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ELECTRON-IMAGE TUBE APPARATUS WITH IMPROVED ACUTENESS OF THE IMAGE CORNERS

Filed May 13, 1963

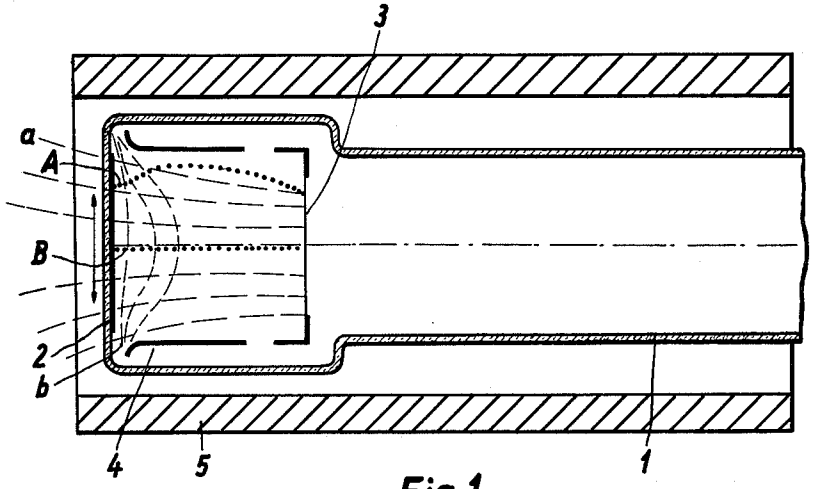



Fig.1

PRIOR ART

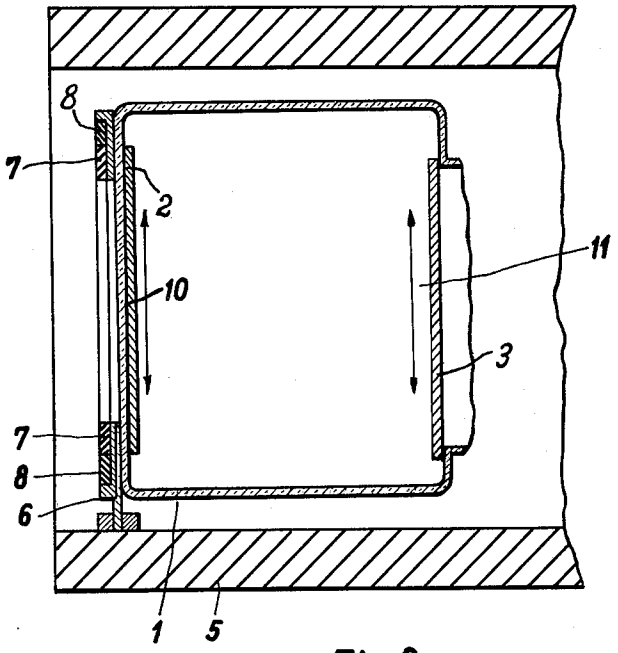



Fig.2

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# ELECTRON-IMAGE TUBE APPARATUS WITH IMPROVED ACUTENESS OF THE IMAGE CORNERS

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This invention relates to electron-image tube apparatus in which an electron image is transferred between plane electrodes. The invention has particular, though not exclusive application in connection with television pickup tubes, in relation to which it will be chiefly described.

In modern television cameras employing 3-inch image-orthicon pickup tubes the resolution has already approximately reached the theoretical value for 5 mc./s. In the central zone of the picture field the resolution has in general a value of more than 80% of the black-white interval at 500 kc./s. A certain loss of resolution arises, however, at the edges of the picture, and in particular at the corners where it may amount to only some 50% of the maximum black/white interval. It is therefore desirable as far as possible to equalize the resolution in the corners to that at the centre of the picture.

