Jan. 31, 1956 L. E. FLORY 2,733,364

MAGNETIC BEAM-FOCUSING SYSTEMS

Filed March 22, 1951

2 Sheets-Sheet 1

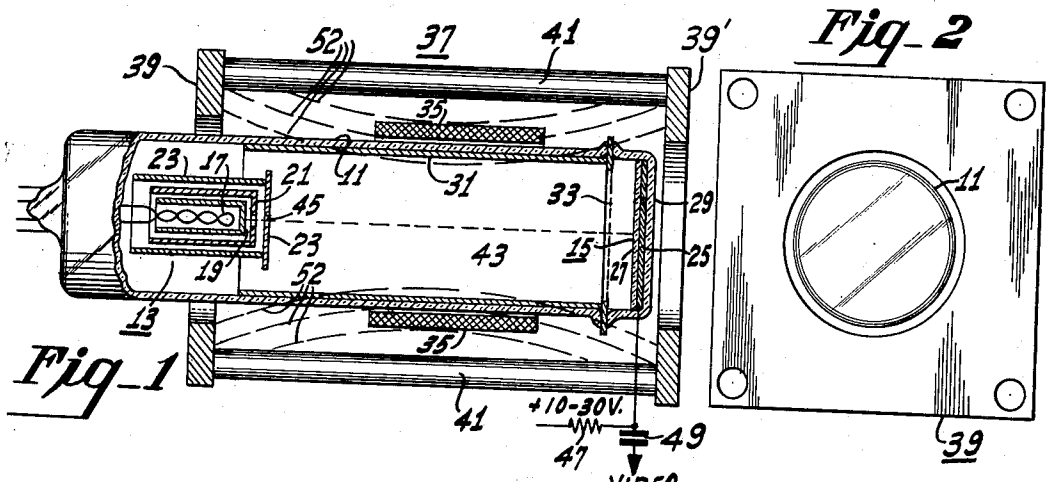


Fig_1

Fig_2

Fig_3

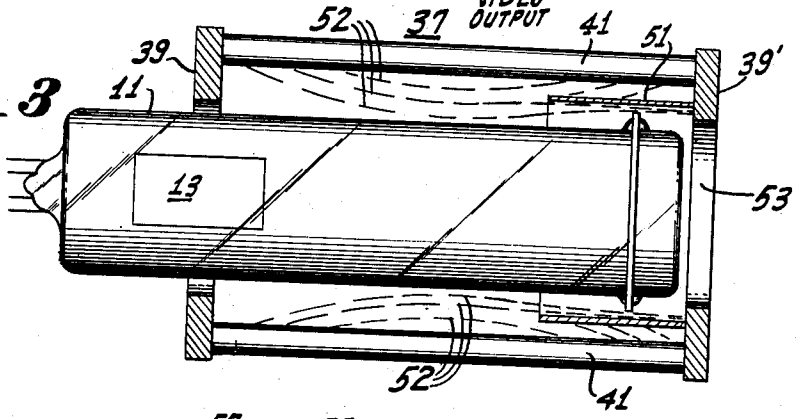
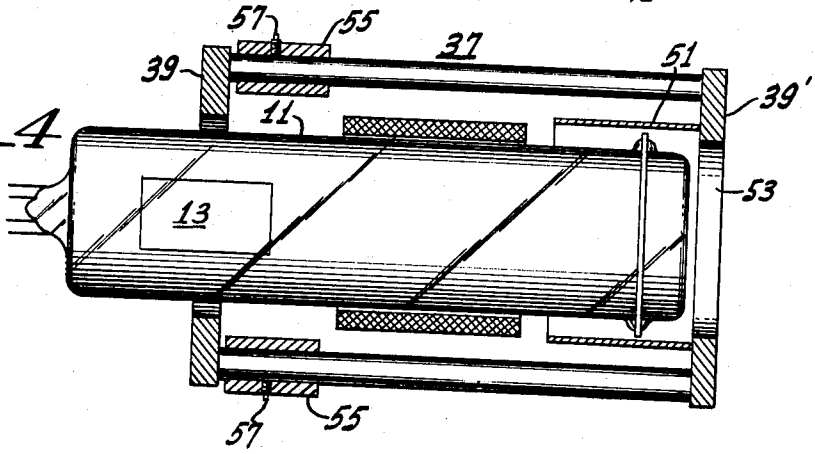


