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(54) MAGNETIC BEAM ADJUSTING ARRANGEMENTS

(71) We, RCA CORPORATION, a corporation organized under the laws of the State of Delaware, United States of America, of 30 Rockefeller Plaza, City and State of New York, 10020, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates generally to magnetic arrangements for beam position adjustment in a multiple-beam cathode ray tube, and particularly to magnetic arrangements of such character which may be employed, for example, to effect static convergence of the plurality of electron beams in an in-line, tri-beam, shadow-mask color kinescope.

In a tri-beam color kinescope employing an in-line configuration, the electron beam sources are aligned to originate beam paths having axes lying essentially in a common plane, with a central beam path oriented in registry with the tube neck axis and with respective outer beam paths symmetrically disposed on opposite sides of the central beam.

For proper picture reproduction, it is desired that the three beams strike coincident regions of the phosphor screen of the kinescope. While the gun structures of the kinescope ideally are designed to effect such convergence of the beams at the screen center in the absence of beam deflection, practical tolerances in the manufacture of the kinescope and associated components dictate the need for associating with the kinescope suitable means for correcting a range of center-of-screen misconvergence errors that may be encountered in actual practice.

Adjustable magnetic fields are usually employed in effecting the requisite static convergence adjustments, and the typical commercially employed arrangement, for both in-line and delta gun configurations, has involved the use of adjustable magnets in association with field-directing pole piece

structures outside and within the neck of the kinescope. The presence of magnetic pole piece structures for convergence purposes in close proximity to the neck region enclosed by the deflection yoke poses a problem of undesired interactions between the fields associated with the respective structures.

The present invention is directed to an adjustable magnet arrangement facilitating the achievement of static convergence of in-line beams without the use of internal field-directing pole piece structures. Pursuant to the principles of the present invention, provision is made for the establishment of adjustable magnetic fields of two different characters in axial spaced regions of the tube neck, one field character being such that it oppositely intersects the respective outer beam paths while having negligible magnitude in the central beam vicinity, and the other field character being such that it intersects with similar direction the respective outer beam paths while also having negligible magnitude in the central beam vicinity. By appropriate adjustment of the orientation, polarity and magnitude of the respective fields, opposite-direction shifts of the positions of the outer beams, and/or like-direction shifts of the positions of the outer beams, may be carried out, as required, to bring the outer beams in registry with the central beam at the center of the screen.

In accordance with illustrative embodiments of the present invention, quadripolar (4-pole) magnet structures are employed for field establishment of the first-named (differential effect on outer beams) character, while sextipolar (6-pole) magnet structures are employed for field establishment of the second-named (common effect on outer beams) character. Adjustably positioned PM (permanent magnet) structures and adjustably energized EM (electromagnet) structures are both feasible for realization of the 4-pole and 6-pole magnet systems.

In an illustrative PM arrangement, a pair of juxtaposed 4-pole magnet rings and a

pair of juxtaposed 6-pole magnet rings are rotatably mounted about axially spaced regions of the tube neck (free of the presence of internal magnetizable structures). Each of the 4-pole rings has four poles symmetrically positioned about the ring periphery and alternating in polarity; i.e., with reference to a given north pole location thereon, the remaining pole locations are: S-90°; N-180°; and S-270°. Each of the 6-pole rings has six poles symmetrically positioned about the ring periphery and alternating in polarity; i.e., with reference to a given north pole location thereon, the remaining pole locations are: S-60°; N-120°; S-180°; N-240°; and S-300°. Conjoint rotation of the rings of a pair alters the direction of the resultant beam shifts, while differential rotation of the rings of a pair alters the beam shift magnitude.