By careful adjustment of the potential applied to the photocathode of an image-orthicon pickup tube it may be determined that the maximum resolution for the image section of the tube occurs at different settings for the centre of the picture and for the margins and corners, where the photocathode requires a different potential applied to it. If, for example, the photocathode voltage for optimum resolution at the centre of the picture is —460 v., the voltage for optimum resolution in the corners of the picture of the photocathode potential may be found to be some —485 v.; in other words, a certain amount of field curvature arises in the image transfer process. In practical operation precedence is always given to the centre of the picture, so that the effect of the field curvature is at its maximum.

The origin of the field curvature mentioned may be understood from the following discussion. Because of the electrode arrangement employed in the image-converter section of an image-orthicon pickup tube the equipotential lines in the image section do not lie in planar surfaces. In front of the photocathode they are often curved to somewhat of a bell form. As the electrons are withdrawn from the photocathode, owing to their very low initial velocity they at first describe a path running exactly perpendicular to the equipotential surfaces. Since the ratio of the electric field strength to the magnetic field strength at the edges of the photocathode is very high in comparison with that at the centre, an electron from the centre of the photocathode will follow a rectilinear path to the target, while an electron emitted from an edge of the photocathode will follow an outwardly curved path. As a first result of this the paths of marginal electrons are therefore somewhat lengthened. More important, however, these electrons now cross the lines of force of the magnetic field at an angle which is not negligible, so that they now follow spirally curved paths resulting in a substantial elongation of the path length. Marginally-emitted photoelectrons therefore form nodes before reaching the target. This effect can apparently only be abolished if it is possible to match the paths of the electrons and the lines of force of the magnetic field to one another, so that the electrons move as far as possible along the magnetic lines of force and the marginal electrons are prevented from following



spiral paths. The resultant shortening of the paths of the marginal electrons ensures that nodes are formed in the plane of the target by marginal electron bundles as well as by axial bundles.

Since the equipotential surfaces of the electric field are determined by the arrangement of the electrodes within the image-orthicon tube and, in view of the complexity of the whole system which could only be altered only at great expense, the only alternative is to modify the paths of the magnetic lines of force in such a manner that the field curvature is equalized.

Focusing systems for the image converters of television camera tubes have already been proposed in which an additional magnetic field is produced in the neighbourhood of the photocathode in order to improve the image forming conditions. In a supericonoscope, for example, in which a magnetic field concentrated in the neighbourhood of the photocathode is employed, a ferromagnetic ring has been arranged within the magnetic focusing coil so that its inner margin extended to the neighbourhood of the picture field. The purpose of this arrangement was to suppress the image aberrations resulting from the S-formed distortion due to the use of a short magnetic focusing coil. It has also been attempted to improve the image quality by the inclusion of a winding in the interior of the magnetic core. In image-orthicon pickup tubes it has also been attempted to increase the magnetic field strength in the plane of the photocathode as compared with that in the plane of the target electrode by arranging on the end surface of the focus coil surrounding the image-orthicon tube a winding of disc form which is traversed by an adjustable current. This arrangement was employed especially with 4½-inch image-orthicon tubes in order to produce a divergent magnetic field through which the image magnification between photocathode and storage target was increased. Increase of the resolution in the corners of the picture was not the purpose of this system and according to present experience such an effect was not in fact produced. Finally, such an additional winding placed on the end face of the main focusing coil was used in order to make the magnetic field in the image-converter section of the pickup tube as homogeneous as possible.

The underlying purpose of the invention, of improving the resolution in the corners of the picture, is also made difficult because, owing to the already specified optical conditions in the television camera and the fixed size of the scanning pattern on the target electrode, the conditions under which the image is transferred from the photocathode to the target electrode can be altered only very little. The use of an iron pole-piece, possible with an additional winding embedded in it, or an auxiliary coil applied to the end face of the deflection coils, does not therefore lead to the required result, for these measures introduce an undesirable modification of the image forming conditions and also yield only an inadequate reduction of the loss of resolution in the corners of the picture.