Fig_4



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Fig_5

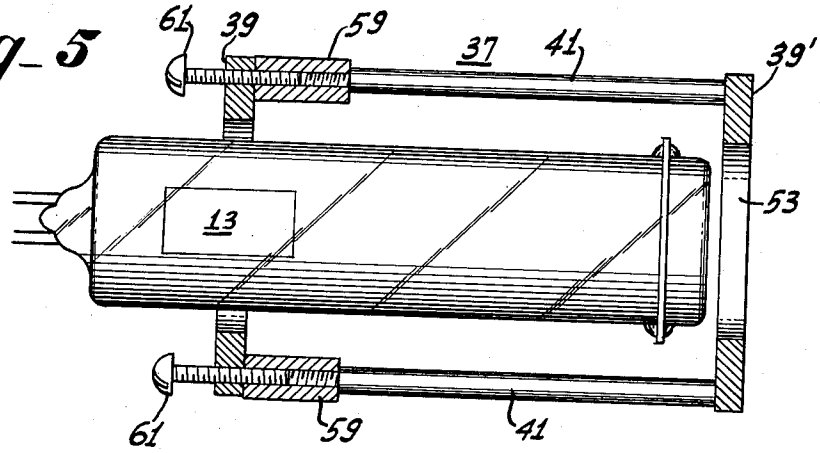
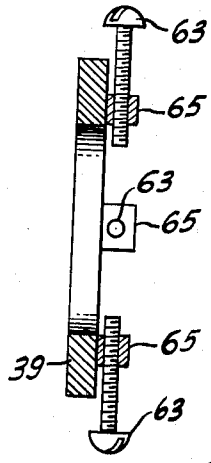


Fig_6



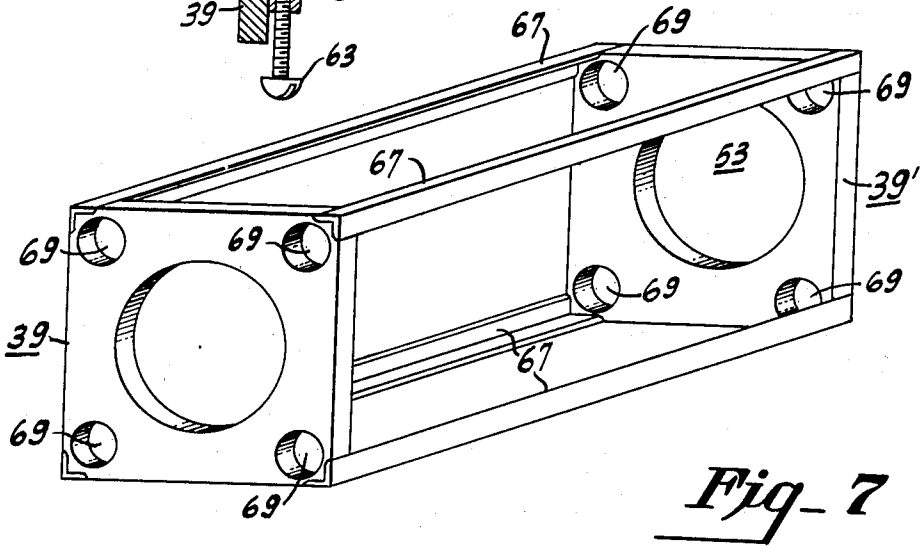


Fig_7

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United States Patent Office 2,733,364 Patented Jan. 31, 1956

2,733,364

MAGNETIC BEAM-FOCUSING SYSTEMS

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Application March 22, 1951, Serial No. 216,857

14 Claims. (Cl. 313—65)

This invention relates to magnetic-focusing and beam-alignment systems for electron-beam tubes and, though not necessarily limited thereto, will be described as applied to a television camera tube of the so-called "vidicon" variety.

Vidicon photo-conductive television cameras are described in an article beginning on page 70 of the May 1950 issue of "Electronics," and in copending U. S. applications: Serial No. 204,045 of S. V. Forgue, filed January 2, 1951, now U. S. Patent 2,710,813 and Serial No. 212,550, of P. K. Weimer, filed February 24, 1951, now U. S. Patent 2,687,484.

