

Aug. 18, 1964

K. SADASHIGE

3,145,321

BEAM CURRENT STABILIZATION IN A CATHODE RAY TUBE

Filed Jan. 16, 1961

Fig. 1.

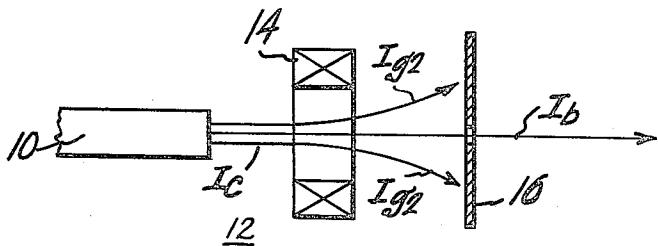


Fig. 2

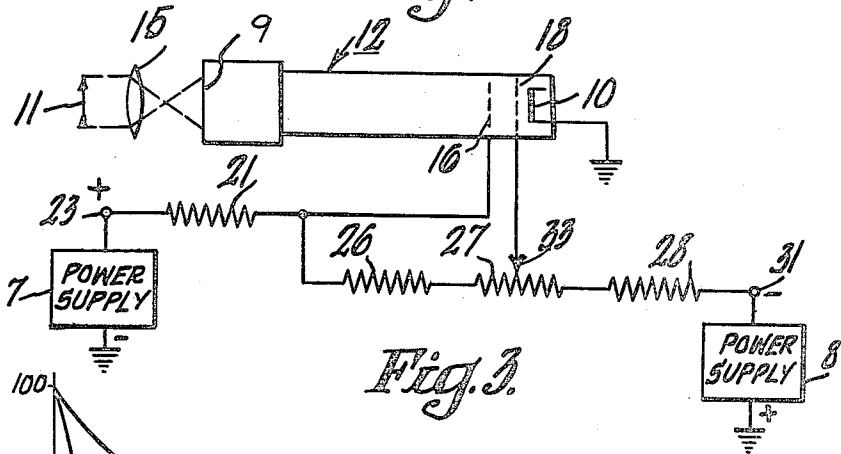
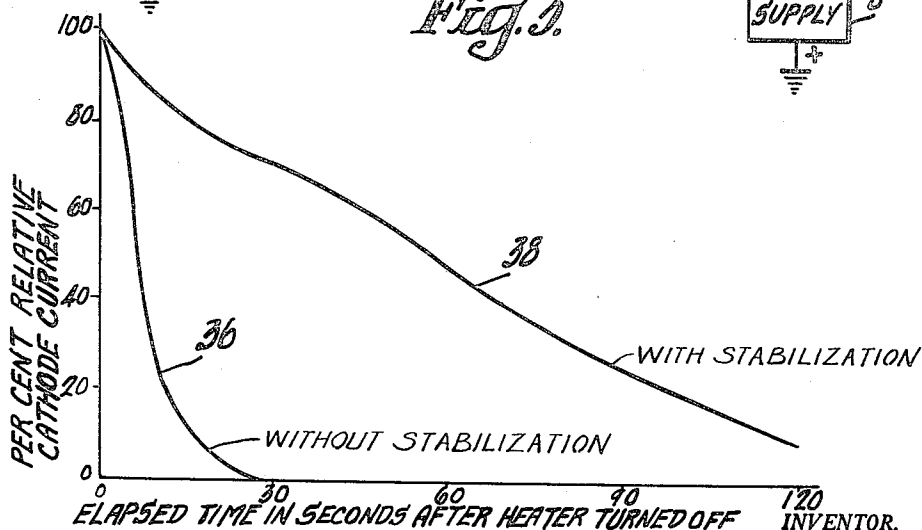


Fig. 3



INVENTOR.
Koichi Sadashige
BY
George T. Craig
ATTORNEY

1

3,145,321

BEAM CURRENT STABILIZATION IN A CATHODE RAY TUBE

Koichi Sadashige, Collingswood, N.J., assignor to Radio Corporation of America, a corporation of Delaware
Filed Jan. 16, 1961, Ser. No. 82,834
3 Claims. (Cl. 315-30)

The present invention relates to cathode ray tubes in which an electron beam is produced, and more particularly to a novel apparatus arrangement for stabilizing the beam current of the electron beam to obtain and maintain optimum signal-to-noise ratio in a tube of one type, and least geometric distortion and best resolution in a tube of another tube in spite of environment changes and variation in supply voltages, during any time period.