To solve the problem underlying the invention, of improving the marginal resolution of the electron image projected on to the storage target in an image-orthicon pickup tube, in accordance with the present invention there is placed directly upon the faceplate of the pickup tube which carries the photocathode an auxiliary coil of small radial height which is traversed by current in the same direction as that in the main focusing coil and is surrounded by this main coil. Preferably there exists between the outer margin of the auxiliary coil and the inner surface of the main focusing coil a distance which is at least as great as the radial height of the auxiliary coil winding. This arrangement ensures that the mag-

netic field is modified chiefly in the rear neighbourhood of the auxiliary coil and a marked restriction of the magnetic field occurs in the neighbourhood of the corners of the picture field on the photocathode, while the field strength at the centre of the photocathode is relatively little changed.

This arrangement may be still further improved by adding yet another auxiliary coil in the interspace between the first-mentioned auxiliary coil and the main focusing coil, this further auxiliary coil being traversed by a current in the direction opposite to that in the first-mentioned auxiliary coil. The result of this arrangement is that a radial dipole field is produced, which allows a high field-strength to be generated in the immediate neighbourhood of the edges of the picture field on the photocathode, this field decaying rapidly towards the centre of the photocathode. This simple arrangement allows a parabolic field distribution to be superimposed upon the substantially constant field strength of the main focusing coil. It has been found that in the case of the 3-inch image-orthicon an increase of the field strength at the corners of the picture of some 15% as compared with that at the centre of the picture is necessary in order to eliminate the field curvature. With a voltage on the photocathode suitable for obtaining maximum resolution at the centre of the picture, the central resolution produced is then more than 80%, as before, while the marginal resolution is at least 65%. Variation of the voltage applied to the photocathode shows that the field curvature is made practically to vanish by the use of the present invention, since it is not possible to find a photocathode voltage at which the corner resolution can be further increased.

The invention will now be more particularly described with reference to the accompanying drawings, comprising FIGURES 1 and 2, of which:

FIGURE 1 is a schematic representation of a partial longitudinal section through an image-orthicon pickup tube and its associated focusing coil, such as has been employed hitherto, showing the equipotential surfaces of the electrostatic field and the lines of force of the magnetic focusing field, together with the resultant electron paths, and

FIGURE 2 is a schematic representation of a partial longitudinal section through a 3-inch image-orthicon pickup tube provided, in accordance with the invention, with an auxiliary focusing coil of the dimensions found by experiment to be the most advantageous.

In FIGURE 1, **1** is the envelope of an image-orthicon pickup tube which carries on its faceplate a photocathode **2**. In addition the tube contains a storage target **3** and an accelerating electrode **4**, which serves to produce a suction field for electrons emitted from the photocathode. Other electrodes contained in the tube, which serve to produce a scanning beam and for the collection of the return beam forming the picture signal are not shown, since the construction of an image-orthicon tube is familiar to the expert and since the present invention is not concerned with these portions of the tube.

The tube is surrounded by a long focusing coil **5**, the field strength of which is so designed that both the electrons in the image-converter section formed by the electrodes **2**, **3** and **4** and also the electrons in the scanning beam are focused upon the storage target. The magnetic lines of force of the focusing coil **5** are indicated by broken lines *a*, while the equipotential surfaces of the electrostatic field in front of the photocathode are indicated by the broken lines *b*. These equipotential surfaces in front of the photocathode will be seen to be somewhat of bell shape. As mentioned in the introduction, an electron leaving the photocathode at a point near its edge will follow an outwardly curved path as indicated by dotted line A, while an electron emitted from the centre of the photocathode will travel rectilinearly to the target as shown by dotted line B. The curvature of the path of the marginal electron is exaggerated in the drawing for the sake of clarity in illustration. The result of these field conditions in the known arrangement is that a loss of resolution occurs at the edges of the picture.