The pickup tube used in this camera features a photo-conductive target, as distinguished from the photo-emissive targets of the iconoscope and orthicon. The greater sensitivity of photo-conductors as a target material permits economy in size and simplification in design, and makes possible a more compact and portable television pickup apparatus.

The operational theory of these pickup tubes is set forth in detail in the references cited above, and will be explained later in this specification. For the present, it suffices to point out that Vidicons require, for the focusing of their electron beam, an essentially uniform longitudinal magnetic field extending from the gun to the target. In addition, a slight adjustment of the direction of the field in the region of the gun is necessary in order to compensate for possible misalignment of the gun and the field.

This focusing and aligning has hitherto been accomplished by a solenoid, surrounding the entire Vidicon from gun to target, and by an auxiliary "alignment coil" in the vicinity of the gun. The alignment coil provides a field which is transverse to the focusing field and is adjustable in direction and intensity.

The power consumption of these focusing and aligning coils is about 4 watts, and must be maintained constant during the operation of the tube in order to keep the electron beam in focus. This requires some type of current regulation. Regulation of this amount of power is somewhat difficult and costly from the viewpoint of the apparatus necessary; and dissipation of the power involved causes an undesirable heating of the Vidicon.

Accordingly, it is an object of the present invention to provide a focusing and beam-alignment system for a cathode ray device which will require less electrical current and will generate less heat than the systems of the prior art.

Another object is to provide an improved apparatus and method for focusing and aligning the electron beam in a cathode ray device.

Another object is to simplify the construction, and increase the compactness of assembly of television pickup tubes.

Another object is to provide an improved television camera of the Vidicon type.

The above mentioned, and other related objects, are accomplished in accordance with a preferred embodiment of the invention by an improved method of magnetic focusing. The focusing apparatus involved comprises a plurality of magnetic rods mounted in spaced relation about, and substantially parallel to, the path of the electron beam. Alignment of the beam as it leaves the gun and enters the accelerating, focusing and deflection fields, is accomplished by means of adjustable slugs which are mounted at the end of the focusing rods near the cathode of the tube. These slugs are adjusted to shift the flux of the magnetic field in the direction and to the extent necessary to accomplish proper alignment of the electron beam.

The invention is described in greater detail in connection with the accompanying two sheets of drawings, wherein:

Fig. 1 is a longitudinal sectional view of a magnetically focused beam-tube of the Vidicon variety, which is provided, in accordance with the invention, with a permanently magnetized focusing system;

Fig. 2 is an end view of the device of Fig. 1;

Fig. 3 is a side elevation, partly in section, of the device of Fig. 1 but having a magnetic shield added at the target end of the structure;

Fig. 4 is a similar view of the assembly, showing adjustable slugs on the magnetic focusing rods for aligning the electron beam;

Fig. 5 is a view similar to Fig. 4 showing another form of beam-aligning mechanism;

Fig. 6 is a vertical section of one end of a magnetic structure similar to the ones shown in the other figures but having vertical instead of horizontal alignment slugs;

Fig. 7 is a view in perspective of a magnetically permeable housing for the beam-tube and its permanent magnets and including angle irons which act as magnetic shunts in cooperation with the focusing rods.

The Vidicon type of television pickup tube shown in Fig. 1 comprises an evacuated envelope **11** containing an electron beam source **13** and a target assembly **15**.

The beam source **13** comprises a heater element **17**, an electron emitter or cathode **19**, a control electrode **21** and an accelerating electrode **23**. The target assembly **15** comprises a light-transparent metal film **25** and a layer of photo-conductive material **27** on the glass face plate **29** of the tube **11**. The film **25** may be of any material which is light-transparent and electrically-conductive and lends itself to application in a thin film upon a glass supporting surface. Aluminum may be used. The layer **27** is comprised of selenium or one of the sulfides, or selenides, which are normally insulators but become conductive under the influence of light. The references cited earlier in the specification may be consulted for suitable materials.

The inner surface of the tube **11** is covered by an electrically conductive coating **31** in the area between the electron beam source **13** and the target **15**. This conductive coating terminates in a wire mesh screen **33** across the tube in the vicinity of the target **15**.