Cathode current of an electron beam pick-up tube in a television camera, for example, without stabilization fluctuates considerably as the environmental conditions change. During the first fifteen minutes of operation of the tube, the value of cathode current changes by an amount which is in the ratio of 3 to 1. The cathode current then settles to a variation of $\pm 10\%$ with a fixed voltage applied to the heater for the cathode and with a fixed bulb temperature. The random fluctuation of $\pm 10\%$ is continuous after about twenty minutes of operation. This is an undesirable condition.

In accordance with the present invention, the beam current of a cathode ray tube is stabilized in a relatively short time by stabilizing its cathode current in a novel manner. Not only is stabilization achieved by the present invention, but, as just stated, it is accomplished in a relatively short time. For example, when teachings of the present invention are applied in a manner to improve operation of a pick-up tube of the type known as an image orthicon, it is possible to cause the cathode current of the tube to reach 90% of its final value within one minute of the time the tube is placed in operation. Stabilization to the final desired value occurs within two minutes after the tube is placed in operation, and is maintained in spite of the usually expected variations in the change of bulb temperature of the pick-up tube and heater voltage fluctuations.

In practicing the invention, a feedback path is employed having a loop gain provided by the inherent transconductance (G_m) between two electrode elements of the pick-up tube. Variation of the cathode current is sampled by utilizing the voltage drop across a resistor in the circuit of one of the electrode elements of the tube and this variation is then fed back to the circuit connected to another electrode element of the tube in a direction to compensate for the original cathode current variation. The invention is particularly applicable for use with an image orthicon or a vidicon pick-up tube. Features of the image orthicon tube are shown in Patent No. 2,433,941, granted to Paul K. Weimer on January 6, 1948, and, also, Patent No. 2,537,250, granted to Paul K. Weimer on June 9, 1951. Features of the vidicon tube are shown in Patent No. 2,951,962, granted to Louis D. Miller et al. on September 6, 1960.

The primary object of the present invention is to provide a novel apparatus arrangement for stabilizing the beam current of the electron beam in a cathode ray tube.

Another object of the present invention is to provide stabilization of the beam current of the electron beam in a cathode ray tube by stabilizing the cathode current of the tube in a novel manner.

A further object of the present invention is to provide novel means which employ the internal electrode elements of a cathode ray tube in a novel manner to provide for controlling the total emission of electrons from the source of electrons in the tube.

2

Still another object of the present invention is to provide a novel means for stabilizing the beam current in a cathode ray tube by employing a feed back path having a loop gain provided by the transductance between two electrode elements of the cathode ray tube.

A still further object of the present invention is to provide novel means for stabilizing the beam current in a cathode ray tube without recourse to means which depend upon secondary emission of the tube elements, separate and expensive power supplies, or reliance upon a high resistance cathode circuit for the tube.

Other objects and advantages of the present invention will become apparent and immediately suggest themselves to those skilled in the art to which the invention is directed from a reading of the following specification in connection with the accompanying drawing in which:

FIG. 1 of the drawing is a schematic showing of two space current paths in a cathode ray tube which are of significance in practicing the present invention;

FIG. 2 of the drawing is a schematic diagram of circuitry arranged in conjunction with certain elements of a cathode ray tube for practicing the present invention; and

FIG. 3 of the drawing is a graph illustrating the effectiveness of the control function exercised by a circuit arrangement employing the present invention.