FIGURE 2 shows an arrangement according to the present invention. The figure shows to an enlarged scale the image converter section of an image-orthicon pickup tube, the electrodes within the tube being omitted for the sake of simplicity in illustration. In this embodiment of the invention there is placed on the faceplate of the envelope **1** which carries the photocathode a member **6** in the form of a frame, which is provided with an auxiliary coil **7**. The inner edge of auxiliary coil **7** lies closely adjacent to the area of the photocathode occupied by the optical image which in operation is projected thereupon, and its outer edge has a substantial separation from the inner edge of the main focusing coil **5**. The frame member **6** is provided at its periphery with several projections which engage in corresponding grooves in the main focusing coil **5**, so that the frame member **6** is firmly anchored to the coil **5**. The magnetic field produced by the coil **7** has the same main direction as that of the coil **5**, and the coil **7** may be so designed that it is traversed by the same focusing current.

The advantage yielded by the invention is obtained because the image forming field of the photocathode interacts with that of the coil to produce a magnetic field with a radial component which gives rise to a restriction of the main magnetic field. Owing to this restriction the magnetic lines of force become curved towards the margins in a manner similar to the paths of the electrons shown by dotted line A in FIGURE 1. In this manner it is ensured that, with the magnetic field strength correctly adjusted, the electrons are imaged in the plane of the storage target both at the edges and in the centre of the target electrode **3**, so that the field curvature is substantially abolished. In certain types of tube, in which it is desirable to vary as little as possible the image magnification between photocathode and storage target, a further improvement may be obtained if the focusing field produced by the auxiliary coil **7** is compensated, as least as regards electrons emitted at the centre of the photocathode, by a further auxiliary coil **8** fitted in the space between the auxiliary coil **7** and the margin of the frame member **6**.

For the former 3-inch image-orthicon cameras there is specified for a distance of 60 mm. between photocathode and storage target, a picture diagonal **10** of some 45 mm. and a raster height **11** on the storage target of some 35 mm. These conditions are necessary in view of the fact that even within the image space the magnetic field of the main focusing coil diverges somewhat. Since, however, owing to unavoidable winding tolerances, the lines of force of the coil **5** are often found to be much too divergent, a certain reduction of the divergence is desirable. This is likewise produced by the field of the auxiliary coil if the dimensions given below are adopted:

Outer diameter of coil **7**=distance between photocathode and target

Ratio of radial height to width of winding section=5:2

Radial height of winding=4 to 5 mm.

The measures described above for improving the corner resolution may naturally also be employed with advantage in image converter tubes, in which there likewise exists the problem of transferring an electron image between plane surfaces, of which in this case one is a photocathode and the other is a fluorescent screen lying at a high potential or a permeable electron-multiplying membrane.

What is claimed as new and desired to be secured by Letters Patent is:

**1.** Electron image tube apparatus, comprising

an electron image tube, said electron image tube including an envelope having a planar member, a first plane electrode positioned on said planar member in said envelope, a second plane electrode in said en-

velope, means for producting electrostatic and electromagnetic fields in said envelope, and means for transferring an electron image having a central area and peripheral corner areas from said first plane electrode to said second plane electrode under the combined effect of said electrostatic and electromagnetic fields;

an elongated main magnetic focusing coil surrounding said electron image tube; and

an auxiliary coil positioned immediately adjacent the first plane electrode of said electron image tube, said auxiliary coil being of substantially annular configuration and having an inner periphery, an outer periphery and a radial width between said inner and outer peripheries, the inner periphery of said auxiliary coil lying adjacent the corners of the area of said first plane electrode occupied by said image, the outer periphery of said auxiliary coil being spaced from said main focusing coil by a distance at least as great as the radial width of said auxiliary coil, said auxiliary coil being adapted to be traversed by a current flowing in the same direction as a current flowing in said main focusing coil to provide an auxiliary electromagnetic field interacting with the electromagnetic field produced in said electron image tube to reshape the electromagnetic field produced in said electron image tube in a determined manner in the corner areas of said image to substantially eliminate field curvature and to substantially avoid variation of the electromagnetic field produced in said electron image tube in the central area of said image.