External to the tube are: a deflection yoke **35**; and a focusing assembly **37** comprising end plates **39** and **39'**, supporting four magnetized rods **41**. As is well known (see for example U. S. Patent No. 2,452,619, issued November 2, 1948, to P. K. Weimer) the deflection yoke **35** comprises 2 pairs of coils, one pair being the horizontal deflecting coils, and the other pair the vertical deflecting coils. One pair of coils produces a deflecting field at a right angle to the axis of the tube to produce line scansion of the target by the beam, and the other pair produces a field at a right angle to the axis and also to the field of the first pair to produce frame scansion. The line scansion coils will be connected to a saw-tooth generator of line scansion frequency, and the other coils will be connected to a saw-tooth generator of frame

scansion frequency. These saw-tooth generators are well-known in the art and are not shown.

Under a preferred set of operating conditions: the cathode **19** is at ground potential; the control electrode **21** is at a negative 30 volts; the accelerating electrode **23** is at a positive 360 volts; the conductive coating **31** and the screen **33** electrically connected thereto are at a positive 200 volts; and the conductive film **25** of the target **15** is at a positive 10 to 30 volts.

In the operation of the tube, the electron beam **43** emerges from an aperture **45** in the accelerating electrode **23** and is caused by voltages applied to the coils of the deflection yoke **35** to scan an image raster upon the photo-conductive layer **27** of the target **15**.

Bombardment of the surface of the photo-conductive layer **27** brings it to the potential of the cathode **19**. Secondary electrons released by the bombardment are collected by the wire mesh **33** and the conductive coating **31**. The effect of this bombardment of the surface of the photo-conductive layer **27** is to produce a condition of electro-static charge across the photo-conductive layer **27** between the bombarded surface and the metal film **25** which is approximately 10 to 30 volts above cathode potential.

When a scene to be televised is focused through the glass face **29** of the tube upon the target assembly **15**, it renders the layer **27** conductive in the areas where light strikes it. The extent to which it becomes conductive in each particular area is determined by the intensity of the light image in that area. When layer **27** under the influence of the light image becomes conductive to various extents in various parts of its total area, it causes a discharge of potential from the bombarded surface of the layer **27** to the conductive film. The layer **27**, under the influence of light, becomes conductive only in a direction substantially parallel to the light rays that impinge upon it, and not in a lateral or crosswise direction. Consequently, the resulting condition upon the surface of the layer **27**, which faces the electron beam **43**, is one of uneven electrical potential. The entire surface has become what might be termed "an electro-static image" of the scene to be televised.

As the electron beam **43** scans the surface of the photo-conductive layer **27**, in this uneven condition of electron charge, which has just been described, it restores the particular area under bombardment to cathode potential. This restoration of the surface of the layer **27** to its original potential causes an electron flow through the output resistor **47** to the conductive film **25**. The extent to which the original charge leaked through the photo-conductor **27** under the influence of light from the scene to be televised determines the amount of electron current that will be necessary to restore the original potential; and variations in this current through the condenser **49** as the electron beam scans a complete raster become the video output of the tube.

The electron beam **43**, as it travels from its source **13** to the target assembly **15**, is maintained in proper focus by the field of the permanent magnet assembly **37**. Satisfactory results have been achieved with four Alnico (aluminum-nickel alloy) rods positioned at the corners of a rectangle about the outside of the tube. These rods are held in place by two soft-iron end plates **39** and **39'**, as shown in Fig. 2.

As shown in Fig. 3, a soft-iron magnetic shield **51** is provided in the area of the target assembly **15**. The shield **51** is cylindrical in shape and is of a diameter larger than both the envelope **11** and the opening **53** in the end plate **39'**. It is connected to the end plate **39'** and, by furnishing a path for the flux from the magnetized rods **41**, it prevents radial field lines from distorting the focus of the beam and provides a magnetic field which is more nearly longitudinal and parallel to the axis of the tube.

The electron beam as it leaves the gun, should enter the accelerating, focusing and deflecting fields substantially at the axis of the tube and from a direction normal to these fields. Things such as stray magnetic fields or mechanical misalignment of the gun interfere with this requirement and make some method of "beam alignment" necessary.