FIG. 1 of the drawing shows, schematically, the cathode 10 of a cathode ray tube 12 which is shown diagrammatically and in outline form in FIG. 2 of the drawing. The present invention, as stated above, is particularly applicable to pick-up tubes employed in television cameras and the like, and more particularly, to an image orthicon and a vidicon pick-up tube. Inasmuch as these tubes and their variants are known, a detailed description of the tube structure will not be included herein. Methods of interconnecting the elements of camera pick-up tubes other than those discussed herein, as well as methods of providing electrode bias potentials, and circuitry for obtaining signal output are known and will not be included herein. The pick-up tube 12, when in operation as a camera tube, has a portion thereof surrounded by an alignment coil 14 (FIG. 1). This coil has two magnetic fields perpendicular to each other and to the axis of the tube and has the function of eliminating any slight mis-centering of the beam due to mechanical imperfections in the tube. A tube element 16 (FIGS. 1 and 2), which will be referred to hereinafter as "a screen grid," is apertured to pass the beam current I_b to the face or target 9 (FIG. 2) of the tube 12. In the tube referred to as the image orthicon, this screen grid 16 is generally designated G-2 in literature dealing with pick-up tubes. In the image orthicon it also functions as the first dynode of an electron multiplier. In the tube referred to as a vidicon, the electrode 16, referred to as a screen grid, performs in a similar function but is not, usually, associated with a multiplier. In the showing of FIG. 1 the screen grid current is designated I_{g2} and represents electrons collected by the screen grid 16. The beam current I_b passes through the aperture in the screen grid 16 and is directed toward the face or target 9. With a fixed and constant alignment field between the electron gun of the tube, which includes the cathode 10 and the beam aperture in the screen grid 16, the ratio between the screen grid current I_{g2} and the beam current I_b ,

$$K = \frac{I_{g2}}{I_b}$$

is constant. The sum of the two currents $I_{g2} + I_b$ is equal to the cathode current I_c . The beam current, therefore, is

$$I_b = \frac{I_c}{1+K} \text{ or } I_b \approx \frac{I_c}{K}$$

assuming $K \gg 1$. The value of the K varies considerably from tube to tube. A typical number for a tube of the vidicon type is approximately 500 and for the image orthicon, it is from about 200 to 1,000 under the best alignment. These values may be expected to increase considerably if beam alignment shifts from its optimum conditions.

Referring to FIG. 2 of the drawing there is shown, schematically, an arrangement in accordance with the invention for stabilizing the beam current of the pick-up tube 12. An image of an object 11 is focused by suitable optical means, for example, by a lens 15, on the face 9 of the cathode ray tube 12. While reference was made to the tube face 9, it will be understood that this may be the photocathode of an image orthicon tube or the target of a vidicon tube. An additional element of the tube 12, namely the control grid 18 thereof, is shown schematically. The cathode 10 is indicated as being connected directly to a point of reference potential for the apparatus of FIG. 2 which may be, for example, ground. The screen grid 16 is connected by way of a load resistor 21 to a positive potential source 7 at a terminal 23. The remaining terminal of the source 7 is connected to ground.

A voltage divider comprising a resistor 26, a potentiometer resistor 27 and a resistor 28 is connected from the screen grid 16 to a source of negative potential 8 at a terminal 31. The remaining terminal of the source 8 is connected to a point of circuit reference potential such as ground whereby the connections of the sources 7 and 8 provide the desired circuit return connection for the cathode 10 in the illustrative, schematic showing of FIG. 2 of the drawing. It will be understood that power supplies 7 and 8 may be combined as a single unit with an appropriate connection to ground at a suitable point between its positive and negative terminals. The control grid 18 is connected to a slider 33 on the potentiometer resistor 27 whereby to provide for manual pre-setting of the cathode current. From the circuitry of FIG. 2 of the drawing as described, it will be noted that the screen grid 16 may be considered as the anode of an amplifier and that the control grid 18 may be considered as the control grid of the same amplifier, and that an amplification factor is involved. In the example to be discussed hereinafter, the amplification factor is in the neighborhood of ten.

In operation of the arrangement of FIG. 2, variations of cathode current I_c are sampled by the load resistor 21 which is in the circuit of the screen grid 16. Variations of the voltage drop across the load resistor 21, which is caused by cathode current shift, changes the voltage across the previously mentioned voltage divider composed of resistors 26, 27 and 28. This voltage divider controls or provides the potential which exists on the control grid 18. The feed back effect shifts the potential existing on the control grid 18 in a direction to restore the cathode current to its desired value.

