

July 15, 1952

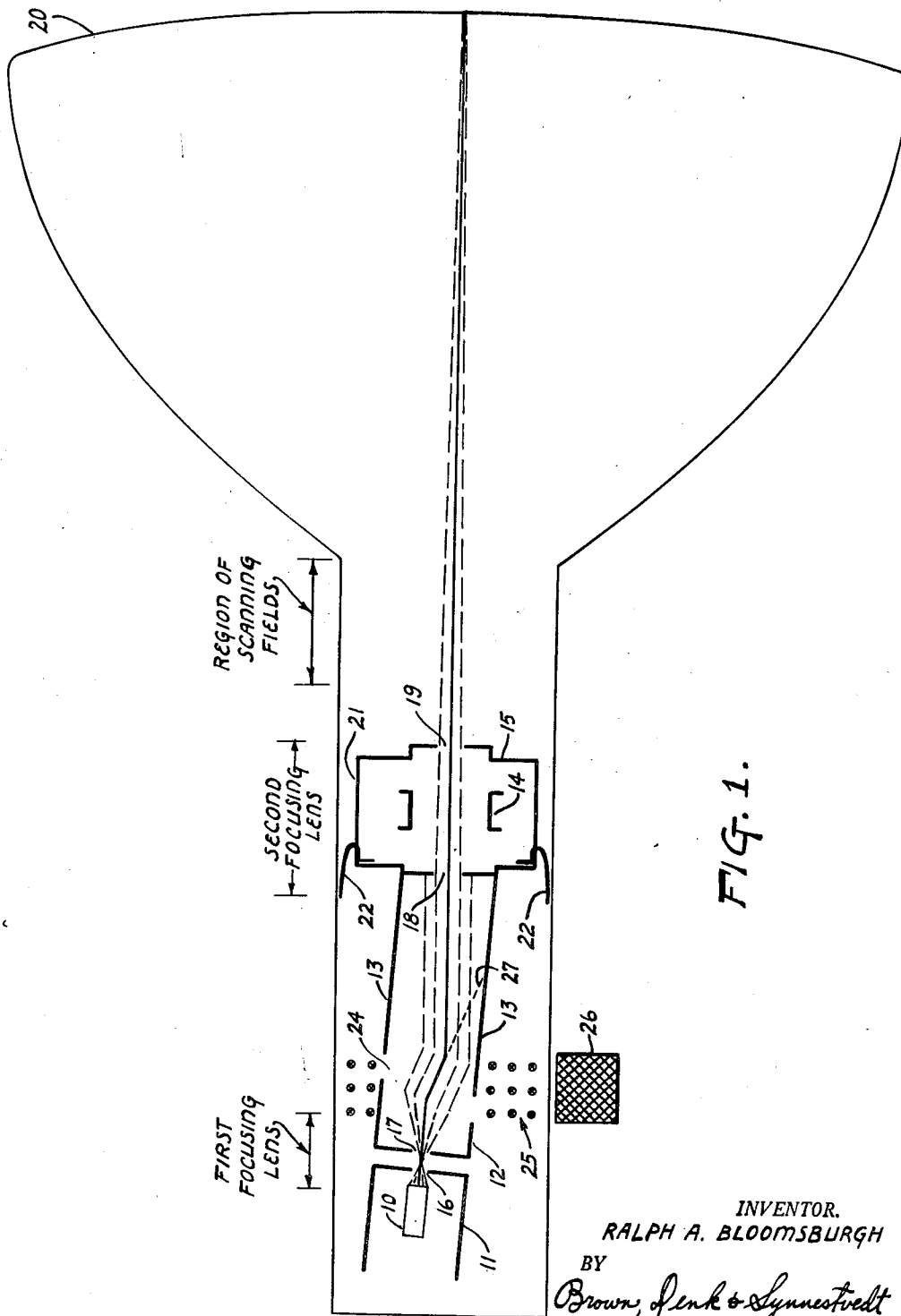
R. A. BLOOMSBURGH

2,603,550

METHOD OF ALIGNING CATHODE-RAY TUBE ASSEMBLIES

Filed July 12, 1951

2 SHEETS—SHEET 1



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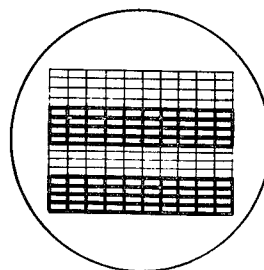
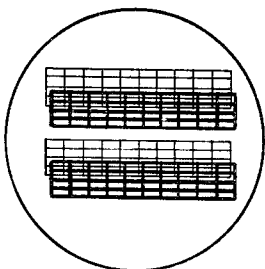
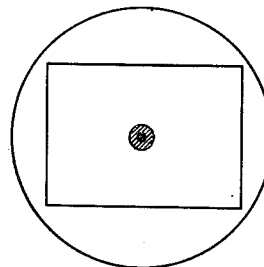
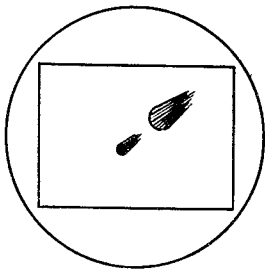
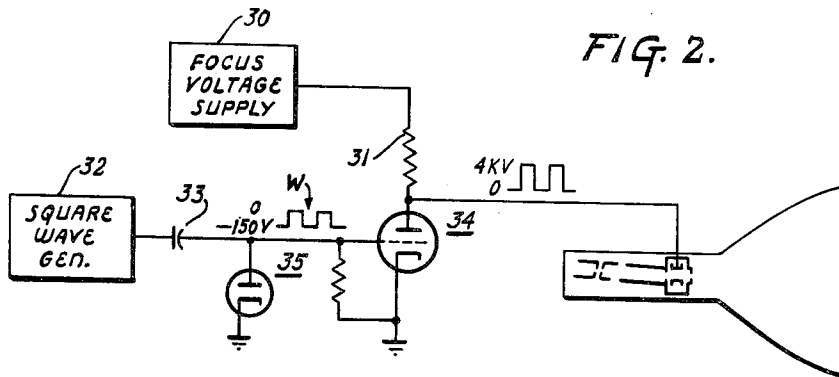
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METHOD OF ALIGNING CATHODE-RAY TUBE ASSEMBLIES

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2 SHEETS--SHEET 2



INVENTOR.
RALPH A. BLOOMSBURGH

BY
Brown, Denk & Lynnestvedt

AGENTS

UNITED STATES PATENT OFFICE

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METHOD OF ALIGNING CATHODE-RAY
TUBE ASSEMBLIES

Ralph A. Bloomsburgh, Lafayette Hill, Pa., as-
signor to Philco Corporation, Philadelphia, Pa.,
a corporation of Pennsylvania

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The invention herein described and claimed relates to a method of testing the electron optical alignment of a cathode-ray tube or of aligning a cathode-ray-tube assembly. The invention may be employed by the manufacturer of a cathode-ray tube to check the alignment of the electron gun within the tube envelope, and/or may be employed by the manufacturer of an end-product incorporating the cathode-ray-tube assembly, as for example, by a television receiver manufacturer, to align the cathode-ray-tube assembly incorporated therein.