Fig. 4 shows a preferred method, in accordance with the invention, for aligning the electron beam with the focusing field as it leaves the electron gun or source **15**. This alignment is accompanied by the use of small "slugs" of magnetic material (i. e. a material which offers a relatively low reluctance path to magnetic flux, such as iron). These slugs are adjusted to shunt the flux of the magnetized rods and asymmetrically distort their fields to produce a shift in the direction desired. In the particular embodiment shown in Fig. 4 the shunting "slugs" comprise soft iron cylinders **55** mounted for slideable movement along the magnetized rods **41** and adapted to be maintained in any selected position by means of set screws **57**.

Fig. 5 shows an alternative type of alignment "slug." In this embodiment, brass cylinders **59** form a continuation of an end of the magnetized rods **41**. These cylinders **59** are equipped with threaded recesses into which iron screws **61** are adjustably secured. The iron screws **61**, as they are worked in toward the magnets **41**, reduce the non-magnetic gap within the cylinders **59** so that by a non-symmetrical arrangement of the positions of the screws the direction of the field can be warped to give the desired correction for alignment.

In the embodiment shown in Fig. 6, alignment of the electron beam is accomplished by iron screws **63** secured in brass blocks **65** which have appropriate threaded recesses and are welded to the end plate **39**. As a screw **63** is worked closer to the tube, a concentration of flux occurs in the vicinity of the screw. The result is an asymmetric shaping of the focusing field and a consequent aligning of the electron beam.

Fig. 7 shows structural apparatus for adjusting the field strength of the magnetized rods **41** to the particular tube with which they are to be used. This apparatus comprises angle irons **67** of magnetic material such as soft iron. These angle irons are secured to the corners of the end plates **39** and **39'** and are parallel and in close proximity to the magnetized rods **41** which are adapted to be received in holes **69** in the end plates **39** and **39'**. The function of the angle irons or strips **67** is to furnish a shunt path for the flux of the magnetized rods **41**, and thereby to furnish a means for regulating the intensity of the magnetic field acting upon the electron beam **43**. The fact that the thickness and width of the angle iron **67** can be rather easily varied makes it unnecessary to demand exactitude in the field strength of the magnets used for the rods **41**.

From the foregoing, it will now be apparent that the present invention provides a simple, inexpensive, and trouble-free beam focusing and alignment system, suitable for use in connection with Vidicon and other cathode-ray tubes.

What is claimed is:

1. The method of controlling an electron beam which comprises: establishing a permanent magnetic field having lines of force extending substantially parallel to and along the entire path to be traversed by said beam, subjecting said beam to the influence of said magnetic field and asymmetrically altering the contour of said lines of force in the region of entry of said beam into said field by shunting said field to correct for any minor departures of said beam from its extended path.

2. A television camera tube having means for producing a beam of electrons; a photo-conductive target for said beam, means for accelerating said beam toward said target, beam deflecting means for causing said beam to scan an image raster upon said target, means for focusing said beam, said means for focusing comprising an assembly of magnetized rods mounted in spaced relation about

and substantially parallel to said electron beam, a plurality of adjustable magnetic slugs at the end of said assembly closest to said means for producing electrons, and a cylindrical magnetic shield between said rods and said electron beam at the end of said assembly closest to said target.

3. A television camera tube having means for producing a beam of electrons, a photo-conductive target for said beam, means for accelerating said beam toward said target, beam deflecting means for causing said beam to scan an image raster upon said target, means for focusing said beam, said means for focusing comprising an assembly of magnetized rods mounted in spaced relation about and substantially parallel to said electron beam, a plurality of adjustable magnetic slugs at the ends of said assembly closest to said means for producing electrons, a cylindrical magnetic shield between said rods and said electron beam at the end of said assembly closest to said target, and strips of magnetic material in shunt relation to said magnetized rods.

4. An electron discharge apparatus comprising means for producing a beam of electrons along a path, a target for said beam of electrons mounted transversely to said beam path, an assembly of magnetized rods mounted in spaced relation about and substantially parallel to said electron beam path for establishing a focusing field for said beam, and auxiliary magnetic shunt means positioned adjacent to said rods for shunting a portion of said field and for changing the contour of said focusing field, said shunt means comprising a plurality of slugs of magnetic material adjustably mounted on said magnetized rods.