2. Electron image tube apparatus, comprising

an electron image tube, said electron image tube including an envelope having a planar member, a first plane electrode positioned on said planar member in said envelope, a second plane electrode in said envelope, means for producing electrostatic and electromagnetic fields in said envelope, and means for transferring an electron image having a central area and peripheral corner areas from said first plane electrode to said second phase electrode under the combined effect of said electrostatic and electromagnetic fields;

an elongated main magnetic focusing coil surrounding said electron image tube;

a first auxiliary coil positioned adjacent the first plane electrode of said electron image tube, said first auxiliary coil being of substantially annular configuration and having an inner periphery, an outer periphery and a radial width between said inner and outer peripheries, the inner periphery of said first auxiliary coil lying adjacent the corners of the area of said first plane electrode occupied by said image, the outer periphery of said first auxiliary coil being spaced from said main focusing coil by a distance at least as great as the radial width of said first auxiliary coil; and

a second auxiliary coil positioned coaxially with and around the outer periphery of said first auxiliary coil within said main focusing coil and adapted to be traversed by a current flowing in a direction opposite that of a current flowing in said main focusing coil.

3. Electron image tube apparatus, comprising

an electron image tube, said electron image tube including an envelope having a planar member, a first plane electrode positioned on said planar member in said envelope, a second plane electrode in said envelope, means for producing electrostatic and electromagnetic fields in said envelope, and means for transferring an electron image having a central area and peripheral corner areas from said first plane electrode to said second plane electrode under the combined effect of said electrostatic and electromagnetic fields;

an elongated main magnetic focusing coil surrounding said electron image tube;



a first auxiliary coil positioned adjacent the first plane electrode of said electron image tube, said first auxiliary coil being of substantially annular configuration and having an inner periphery, an outer periphery and a radial width between said inner and outer peripheries, the inner periphery of said first auxiliary coil lying adjacent the corners of the area of said first plane electrode occupied by said image, the outer periphery of said auxiliary coil being spaced from said main focusing coil by a distance at least as great as the radial width of said first auxiliary coil, said first auxiliary coil being adapted to be traversed by a current flowing in the same direction as a current flowing in said main focusing coil; and

a second auxiliary coil positioned coaxially with and around the outer periphery of said first auxiliary coil within said main focusing coil and adapted to be traversed by a current flowing in a direction opposite that of a current flowing in said main focusing coil.

4. Electron image tube apparatus, comprising

an electron image tube, said electron image tube including an envelope having a planar member, a first plane electrode positioned on said planar member in said envelope, a second plane electrode in said envelope, means for producing electrostatic and electromagnetic fields in said envelope, and means for transferring an electron image having a central area and peripheral corner areas from said first plane electrode to said second plane electrode under the combined effect of said electrostatic and electromagnetic fields;

an elongated main magnetic focusing coil surrounding said electron image tube;

a first auxiliary coil positioned adjacent the first plane electrode of said electron image tube, said first auxiliary coil being of substantially annular configuration and having an inner periphery, an outer periphery, and a radial width between said inner and outer peripheries, the inner periphery of said first auxiliary coil lying adjacent the corners of the area of said first plane electrode occupied by said image, the outer periphery of said first auxiliary coil being spaced from said main focusing coil by a distance at least as great as the radial width of said first auxiliary coil, said first auxiliary coil being adapted to be traversed by a current flowing in the same direction as a current flowing in said main focusing coil to provide an auxiliary electromagnetic field interacting with the electromagnetic field produced in said electron image tube to reshape the electromagnetic field produced in said electron image tube in a determined manner in the corner areas of said image to substantially eliminate field curvature and to substantially avoid variation of the electromagnetic field produced in said electron image tube in the central area of said image; and

a second auxiliary coil positioned coaxially with and around the outer periphery of said first auxiliary coil within said main focusing coil and adapted to be traversed by a current flowing in a direction opposite that of a current flowing in said main focusing coil.