In use of the above-described PM arrangement, an additional pair of rotatable magnet rings, of a bipolar (2-pole) form, may conveniently be supported on a common mount with the other ring pairs, the additional ring pair providing a facility for common shifting all three beams for conventional purity correction purposes. While the precise locations of the respective ring pairs along the tube neck axis to the rear of the deflection yoke does not appear to be critical, an order of locations which places the 6-pole ring pair centrally, with the 4-pole rings to the fore and the 2-pole rings to the rear, appears advantageous for readily obtaining adequate adjustment sensitivity for all of the desired fields other location orders, however, are recognized as being feasible.

Desirably, in the above-described PM magnet arrangement, realization of the desired 4-pole and 6-pole magnet systems is effected by employment of low permeability magnetic material (such as barium ferrite) to minimize disturbance of, or other interaction with, the deflection yoke field. This may be of particular concern in one contemplated application of the present invention where the design of the color kinescope and associated deflection yoke are such as to substantially maintain (i.e., within tolerances acceptable to an average viewer) the center-of-screen convergence conditions throughout the scanning of a raster. The described arrangements of the present invention are particularly suitable for such application by providing means for readily obtaining accurate center-of-screen convergence with structures suffering little or no interference from fringe yoke fields, and, in turn, causing little or no disturbance to the formation of precision yoke fields suitable for convergence maintenance.

In the aforementioned application of the present invention, the array of 2-pole, 6-pole and 4-pole magnet ring pairs constitute the

only neck components (exclusive of the deflection yoke apparatus) required in set-up and operation of the color kinescope.

An object of the present invention is to provide magnet arrangements for adjusting beam positions in plural-beam cathode ray tubes.

Other objects and advantages of the present invention will be readily recognized by those skilled in the art upon a reading of the following detailed description and an inspection of the accompanying drawings, in which:

Figure 1 is a side elevation view of a color kinescope assembly incorporating PM-type beam position adjusting apparatus in accordance with an embodiment of the present invention;

Figure 2 is a sectional view along the line 2-2 of Figure 1, simplified to omit a showing of structure within the kinescope neck;

Figure 3 is an exploded perspective view of several magnet ring elements of the beam position adjusting apparatus of Figure 1;

Figures 4a, 4b and 4c are diagrammatic showings illustrating various directions of beam position shifts obtainable with various rotational positions of 4-pole magnet ring elements of the Figure 1 apparatus;

Figure 5a, 5b and 5c are diagrammatic showings illustrating various directions of beam position shifts obtainable with various rotational positions of 6-pole magnet ring elements of the Figure 1 apparatus;

Figures 6a, 6b and 6c are diagrammatic showings illustrating various directions of beam position shifts obtainable with various rotational positions of 2-pole magnet ring elements of the Figure 1 apparatus;

Figures 7a and 7b are further diagrammatic showings, illustrating how differential rotation of 4-pole magnet ring elements from their Figure 4a positions affects beam shift magnitude;

Figures 8a and 8b diagrammatically illustrate 4-pole electromagnet structures that may be employed pursuant to an EM modification of the Figure 1 embodiment of the present invention.

In the side elevation view of Figure 1, an in-line, tri-beam, shadow-mask color kinescope 20, having at its base end a cylindrical neck section 21 and at its viewing end a funnel portion 23, is illustrated in assembly with associated external neck components. The latter include deflection yoke apparatus 27 (not shown in detail) encircling the forward end of the kinescope neck 21 and an adjoining flared portion of the funnel section 23.

To the rear of the deflection yoke are the remaining neck components, in the form of six rotatable magnet rings 30A, 30B, 40A, 40B, 50A and 50B mounted on a common (non-magnetic) cylindrical support 70 en-

circling the neck 21. As better indicated in the sectional view of Figure 2, which shows the front face of the forwardmost ring 50B, each ring is formed with a pair of projecting tabs (e.g., 51B, 52B) to facilitate manual adjustment of the rotational position of the ring about the support 70. Details of the internal structure of the kine-

scope neck have not been shown in the sectional view of Figure 2 to simplify the drawing, but nominal beam axis locations I, II and III have been shown within the tube neck to indicate the in-line configuration of the beam paths; the central beam axis II is shown as substantially coincident with the tube neck axis. The interior of the tube neck 21 encircled by the magnet rings is free of magnetic pole pieces or other magnetizable structures.