5. An electron discharge apparatus comprising means for producing a beam of electrons along a path, a target for said beam of electrons mounted transversely to said beam path, an assembly of magnetized rods mounted in spaced relation about and substantially parallel to said electron beam path for establishing a focusing field for said beam, and auxiliary magnetic shunt means positioned adjacent to said rods for shunting a portion of said field and for changing the contour of said focusing field, said shunt means comprising a plurality of slugs of magnetic material adjustably mounted in recesses at the ends of said magnetized rods.

6. An electron discharge apparatus comprising means for producing a beam of electrons along a path, a target for said beam of electrons mounted transversely to said beam path, an assembly of magnetized rods mounted in spaced relation about and substantially parallel to said electron beam path for establishing a focusing field for said beam, and auxiliary magnetic shunt means positioned adjacent to said rods for shunting a portion of said field and for changing the contour of said focusing field, said shunt means comprising a plurality of slugs of magnetic material adjustably mounted in recesses adjacent to the ends of said magnetized rods.

7. Apparatus for controlling an electron beam projected along a path, said apparatus comprising an assembly of magnetized rods supported about an axis and adapted to be mounted in spaced relationship about the path of said beam with said axis substantially coincident with said beam path, and beam deflecting means disposed about said axis and positioned between the extreme ends of said rods.

8. Apparatus for controlling an electron beam along a path, said apparatus comprising an assembly of magnetized rods supported about an axis and adapted to be mounted in spaced relationship about and substantially parallel to the path of said beam, and beam deflecting means disposed about said axis and surrounded by said rods.

9. Apparatus for controlling an electron beam along a path, said apparatus comprising an assembly of magnetized rods supported about an axis and adapted to be

mounted in spaced relationship about and substantially parallel to the path of said beam, a tubular deflecting yoke, and means supporting said yoke coaxially about said axis and within said rod assembly.

10. Apparatus for controlling an electron beam along a path, said apparatus comprising an assembly of magnetized rods supported about an axis and adapted to be mounted in spaced relationship about and substantially parallel to the path of said beam, a tubular deflecting yoke within said rod assembly, and a tubular envelope coaxially supporting said yoke about said axis.

11. A television camera tube comprising an electron gun for producing and accelerating a beam of electrons along a path, a photosensitive target mounted transversely to said beam path, beam deflection means between said gun and target for causing said beam to scan an image raster upon said target, and means for focussing said beam including an assembly of magnetized rods mounted in spaced relationship about and substantially parallel to said electron beam path, said assembly surrounding said beam deflection means.

12. A television camera tube comprising a tubular envelope, an electron gun within said envelope for producing and accelerating a beam of electrons along a path, a photosensitive target mounted transversely to said beam path, beam deflection means between said gun and target for causing said beam to scan an image raster upon said target, and means for focussing said beam including an assembly of magnetized rods supported by said tubular envelope and mounted in spaced relationship about and substantially parallel to said electron beam path, said assembly surrounding said beam deflection means.

13. Means for focussing and aligning an electron beam in an electron discharge apparatus having means for producing a beam of electrons along a path and a target for said beam of electrons mounted transversely to said beam path, said focussing and aligning means comprising an assembly of magnetized rods adapted to be mounted in spaced relation about and substantially parallel to said electron beam path for establishing a focussing field for said beam, and auxiliary magnetic shunt means positioned adjacent to said rods for shunting a portion of said field and for changing the contour of said focussing field, said shunt means comprising a plurality of slugs of magnetic material adjustably mounted on said magnetized rods.

14. Means for focussing and aligning an electron beam in an electron discharge apparatus having means for producing a beam of electrons along a path and a target for said beam of electrons mounted transversely to said beam path, said focussing and aligning means comprising an assembly of magnetized rods adapted to be mounted in spaced relation about and substantially parallel to said electron beam path for establishing a focussing field for said beam, and auxiliary magnetic shunt means positioned adjacent to said rods for shunting a portion of said field and for changing the contour of said focussing field, said shunt means comprising a plurality of slugs of magnetic material adjustably mounted in recesses at the ends of said magnetized rods.

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