5. Electron image tube apparatus, comprising

an electron image tube, said electron image tube including an envelope having a planar member, a first plane electrode positioned on said planar member in said envelope, a second plane electrode in said envelope, said first and second plane electrodes being spaced a determined distance from each other, means for producing electrostatic and electromagnetic fields in said envelope, and means for transferring an electron image having a central area and peripheral corner areas from said first plane electrode to said second plane electrode under the combined effect of said electrostatic and electromagnetic fields;

an elongated main magnetic focusing coil surrounding said electron image tube; and

an auxiliary coil positioned immediately adjacent the first plane electrode of said electron image tube, said auxiliary coil being of substantially annular configuration and having an inner periphery, an outer periphery, a radial width between said inner and outer peripheries and an outer diameter of said outer periphery substantially equal to the distance between said first and second plane electrodes, the inner periphery of said auxiliary coil lying adjacent the corners of the area of said first plane electrode occupied by said image, the outer periphery of said auxiliary coil being spaced from said main focusing coil by a distance at least as great as the radial width of said auxiliary coil, said auxiliary coil being adapted to be traversed by a current flowing in the same direction as a current flowing in said main focusing coil to provide an auxiliary electromagnetic field interacting with the electromagnetic field produced in said electron image tube to reshape the electromagnetic field produced in said electron image tube in a determined manner in the corner areas of said image to substantially eliminate field curvature and to substantially avoid variation of the electromagnetic field produced in said electron image tube in the central area of said image.

6. Image orthicon tube apparatus, comprising

an image orthicon tube, said image orthicon tube including an envelope having a planar member, an illuminated planar photocathode in said envelope positioned on said planar member in said envelope, a planar raster electrode in said envelope, means for producing electrostatic and electromagnetic fields in said envelope, and means for transferring an electron image having a central area and peripheral corner areas from said photocathode to said raster electrode under the combined effect of said electrostatic and electromagnetic fields;

an elongated main magnetic focusing coil surrounding said image orthicon tube; and

an auxiliary coil positioned immediately adjacent the photocathode of said image orthicon tube, said auxiliary coil being of substantially annular configuration and having an inner periphery, an outer periphery and a radial width between said inner and outer peripheries, the inner periphery of said auxiliary coil lying adjacent the corners of the area of said photocathode occupied by said image, the outer periphery of said auxiliary coil being spaced from said main focusing coil by a distance at least as great as the radial width of said auxiliary coil, said auxiliary coil being adapted to be traversed by a current flowing in the same direction as a current flowing in said main focusing coil to provide an auxiliary electromagnetic field interacting with the electromagnetic field produced in said image orthicon tube to reshape the electromagnetic field produced in said image orthicon tube in a determined manner in the corner areas of said image to substantially eliminate field curvature and to substantially avoid variation of the electromagnetic field produced in said image orthicon tube in the central area of said image.

7. Image orthicon tube apparatus, comprising

an image orthicon tube, said image orthicon tube including an envelope having a planar member, an illuminated planar photocathode in said envelope positioned on said planar member in said envelope, a planar raster electrode in said envelope, means for producing electrostatic and electromagnetic fields in said envelope, and means for transferring an electron image having a central area and peripheral corner areas from said photocathode to said raster electrode under the combined effect of said electrostatic and electromagnetic fields;

an elongated main magnetic focusing coil surrounding said image orthicon tube, said main focusing coil



having an inner peripheral area with grooves formed therein;

a frame member positioned adjacent the planar member of the envelope of said image orthicon tube outside the envelope thereof and having an outer peripheral area with projections extending therefrom and adapted to cooperate with corresponding grooves in said main focusing coil; and