The inner diameter of support 70 is of sufficient width to permit the support to slide over the tube neck 21. A clamping strap 80 provides means for securing the support 70 in a desired fixed position on the neck 21. Axially spaced (nonmagnetic) positioning rings 60, suitably secured to the support 70, establish a trio of appropriately spaced gaps along the length of the support 70 for occupancy by the rotatable rings in respective pairs (30A, 30B; 40A, 40B; and 50A, 50B). Thin washers (not illustrated) of suitable material (e.g., paper) may be provided between the rings of each pair to facilitate independent ring rotation.

In the simplified exploded view of Figure 3, only the magnet rings (minus their tabs) are shown in order to illustrate the magnetization pattern associated with each of the rings. Each of the rings 30A, 30B of the rearmost pair has a two-pole magnetization pattern in which a north pole location is diametrically opposed to a south pole location. Each of the rings 40A, 40B of the central pair has a six-pole magnetization pattern, with the poles equally spaced (at 60° intervals) about the ring periphery and alternating in polarity. Each of the rings 50A, 50B of the forwardmost pair has a four-pole magnetization pattern, with the poles equally spaced (at 90° intervals) about the ring periphery and alternating in polarity.

The diagrammatic showing of Figure 4a illustrates the nature of the beam position shifts that result from the fields of the 4-pole ring pair (50A, 50B) for a particular orientation thereof. In the orientation of Figure 4a, ring 50A is positioned with its north poles directly above and below the axial beam location II; ring 50B is similarly positioned (whereby the fields of the two rings are similarly directed, and are fully aiding). With the indicated orientation, the field at beam location I is laterally directed with a polarity producing a downward shift of the electron beam at location I (electron

motion being into the plane of the paper in the views of Figures 4a, et seq.). The field at beam location III is also laterally directed but with opposite polarity, producing an upward shift of the electron beam at location III.

In the orientation of Figure 4b, rings 50A and 50B have both been rotated 45° counterclockwise from their Figure 4a positions. In the Figure 4b positions, the field direction at location I is vertically downward while the field direction at location III is vertically upward; the resultant beam position shifts are laterally leftward at location I and laterally rightward at location III. Figure 4c illustrates that a further counterclockwise rotation (of approximately 22.5°) of both rings results in opposite diagonally directed beam position shifts (upward and rightward at location I, and downward and leftward at location III).

It will be noted that no beam position shift is indicated for the electron beam at the axial location II in any of Figures 4a, 4b or 4c. This follows from the fact that the central region of the aperture of the 4-pole rings is substantially field free, whereby a beam at the axial location II is substantially unaffected by the 4-pole rings no matter what their orientation may be. The quadrupolar field provided by rings 50A, 50B thus constitutes a facility for introducing, in any required direction, equal-but-opposite shifts of the outer beams of an in-line trio without disturbing the central, axial beam (which may thus serve as a reference for the desired spot registry at the kinescope screen).

The diagrammatic showing of Figure 5a illustrates the nature of the beam position shifts that result from the fields of the 6-pole ring pair (40A, 40B) for a particular orientation thereof. In the orientation of Figure 5a, ring 40A is positioned with a pair of diametrically opposed poles in horizontal alignment with in-line locations I, II and III, the north pole of the pair being adjacent location I; ring 40B is similarly positioned. With the indicated orientation, the field direction at location I is lateral with a polarity producing an upward shift of an electron beam at location I; the field direction at location III is also lateral and with like polarity, this also producing an upward shift of an electron beam at location III. Figure 5b illustrates that a 30° counterclockwise rotation of rings 40A and 40B from their Figure 5a positions results in laterally leftward shifts at both of the locations I and III. Figure 5c illustrates that a smaller degree of counterclockwise rotation (15°) results in like diagonally directed shifts at locations I and III.