As is known, the vast majority of television receivers now being produced employ magnetic rather than electrostatic deflection, and since the ions in the cathode-ray beam are not deflected appreciably by the magnetic deflection fields, it is customary to employ some sort of arrangement to prevent the ions from producing a spot at and possibly damaging the center of the fluorescent screen. The arrangement presently employed in practically all television receiver cathode-ray-tube assemblies comprises a bent or inclined electron gun in combination with a beam-bending or ion-trap magnet. The bent or inclined gun is so constructed that the electrified particles emitted by the cathode, including both ions and electrons, are directed toward the side of the tube instead of toward the screen. It is the function of the beam-bending or ion-trap magnet to alter the course of the electrons (but not of the ions) in such a way that the electrons pass through one or more, and in the case of electrostatically-focused tubes two or more, successively-positioned, axially-aligned, small apertures in the gun structure and reach the fluorescent screen of the tube, whereas the ions, whose course is not sufficiently altered by the magnetic field of the beam-bending magnet, fail to pass through the apertures and hence fail to reach the screen of the tube.

It is known that for a given bias on the cathode-ray tube, i. e. for a given fixed position of the brightness control of the television receiver, the picture is of maximum brightness when the beam-bending magnet is so adjusted that a maximum number of electrons pass through the successive apertures located between the field of the said magnet and the fluorescent screen of the tube. Consequently, it has been the customary practice of the prior art, in aligning a television receiver as it comes off the factory production line, to adjust the beam-bending magnet for maximum picture brightness. This procedure is, however, unsatisfactory in several respects.