an auxiliary coil positioned in said frame immediately adjacent the photocathode of said image orthicon tube, said auxiliary coil being of substantially annular configuration and having an inner periphery, an outer periphery and a radial width between said inner and outer peripheries, the inner periphery of said auxiliary coil lying adjacent the corners of the area of said photocathode occupied by said image, the outer periphery of said auxiliary coil being spaced from said main focusing coil by a distance at least as great as the radial width of said auxiliary coil, said auxiliary coil being adapted to be traversed by a current flowing in the same direction as a current flowing in said main focusing coil to provide an auxiliary electromagnetic field interacting with the electromagnetic field produced in said image orthicon tube to reshape the electromagnetic field produced in said image orthicon tube in a determined manner in the corner areas of said image to substantially eliminate field curvature and to substantially avoid variation of the electromagnetic field produced in said image orthicon tube in the central area of said image.

8. Image orthicon tube apparatus, comprising

an image orthicon tube, said image orthicon tube including an envelope having a planar member, an illuminated planar photocathode in said envelope positioned on said planar member in said envelope, a planar raster electrode in said envelope, means for producing electrostatic and electromagnetic fields in said envelope, and means for transferring an electron image having a central area and peripheral corner areas from said photocathode to said raster electrode under the combined effect of said electrostatic and electromagnetic fields;

an elongated main magnetic focusing coil surrounding said image orthicon tube; and

an auxiliary coil positioned immediately adjacent the photocathode of said image orthicon tube, said auxiliary coil being of substantially annular configuration and having an inner periphery, an outer periphery and a radial width between said inner and outer peripheries, the inner periphery of said auxiliary coil lying adjacent the corners of the area of said photocathode occupied by said image, the outer periphery of said auxiliary coil being spaced from said main focusing coil by a distance at least as great as the radial width of said auxiliary coil, the distance between the outer periphery of said auxiliary coil and said main focusing coil being approximately three times the radial width of said auxiliary coil, said auxiliary coil being adapted to be traversed by a current flowing in the same direction as a current flowing in said main focusing coil to provide an auxiliary electromagnetic field interacting with the electromagnetic field produced in said image orthicon tube to reshape the electromagnetic field produced in said image orthicon tube in a determined manner in the corner areas of said image to substantially eliminate field curvature and to substantially avoid variation of the electromagnetic field produced in said image orthicon tube in the central area of said image.

9. Image orthicon tube apparatus, comprising,

an image orthicon tube, said image orthicon tube including an envelope having a planar member, an illuminated planar photocathode in said envelope po-

sitioned on said planar member in said envelope, a planar raster electrode in said envelope, means for producing electrostatic and electromagnetic fields in said envelope, and means for transferring an electron image having a central area and peripheral corner areas from said photocathode to said raster electrode under the combined effect of said electrostatic and electromagnetic fields;

an elongated main magnetic focusing coil surrounding said image orthicon tube; and

an auxiliary coil positioned immediately adjacent the photocathode of said image orthicon tube, said auxiliary coil being of substantially annular configuration and having an inner periphery, an outer periphery and a radial width between said inner and outer peripheries, the inner periphery of said auxiliary coil lying adjacent the corners of the area of said photocathode occupied by said image, the outer periphery of said auxiliary coil being spaced from said main focusing coil by a distance at least as great as the radial width of said auxiliary coil, the distance between the outer periphery of said auxiliary coil and said main focusing coil being approximately three times the radial width of said auxiliary coil, said auxiliary coil having a cross-sectional area formed by said radial width and the thickness of said auxiliary coil, said radial width being approximately 2½ times said thickness, said auxiliary coil being adapted to be traversed by a current flowing in the same direction as a current flowing in said main focusing coil to provide an auxiliary electromagnetic field interacting with the electromagnetic field produced in said image orthicon tube to reshape the electromagnetic field produced in said image orthicon tube in a determined manner in the corner areas of said image to substantially eliminate field curvature and to substantially avoid variation of the electromagnetic field produced in said image orthicon tube in the central area of said image.



**References Cited by the Examiner**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,803,770 | 8/1957 | Harkensee | 315—10 X |
| 3,048,681 | 8/1962 | Polinko | 313—252 X |

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