As in the previous 4-pole ring case, no motion is shown for a beam at the axial location II; again, the reason is that the cen-

tral region of the apertures of the 6-pole rings is substantially field free. The sextipolar field provided by rings 40A, 40B thus constitutes a facility for introducing, in any required direction, equal-and-common shifts of the outer beams of an in-line trio without disturbing the central, reference beam.

In contrast with the previously described effects of the 4-pole and 6-pole rings, the 2-pole rings 30A and 30B have an effect on all three beams. This is illustrated in Figure 6a where common lateral shifts of all three beams result from a vertical orientation of the poles of the 2-pole rings, in Figure 6b where common vertical shifts of all three beams result from a lateral orientation of the poles of the 2-pole rings, and in Figure 6c where common diagonal shifts of all three beams result from a diagonal orientation of the poles of the 2-pole rings.

With the noted common shift effect for all three beams, the bipolar field provided by the 2-pole rings 30A and 30B constitutes a facility for adjusting the angles of approach of the trio to the kinescope's shadow-mask to ensure landing of each on the appropriate phosphor area (i.e., to establish optimum "purity").

In all of the illustrations of Figures 4, 5 and 6, like positioning of each ring of a pair has been assumed. Such relationship provides maximum magnitude for the associated beam shift effects. Figures 7a and 7b illustrate how relative rotation of the rings of a pair away from direct alignment introduces a reduction of the magnitude of the associated beam shift effects. Chosen for illustration purposes are the 4-pole rings 50A and 50B. In Figure 7a, the 4-pole ring 50A has been rotated 15° clockwise from its Figure 4a position, while the 4-pole ring 50B has been rotated 15° counterclockwise from its Figure 4a position. As suggested by the arrow directions and lengths in Figure 7a, the beam shift directions at locations I and III are the same as in Figure 4a but the beam shift magnitudes are both reduced. This magnitude reduction effect accompanying the "spreading" of the magnet rings of a like pair will be familiar to those acquainted with the use of prior art purity ring pairs or centering ring pairs, and should not require further explanation herein.

While PM structures have been described above for producing the desired field patterns, it will be appreciated that such patterns may also be produced with EM structures. Figures 8a and 8b respectively illustrate a pair of four-pole EM ring structures, 50A¹ and 50B¹, each having four coils symmetrically positioned about its periphery, with adjacent coils oppositely wound. Ring 50A¹, as shown in Figure 8a, is fixedly positioned with its poles in the orientation of Figure 4a to introduce oppositely directed

vertical shifts at locations I and III. Ring 50B¹, as shown in Figure 8b, is fixedly positioned with its poles in the orientation of Figure 4b to introduce oppositely directed lateral shifts at locations I and III. By adjusting the polarity and magnitude of the current flowing serially in the coils of the respective rings (through tap adjustments of the respective potentiometers 90 and 100), one may duplicate any of the effects provided by the rotations of the PM rings 50A, 50B. It will be recognized that comparable techniques may be employed with six-pole EM ring structures to duplicate the effects provided by the rotation of the PM rings 40A, 40B.

As previously indicated, the illustrated order for the respective bipolar, sextipolar and quadripolar fields is preferred, placing the sextipolar field centrally to maximize its effectiveness. It may also be noted that there is a concomitant preferred order of field adjustment to minimize retouching requirements. Preferably the bipolar field is adjusted first to optimize purity, establishing the position of the reference beam. Thereafter, the sextipolar field is adjusted to provide the required common shifts of the outer beams relative to the axial beam. Finally, the quadripolar field is adjusted to provide the required opposing shifts of the outer beams, necessary to achieve final registry. Such order of adjustment (in the order of location along the beam path) has the advantage that a given field adjustment does not alter the beam locations in the region of a previously adjusted field.