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In the first place, it is quite difficult for the eye to make a rapid judgment of maximum brightness. Even if due care be taken, the observer will frequently find a range of positions for the beam-bending magnet within which the screen appears to be equally bright. The conventional practice has been to assume that any position within this range is equally satisfactory and acceptable. In other words, the beam-bending or ion-trap magnet has been adjusted heretofore with but one purpose in mind, namely, that of getting a maximum number of electrons through the apertures to the fluorescent screen.

I have discovered, however, that there is but one position of the beam-bending magnet for best overall results and that at any other position, though the screen may appear equally right, the focal quality suffers. Heretofore, in adjusting the beam-bending magnet the prior art has failed to recognize the effect which the beam-bending magnet has on focal quality. The prior-art practice has assumed that the focal quality of the beam is a quality to be controlled by adjustment of the focusing lens. For example, in the case of a tube having an electromagnetic focusing coil external of the tube, the prior art has controlled the focal quality by adjustment of the physical position of, and/or current through, the electromagnetic focusing coil. In the case of a tube having an external permanent magnet type of focusing lens, the prior art has adjusted the physical position of the permanent magnet or of an associated shunt element to control the quality of the focus. And, in the case of the electrostatic focusing lens, the prior art has adjusted the voltage applied to the internal focusing electrodes to control the focal quality.

I have found, however, that the focal quality is also influenced to an important extent by the beam-bending magnet and that, for a given focusing lens, best focal quality is obtained at but one position of the beam-bending magnet. By best focal quality, it is meant that the beam spot is of circular shape, i. e., free from astigmatism, is of minimum size, and is of maximum intensity for a particular value of tube bias.

It is an important object, then, of the present invention to provide an improved method of adjusting the beam-bending magnet of a cathode-ray-tube assembly, not merely so as to direct the beam in that direction which appears to produce maximum brightness of the screen, but so as to direct the beam in that direction which produces best focal quality, as above defined.

It will be noted that, as used herein, best focal

quality means maximum brightness as well as freedom from astigmatism and smallness of spot size. It is possible, of course, that due to deviations in the electron-gun structure which may or may not fall outside the tolerances imposed by the cathode-ray-tube manufacturer there is no position of the beam-bending magnet which produces best focal quality. The method proposed by the present invention readily indicates whether such is the case and permits a ready decision as to whether the tube should be rejected or accepted.

It is, accordingly, a further object of the present invention to provide an improved method of determining the alignment of the electron-gun assembly in a cathode-ray tube.

The foregoing objects are achieved, in accordance with the present invention, by employing a method which recognizes and utilizes the fact that if the electron-gun elements be in proper alignment, and if the beam-bending magnet be properly adjusted, then if the beam be varied in and out of focus, the out-of-focus presentation on the face of the tube will be less sharp than the in-focus presentation, but the in-focus and out-of-focus presentations will not be displaced either vertically or horizontally with respect to each other. Stated another way, if the electron-gun elements be in proper alignment, and the beam-bending magnet be properly adjusted, the position of the image on the face of the tube will not change as the focus is changed; only the sharpness of the image will change.

The method proposed by the present invention may be employed with the cathode-ray tube operating either with the beam not scanning, hereinafter sometimes referred to as spot presentation, or with normal scanning, hereinafter sometimes referred to as raster presentation.

While the method proposed by the present invention is also applicable to a magnetically focused tube, it is of particular utility in connection with an electrostatically focused tube where the focusing electrodes are within the tube envelope and, hence, not subject to physical adjustment. Accordingly, in the description which follows, an electrostatically focused tube will be assumed.

