the total voltage of both Zener voltages from **34** and **35** is less than the sum of the voltages V and $-V_B$. In this case, the transistor **25** also opens due to a lack of a current. The same occurs if the amounts of each of the voltages +V and $-V_B$ become too low.

The cathode-ray beam of the picture tube **1** must sometimes be dark-keyed, for example when changing from one written character to another separate new character which is to be written. In order to assure this blockage of the beam, a voltage of at least −70 V must be applied to the intensity control grid G1. The differential amplifier would reach a saturation state with respect to its operating point if the beam current were completely switched off as a result of a severing of the control circuit, from which saturation state it could be returned into the active range only with a considerable delay. A substituted circuit is thus provided for this blocking purpose which circuit is shown in FIG. **2.** The blocking circuit includes a controllable resistor R1 connected between the operating voltage +V and the amplifier input **4** and a resistor R2 connected between the amplifier input **4** and the amplifier output **3.** The thus formed voltage divider closes the resulting circuit as a substituate circuit even when the picture tube system is switched off and the intensity control voltage is zero.

The circuit maintains an operating point which, since it can be set by use of the variable resistance R1, furnishes the necessary blocking voltage of −70 V for the intensity control grid G1. Since when the intensity control voltage v_i is applied, resistances R1, R2 are negligible as compared to the measuring resistance R and the comparably greater internal resistance $Ri = 1/S$ (S = steepness of the picture tube) which effectively exists at the cathode, the operation of the resulting circuit is not changed by the presence of the substitute circuit with R1 and R2.

The intensity control voltage v_i is preferably derived from the current fluctuations in the deflector coil in the manner disclosed in German Pat. No. 1,916,851.

In this case in particular, the described regulating circuit must provide an extremely fast operation, i.e., with a very slight delay with respect to the changes in the intensity control voltage. This can be accomplished with the above-described configuration of the regulating circuit, particularly by using transistors in the differential amplifier having a high frequency limit.

The described simple way of effecting capacitance compensation of the dynamic portion of the beam current requires no further frequency reducing RC members to correct the frequency response in the regulating circuit in order to assure stability of the regulating circuit. This capacitive compensation is furthermore not influenced with respect to ground by the capacitances of a measuring scanning head at the intensity control grid when the bridge of FIG. 2 is being tuned.

In this circuit arrangement, a switch between characters composed of very short vectors and substantially longer vectors is not necessary. Vectors which extend over the entire diagonal length of the screen can be written with uniform brightness. Additionally in this circuit the brightness is independent of the preacceleration voltage at the grid G2 and the individual $V^{3/2}$ characteristic of the picture tube no longer has any influence on the brightness.

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 character writing cathode-ray picture tube having a cathode constituting a cathode-ray electron beam source, an intensity control grid within the tube for controlling the magnitude of the electron beam current, and an intensity control means for providing an intensity control voltage which is proportional to the deflection speed of a spot traveling across the face of the cathode-ray tube, the improvement comprising blocking means coupled to said control grid for providing a signal to block out the electron beam and a circuit arrangement for causing the magnitude of the beam current to be proportional to the deflection speed, said circuit including: a measuring resistor connected to said cathode for receiving a current proportional to the beam current; regulating means including a differential amplifier having a first input connected to receive the voltage across said measuring resistor, a second input connected to the output of said intensity control means, and an output directly conductively connected to said control grid for regulating the beam current such that the difference between the voltage across said measuring resistor and the intensity control voltage remains substantially at zero.

2. A circuit arrangement as defined in claim **1,** further comprising a connecting resistor having a resistance value equal to that of said measuring resistor and connected between said second input of said regulating means and the output of said intensity control means such that the intensity control voltage is connected to said regulating means via said connecting resistor wherein said measuring resistor and said connecting resistor both have a voltage across them with respect to the same reference potential.

3. A circuit arrangement as defined in claim **2** wherein the reference potential is ground.

4. A circuit arrangement as defined in claim **2** wherein said control grid exhibits a stray grid capacitance and said cathode exhibits a stray cathode capacitance, both of which capacitances are effectively connected to said first input of said regulating means, said arrangement further comprising: first and second variable capacitors connected to said second input of said regulating means for matching the stray grid and cathode capacitances.

5. A circuit arrangement as defined in claim **4** wherein said measuring resistor and said cathode are connected such that said stray capacitances and said measuring resistor form a first branch, said variable capacitors and said connecting resistor are connected to form a second branch, and said first and second branches are disposed so as to form parallel branches of a bridge circuit having two output terminals forming said first and second inputs of said regulating means.

6. A circuit arrangement as defined in claim **5,** further comprising a negative voltage source and a positive voltage source; wherein said differential amplifier has an initial stage and an end stage, each said stage has first and second terminals, said first terminals of said stages are connected to said negative voltage source and said second terminals are connected to said positive voltage source.

7. A circuit arrangement as defined in claim **6** wherein said end stage includes a protective switch means for interrupting the current flowing within said differential amplifier towards said output of said differential amplifier when at least one of the voltages from said voltage sources is reduced.

8. A circuit arrangement as defined in claim **6,** further comprising a maintaining capacitor connected within said differential amplifier so as to be charged by said negative voltage source and having an output coupled to said control grid so as to temporarily supply a negative potential upon the occurrence of a reduction in the voltage of said negative voltage source.

9. A circuit arrangement as defined in claim **1** wherein the cathode ray tube includes deflection coils and the intensity control means derives the intensity control voltage in dependence upon current fluctuations in the deflection coils.

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