Illustratively, a low permeability material, such as barium ferrite, may be used in forming the several magnet rings of the Figure 1 assembly to minimize undesired interactions between the deflection field and the convergence and purity fields. However, for the illustrated order of ring pairs, which places the purity rings 30A and 30B in a remote location relative to the yoke 27, this precaution may readily be omitted in the case of the purity rings; i.e., a more inexpensive material, such as a suitable steel, may be used for the purity rings 30A, 30B with little adverse consequence.

It will be appreciated that conditions may be encountered in practice where no quadripolar field correction and/or sextipolar field correction is required. Reduction of the shift effect of any of the ring pairs may readily be eliminated by aligning the rings of a pair in cancelling relationship, as shown, for example, in Figure 7b.

WHAT WE CLAIM IS:—

1. The combination comprising:
a tri-beam color kinescope having a cylindrical neck enclosing a trio of in-line beam paths, a central one of said in-line beam

tral region of the apertures of the 6-pole rings is substantially field free. The sextipolar field provided by rings 40A, 40B thus constitutes a facility for introducing, in any required direction, equal-and-common shifts of the outer beams of an in-line trio without disturbing the central, reference beam.

In contrast with the previously described effects of the 4-pole and 6-pole rings, the 2-pole rings 30A and 30B have an effect on all three beams. This is illustrated in Figure 6a where common lateral shifts of all three beams result from a vertical orientation of the poles of the 2-pole rings, in Figure 6b where common vertical shifts of all three beams result from a lateral orientation of the poles of the 2-pole rings, and in Figure 6c where common diagonal shifts of all three beams result from a diagonal orientation of the poles of the 2-pole rings.

With the noted common shift effect for all three beams, the bipolar field provided by the 2-pole rings 30A and 30B constitutes a facility for adjusting the angles of approach of the trio to the kinescope's shadow-mask to ensure landing of each on the appropriate phosphor area (i.e., to establish optimum "purity").

In all of the illustrations of Figures 4, 5 and 6, like positioning of each ring of a pair has been assumed. Such relationship provides maximum magnitude for the associated beam shift effects. Figures 7a and 7b illustrate how relative rotation of the rings of a pair away from direct alignment introduces a reduction of the magnitude of the associated beam shift effects. Chosen for illustration purposes are the 4-pole rings 50A and 50B. In Figure 7a, the 4-pole ring 50A has been rotated 15° clockwise from its Figure 4a position, while the 4-pole ring 50B has been rotated 15° counterclockwise from its Figure 4a position. As suggested by the arrow directions and lengths in Figure 7a, the beam shift directions at locations I and III are the same as in Figure 4a but the beam shift magnitudes are both reduced. This magnitude reduction effect accompanying the "spreading" of the magnet rings of a like pair will be familiar to those acquainted with the use of prior art purity ring pairs or centering ring pairs, and should not require further explanation herein.

While PM structures have been described above for producing the desired field patterns, it will be appreciated that such patterns may also be produced with EM structures. Figures 8a and 8b respectively illustrate a pair of four-pole EM ring structures, 50A¹ and 50B¹, each having four coils symmetrically positioned about its periphery, with adjacent coils oppositely wound. Ring 50A¹, as shown in Figure 8a, is fixedly positioned with its poles in the orientation of Figure 4a to introduce oppositely directed

vertical shifts at locations I and III. Ring 50B¹, as shown in Figure 8b, is fixedly positioned with its poles in the orientation of Figure 4b to introduce oppositely directed lateral shifts at locations I and III. By adjusting the polarity and magnitude of the current flowing serially in the coils of the respective rings (through tap adjustments of the respective potentiometers 90 and 100), one may duplicate any of the effects provided by the rotations of the PM rings 50A, 50B. It will be recognized that comparable techniques may be employed with six-pole EM ring structures to duplicate the effects provided by the rotation of the PM rings 40A, 40B.