In accordance with the present invention, with normal focusing voltage applied to the electrostatic focusing electrodes so as to focus the beam sharply on the screen, a wave of suitable frequency and sufficient amplitude is utilized to vary the beam in and out of focus. If spot presentation is being employed, i. e. if the beam is not scanning, the cathode-ray tube then displays alternately a small in-focus spot and a larger out-of-focus spot. To obtain best focal quality, it is proposed by the present invention to adjust the beam-bending magnet until the centers of the in-focus and out-of-focus spots coincide, there being but one position of the ion-trap magnet which will effect this result. Assuming the electron-gun elements to be in proper alignment with respect to each other, when the centers of the in-focus and out-of-focus spots are brought into coincidence, the beam will be at the center of the shadow of the gun limiting apertures. The spots will be free from astigmatism and maximum light output will be attained. Further, if the electron-gun assembly is in proper alignment with respect to the tube envelope, the spot position when the centers coincide will be at the center of the tube face.

When the present invention is employed using raster presentation (i. e. normal scanning), the

frequency of the wave which is utilized to vary the beam in and out of focus may preferably, though not necessarily, be an integral multiple of the vertical deflection frequency. The picture will then be divided into alternate horizontal segments of in-focus and out-of-focus condition. To adjust the beam-bending magnet for best focal quality, the magnet is adjusted in an axial direction, i. e. forwardly or rearwardly on the tube neck, until the vertical lines in the in-focus and out-of-focus segments are in alignment. Then the magnet is rotated until the boundaries of the in-focus and out-of-focus segments butt together, without overlap and without gap therebetween. A ready way of determining when this latter condition obtains is to observe the background illumination and rotate the magnet until the illumination is uniform throughout the picture area, without either light or dark horizontal bars.

While the above constitutes a brief summary of the invention, the invention will be most readily understood from a consideration of the following detailed description of a preferred embodiment wherein reference is made to the accompanying drawing in which:

Figure 1 is a schematic representation of an electrostatically focused cathode-ray tube showing the electron-gun assembly and the position of the electron beam after adjustment of the beam-bending magnet;

Figure 2 is a schematic representation of one form of pulsing circuit which may be conveniently employed to vary the focus of the beam during the alignment test;

Figure 3 depicts the spots produced by an undeflected beam under in-focus and out-of-focus conditions and before adjustment of the beam-bending magnet;

Figure 4 depicts the spots produced by an undeflected beam under in-focus and out-of-focus conditions after the beam-bending magnet has been properly adjusted, assuming the electron-gun elements to be mounted in correct alignment with respect to each other;

Figure 5 illustrates a test pattern of generally cross-hatch configuration as reproduced on the face of the picture tube when the beam is scanning in normal manner but prior to adjustment of the beam-bending magnet; and

Figure 6 illustrates the same cross-hatch test pattern as it appears on the face of the picture tube after the beam-bending magnet has been properly adjusted, assuming the electron-gun elements to be properly aligned.

Referring now to Figure 1, there is shown a typical electron-gun assembly for an electrostatically focused cathode-ray tube. The gun assembly shown comprises cathode 10, first grid 11, second grid 12, third grid 13, fourth grid 14 and fifth grid 15. First grid 11 is the control grid and functions to vary the intensity of the beam in accordance with the video signal applied to the grid. This grid is in the form of a cylindrical sleeve surrounding the cathode 10 and its right end is closed except for a small circular aperture 16 opposite the cathode emitting area.

Second grid 12 is frequently referred to as the first anode. This grid is also cylindrical in form and is closed at the end facing the cathode except for a small central aperture 17. The end of the cylinder facing toward the fluorescent screen 20 is open but is cut diagonally so that the edge terminates in a plane which is inclined

with respect to the axis of the grid cylinder. A potential of about +300 volts may, in a typical case, be applied to grid 12. Grid 12, control grid 11, and cathode 10 together form the first focusing lens.

Grid 13 is also cylindrical in form. The end of the cylinder which faces the cathode is open and is cut diagonally so that its edge is parallel to that of grid 12. Except for a small central aperture 18, the end of grid 13 which faces the fluorescent screen 20 is closed in a plane perpendicular to the axis of the tube envelope.

Grid 14, which is located between grids 13 and 15, is a cylinder of very short length, both ends of which are open. Grid 15, located beyond grid 14, is in the form of a disc having a small central aperture 19. Grids 13 and 15 are connected together electrically, as by conductive strips 21, and these grids comprise the second anode electrodes. Grid 14 is the electrostatic focusing electrode. Grids 13, 14 and 15 together form the second focusing lens. In a typical case, a voltage of about +4000 volts may be applied to grid 14, while a voltage of the order of +15,000 volts may be applied to grids 13 and 15. Grid 13 is usually equipped with fingers 22 which, in addition to centering the gun structure within the neck of the tube, make contact with the aquadag coating (not shown) on the inner surface of the cathode-ray tube.