Solely by way of example, operation of the circuitry of FIG. 3 will be examined when a type 7513 three inch image orthicon is used as the tube 12. The desired cathode current I_c is 75 microamperes. The previously discussed current division ratio K is equal to 500. The beam current I_b is equal to $I_c/500$ or .15 microampere. In the example under discussion, the loop gain of the D.C. path is quite high and, as stated above, has a value of ten, since, with the screen grid 16 considered as an amplifier anode and the control grid considered as the control grid of the same amplifier, the transconductance is about 20 micro-mhos when I_c is 75 microamperes, and the value of the load resistor 21 can be made high. In the illustrative example when 280 volts positive is applied at the terminal 23 and 500 volts negative is applied to the terminal 31 the resistor 21 may have a value of 560,000 ohms. Also, and solely by way of example, the resistor 26 may have a value of 2.2 megohms, the potentiometer resistor 27 may have a value of 2 megohms, and the resistor 28 may have a value of 5.6 megohms. The slider 33 is adjusted to bias

the control grid 18 at a suitable negative potential with respect to the cathode.

Referring to FIG. 3 of the drawing, the curves indicate decay characteristics of the cathode current after its heater is turned off completely. The curve 36 shows the decay curve without benefit of the present invention as by applying the positive potential directly to the electrode 16. The curve 38 indicates the decay characteristic when the stabilization arrangement of the present invention is employed. It has been found that the cathode current decay curve indicates both warm up and long-term stability of the system. In the foregoing, it was pointed out that the cathode current of the tube was stabilized at its final value within approximately two minutes after current is turned on.

What is claimed is:

1. In combination with a cathode ray image pickup tube having means including an electron-emitting cathode, an intensity control grid and an apertured accelerating and beam-forming electrode for producing an electron beam, and a target electrode toward which said beam is directed, means for stabilizing said electron beam current, comprising:

means including a resistor for biasing said apertured electrode positively relative to said cathode to cause the major portion of said cathode-emitted electrons to flow to the body of said apertured electrode and the remainder of said electrons to pass through the aperture of said apertured electrode in a small well-defined beam to said target electrode and to produce voltage variations at said apertured electrode resulting from any changes in the electron current flow to said apertured electrode and through said resistor;

and means consisting only of passive circuit elements coupling said apertured electrode to said control grid to apply said voltage variations to said control grid to vary the electron emission from said cathode oppositely to said changes in the electron current flow to said apertured electrode, thereby maintaining the intensity of said beam substantially constant.

2. In combination with a cathode ray image pickup tube having means including an electron-emitting cathode, an intensity control grid and an apertured accelerating and beam-forming electrode for producing an electron beam, and a target electrode toward which said beam is directed, means for stabilizing said electron beam current, comprising:

means including a resistor for biasing said apertured electrode positively relative to said cathode to cause the major portion of said cathode-emitted electrons to flow to the body of said apertured electrode and the remainder of said electrons to pass through the aperture of said apertured electrode in a small well-defined beam to said target electrode and to produce voltage variations at said apertured electrode resulting from any changes in the electron current flow to said apertured electrode and through said resistor; and means consisting only of a passive resistive circuit coupling said apertured electrode to said control grid to apply said voltage variations to said control grid to vary the electron emission from said cathode oppositely to said changes in the electron current flow to said apertured electrode, thereby maintaining the intensity of said beam substantially constant.

3. In combination with an image orthicon television image pickup tube having an electron-emitting cathode, an electron intensity control grid and an apertured electron accelerating and beam-forming electrode, and a target electrode toward which said beam is directed, means for stabilizing said electron beam current, comprising:

means for biasing said control grid relative to said cathode to produce an unmodulated electron current emission from said cathode;

means including a first resistor for biasing said apertured electrode positively relative to said cathode to

5

cause the major portion of said cathode-emitted electrons to flow to the body of said apertured electrode and the remainder of said electrons to pass through the aperture of said apertured electrode in a small well-defined beam to said target electrode and to produce voltage variations at said apertured electrode resulting from any changes in the electron current flow to said apertured electrode and through said resistor, said apertured electrode also functioning as an electron multiplier dynode for the image light-modulated electron return beam from said target electrode; and means including a second resistor coupling said apertured electrode to said control grid to apply said

5

10

6

voltage variations to said control grid to vary the electron emission from said cathode oppositely to said changes in the electron current flow to said apertured electrode, thereby maintaining the intensity of said beam substantially constant.

References Cited in the file of this patent

UNITED STATES PATENTS

2,911,561	Fathauer	Nov. 3, 1959
2,911,562	Fathauer	Nov. 3, 1959
2,926,309	Norris	Feb. 23, 1960
2,930,929	Shelton	Mar. 29, 1960