As previously indicated, the illustrated order for the respective bipolar, sextipolar and quadripolar fields is preferred, placing the sextipolar field centrally to maximize its effectiveness. It may also be noted that there is a concomitant preferred order of field adjustment to minimize retouching requirements. Preferably the bipolar field is adjusted first to optimize purity, establishing the position of the reference beam. Thereafter, the sextipolar field is adjusted to provide the required common shifts of the outer beams relative to the axial beam. Finally, the quadripolar field is adjusted to provide the required opposing shifts of the outer beams, necessary to achieve final registry. Such order of adjustment (in the order of location along the beam path) has the advantage that a given field adjustment does not alter the beam locations in the region of a previously adjusted field.

Illustratively, a low permeability material, such as barium ferrite, may be used in forming the several magnet rings of the Figure 1 assembly to minimize undesired interactions between the deflection field and the convergence and purity fields. However, for the illustrated order of ring pairs, which places the purity rings 30A and 30B in a remote location relative to the yoke 27, this precaution may readily be omitted in the case of the purity rings; i.e., a more inexpensive material, such as a suitable steel, may be used for the purity rings 30A, 30B with little adverse consequence.

It will be appreciated that conditions may be encountered in practice where no quadripolar field correction and/or sextipolar field correction is required. Reduction of the shift effect of any of the ring pairs may readily be eliminated by aligning the rings of a pair in cancelling relationship, as shown, for example, in Figure 7b.

WHAT WE CLAIM IS:—

1. The combination comprising:
a tri-beam color kinescope having a cylindrical neck enclosing a trio of in-line beam paths, a central one of said in-line beam



paths substantially coinciding with the longitudinal axis of said neck with the remaining outer ones of said in-line beam paths being substantially symmetrically disposed on opposite sides of said axis, and with all of said in-line beam paths traversing a region of the interior of said neck which is free of magnetizable structures,

a first adjustable magnetic field producing means mounted on said neck for causing mutually opposing shifts of said outer beam paths in said region without substantially disturbing said central beam path; and

a second adjustable magnetic field producing means mounted on said neck for causing like direction shifts of said outer beam paths in said region without substantially disturbing said central beam path.

2. A combination as claimed in Claim 1 in which said first field producing means comprises means for developing a quadripolar field pattern in said region; and

said second field producing means comprises means for developing a sextipolar field pattern in said region.

3. A combination as claimed in claim 2 in which

said quadripolar field pattern developing means comprises a pair of four-pole magnet rings encircling a portion of said region; and

said sextipolar field pattern developing means comprises a pair of six-pole magnet rings encircling a second portion of said region axially spaced from said first-named region.

4. A combination as claimed in claim 3 in which all of said magnet rings comprise individually rotatable permanent magnet rings.

5. The combination as claimed in claim 3 or 4 comprising

a cylindrical support encircling said neck of said kinescope, a pair of two-pole magnet rings, each magnetized across a ring diameter;

said pair of four-pole magnet rings, each having poles, alternating in polarity, at 90° intervals about the ring periphery; and

a pair of six-pole magnet rings, each having poles, alternating in polarity, at 60° intervals about the ring periphery;

said ring pairs being mounted for rotation concentrically about said support at respective longitudinally spaced locations on said support.

6. Apparatus as claimed in claim 5 comprising

a deflection yoke mounted on said neck, said four-pole magnet rings being mounted on said support in a location adjacent to said deflection yoke, said two-pole magnet rings being mounted on said support in a location remote from said deflection yoke, and said six-pole magnet rings being mounted on said support in a location intermediate the locations of said two-pole and four-pole magnet rings.

7. A magnetic beam adjuster for mounting on the neck of a tri-beam color kinescope, and substantially as hereinbefore described with reference to Figures 1 to 7b, or Figures 1 to 7b as modified by Figures 8a and 8b.

8. A magnetic beam adjuster according to claim 7 in combination with and mounted on a color kinescope, substantially as hereinbefore described.

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