As shown in Figure 1, the first focusing lens (comprised of cylindrical grids 11, 12 and 13) has an axis which is inclined with respect to the axis of the neck of the tube. The emitted particles are focused by the said first focusing lens and have a first cross-over in the electrostatic field established by grids 14 and 15. This first cross-over is the object whose image is reproduced on the fluorescent screen of the tube.

An electrostatic field is also developed by grids 12 and 13 in the diagonal gap 24 located therebetween. The axis of this field is inclined with respect to the axis of the first focusing lens, the inclination being in the same direction as that in which the axis of the first lens is inclined with respect to the axis of the tube. The combined effect of the inclinations of the first lens and of the electrostatic field in gap 24 is to cause the electrified particles to proceed toward the side of the tube rather than toward the fluorescent screen 20.

Located in substantially the same region of the tube as the inclined electrostatic field in gap 24 is the magnetic field 25 established by the beam-bending or ion-trap magnet 26. This magnet is ordinarily provided with arcuately shaped pole pieces partially surrounding the neck of the tube, but these pole pieces have been omitted from the drawing to avoid confusion of lines. The magnetic field 25 established by the ion-trap magnet is effective to change the course of the electrons (but not of the ions) so that the electrons are deflected away from the neck of the tube (upwardly in Figure 1) and thereafter pursue a course which leads toward and through the small centrally-positioned apertures 18 and 19 in second-anode grids 13 and 15. The ions, however, are heavier, and their course is not appreciably altered by the magnetic field 25 of the ion-trap magnet. Accordingly, the ions follow a course indicated generally by the dotted-line 27 and strike the side of the cylindrical grid 13, or at least the end wall thereof. Thus, the ions fail to pass through the aper-

tures 18, 19 and fail to reach the fluorescent screen 20.

Assuming an undeflected beam (i. e., assuming the beam to be undeflected by the scanning electrodes located beyond grid 15 but not shown in the drawing) the axis of the beam through apertures 18, 19 to the fluorescent screen 20 is controlled by the position of the ion-trap magnet 26. For best focal quality, the axis of the beam between the magnetic field 25 and fluorescent screen 20 should coincide with the axis of the second focusing lens, which in turn should coincide with the axis of the tube. If these conditions be not met, i. e. if the beam enters the second focusing lens off center or at an angle, the spot at the screen 20 will suffer from astigmatism and coma in proportion to the extent of the misalignment. These aberrations in a practical cathode-ray-tube assembly can reach such magnitude as to render the picture quality quite unacceptable.

The method heretofore used to determine the position of the ion-trap magnet 26 comprised adjusting the magnet for maximum picture brightness. However, as has been previously indicated hereinabove, several positions of the ion-trap magnet may seem to produce equal brightness of the screen. However, only one of these positions will provide best focal quality, and that position is the one which places the axis of the beam on the axis of the second focusing lens.

In accordance with the present invention, the ion-trap magnet may be readily and quickly adjusted to the unique position which produces best focal quality by employing a method whereby the focus of the beam is varied at a suitable rate (preferably the beam is varied in and out of focus) while the spots on the fluorescent screen are observed and the ion-trap magnet 26 is moved lengthwise along the tube neck and rotatively with respect thereto until the centers of the differently focused (preferably in-focus and out-of-focus) spots coincide. When the spot centers coincide, the ion-trap magnet occupies the one position which provides best focal quality.

Before the ion-trap magnet is placed in the unique position which provides best focal quality, if the beam be varied in and out of focus, two spots will appear on the screen, neither of which is circular, and both of which are characterized by coma. This is illustrated in Figure 3 which shows the small in-focus and the larger out-of-focus comet-like spots displaced from each other.

Figure 4 illustrates the small in-focus and the larger out-of-focus spots after the ion-trap magnet 26 has been placed in its unique position. Note that the spots are circular and their centers coincident.

In Figure 2, convenient means are shown for varying the beam in and out of focus. The normal focus supply voltage 30 is connected to the electrostatic focusing electrodes by way of a large resistance 31, which may, for example, be of the order of 2 megohms. A wave W of suitable voltage and frequency from a square wave generator 32 is applied by way of coupling capacitor 33 to the grid of a triode 34. Wave W may, for example, have an amplitude of 150 volts and a frequency of 60 cycles per second. The plate of triode 34 is connected to the focusing electrodes of the cathode-ray tube and the cathode is connected to ground. A diode 35 acts as a clamping tube holding the extreme positive amplitude of the square wave W at ground potential and allowing the grid of triode 34 to go negative

only. The amplitude of the wave W is sufficiently large so that triode 33 is cut off during the negative portion of the cycle but conducts sharply during the positive portion. When triode 33 conducts, the electrostatic focusing electrodes are grounded through the tube and their voltage is reduced substantially to zero. However, when triode 33 is cut off, the full focusing voltage, indicated in the drawing to be of the order of +4,000 volts, is impressed upon the focusing electrodes. Thus, the beam is pulsed in and out of focus by the arrangement shown in Figure 2.

With the beam thus pulsed in and out of focus, to place the ion-trap magnet in the unique position which provides best focal quality, the operator merely moves the magnet rotationally and axially until the centers of the in-focus and out-of-focus spots are coincident.

If the operator is unable to so position the ion-trap magnet that coincidence is obtained with respect to the centers of the in-focus and out-of-focus spots, the probability is that the electron-gun elements are out of alignment and rejection of the tube may be in order.

The method described above may be employed by the manufacturer of cathode-ray tubes for the purpose of checking the alignment of the gun structure within the tube, and may be employed by the end-product manufacturer, for example, the television receiver manufacturer, to correctly position the ion-trap magnet during alignment of the receiver.

As an alternative to the spot-presentation method above described (wherein the ion-trap magnet is adjusted while the beam is undeflected by scanning fields as it is varied in and out of focus) the position of the ion-trap magnet may be adjusted, and the accuracy of alignment of the electron gun may be checked, while the beam is being deflected vertically and horizontally in normal scanning pattern. The scene being reproduced on the face of the tube may comprise a test pattern, preferably one having a substantial number of vertical and horizontal lines, as, for example, a cross-hatch pattern. The means shown in Figure 2 for pulsing the beam in and out of focus, described above in connection with spot presentation, may also be used for raster presentation.

For raster presentation, I prefer to pulse the beam in and out of focus at a frequency which is the n th multiple of the vertical scanning field frequency, where n is an integer, preferably greater than one. If desired, however, the beam may be pulsed at a frequency which is equal to, or an integral sub-multiple of, the vertical scanning field frequency. The reason I prefer to use a pulsing frequency which is the n th multiple of the vertical scanning field frequency, where n is an integer greater than one, is that the face of the tube then displays two times n horizontal segments of alternately in-focus and out-of-focus condition. This is shown in Figure 5, where I have illustrated how the screen will appear, prior to adjustment of the ion-trap magnet to its unique position, assuming the use of a generally cross-hatch test pattern and a pulsing frequency which is the second multiple of vertical scanning field frequency. It will be seen that the raster is divided into four (two times two) horizontal segments of alternately in-focus and out-of-focus condition. (A higher pulsing frequency may preferably be used but it was more convenient to show a drawing in which the image was divided into but four horizontal sections.)

It will be seen that the lines forming the generally cross-hatch test pattern are broader in the out-of-focus segments than in the in-focus segments, that the vertical lines in the out-of-focus segments are displaced horizontally relative to those in the in-focus segments, and that the in-focus and out-of-focus segments are displaced vertically with respect to each other. Figure 5 shows the lower portion of the in-focus areas and the upper portion of the out-of-focus areas as overlapping, while the lower portion of the out-of-focus and the upper portion of the in-focus areas fail to meet. The displacement could, of course, be different from that illustrated in Figure 5.

To adjust the ion-trap magnet for optimum focus, when raster presentation is being employed, the operator merely adjusts the magnet axially along the tube neck until the narrow vertical lines of the in-focus sections and the broad vertical lines of the out-of-focus sections are brought into alignment. Then the operator rotates the magnet about the tube neck until the in-focus and out-of-focus areas abut without overlap and without space therebetween, as shown in Figure 6. This condition is most readily recognized by observing the average background illumination; when the background illumination is uniform, without either light or dark horizontal stripes, the in-focus and out-of-focus areas are no longer displaced.

It will be seen that the present invention provides a method of quickly and accurately placing the ion-trap magnet in the one position which produces optimum focal quality, which as herein defined means that the beam spot is of circular shape, i. e. free of astigmatism and coma, is of minimum size, and is of maximum intensity for a particular value of tube bias. Of course, if the electron-gun elements are not properly aligned within the tube envelope, increased brightness may be obtainable at a different setting of the ion-trap magnet, but only at a sacrifice of spot shape and size. In such case, a compromise between light output and focal quality will have to be made if the tube is to be accepted.

The method heretofore used, of adjusting the ion-trap magnet solely for maximum picture brightness, fails readily to reveal defective tubes and may very easily provide a spot whose shape and size are not the best obtainable with the particular tube, as is the case when the ion-trap magnet is so adjusted that the beam enters the second focusing lens off-center or at an angle. Using the method proposed by the present invention ensures the beam being so directed through the tube that the axes of the beam and of the second-focusing lens coincide, provided, of course, that the gun elements are properly aligned within the tube envelope. If they are not, the method of the present invention quickly reveals that fact and a decision may quickly be reached as to whether the tube should be accepted or rejected.

It will be seen from the foregoing description that the present invention obtains optimum focal quality by adjustment of a beam-bending magnet having no lens properties, per se.

Having described my invention, I claim:

1. The method of aligning a cathode-ray-tube assembly having a fluorescent screen, an electron beam, an adjustable electron lens for controlling the area of impingement of said beam on said screen, and a beam-bending magnet for con-

trolling the location of the axis of the beam relative to that of said lens, said method comprising the steps of varying the strength of the said electron lens alternately and repeatedly between two predetermined values to vary the size of the area of beam impingement on said screen alternately and repeatedly between two different values, and adjusting the beam-bending magnet until said alternate differently sized areas of beam impingement are in substantial registry.

2. The method of aligning a cathode-ray tube assembly having a fluorescent screen, an electron beam, an adjustable electron lens for controlling the focus of the beam, and a beam-bending magnet for controlling the location of the axis of the beam relative to that of the said lens, said method comprising the steps of varying the strength of the said electron lens to vary the beam repeatedly in and out of focus on the screen of said tube, and manually adjusting the beam-bending magnet until the in-focus and out-of-focus images produced on said screen are in substantial alignment.

3. The method of aligning a cathode-ray tube assembly having a fluorescent screen, an electron beam, an adjustable electron lens for controlling the focus of said beam, and a beam-bending magnet for controlling the location of the axis of said beam relative to that of the said lens, said method comprising the steps of adjusting the said lens to focus the beam in a spot on said screen, varying the strength of the said lens to vary the beam alternately and repeatedly in and out of focus, thereby to vary the spot size on said screen, and adjusting the beam-bending magnet until the center of the out-of-focus spot substantially coincides with that of the in-focus spot.

4. The method of aligning a cathode-ray-tube assembly having a fluorescent screen, an electron beam, an adjustable electron lens for controlling the focus of said beam, a beam-bending magnet for controlling the position of the axis of the beam relative to that of the said electron lens, and means for deflecting said beam horizontally and vertically in a scanning pattern, said method comprising the steps of deflecting said beam in said scanning pattern, varying the strength of said lens to vary the beam alternately and repeatedly in and out of focus, and adjusting the

beam-bending magnet until the in-focus and out-of-focus images produced on the screen are in substantial alignment.

5. The method of aligning a cathode-ray-tube assembly having a fluorescent screen, an electron beam, an adjustable electron lens for controlling the focus of said beam, a beam-bending magnet for controlling the position of the axis of the beam relative to that of the said electron lens, and means for deflecting said beam horizontally and vertically in a scanning pattern, said method comprising the steps of deflecting said beam in said scanning pattern, varying the strength of said lens to vary the beam alternately in and out of focus at a frequency which is an integral multiple or integral sub-multiple of the vertical scanning frequency, thereby to produce in-focus and out-of-focus images on said screen, and adjusting the beam-bending magnet until the in-focus and out-of-focus images are in substantial alignment.

6. The method as claimed in claim 5 characterized by the fact that the strength of said lens is varied at a frequency which is n times the vertical scanning frequency, where n is an integer.

RALPH A. BLOOMSBURGH.

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