

SPECIFICATION

Deflection unit for colour television display tubes

The invention relates to a deflection unit for a colour television display tube of the type in which the electron beams lie substantially in a single plane on which plane the longitudinal axis lies, the central one of said beams, when undeflected, substantially coinciding with said longitudinal axis, and having a display screen and an electron gun assembly for producing said electron beams, said deflection unit comprising a field deflection coil, a line deflection coil, an annular core member of soft magnetic material surrounding at least the line deflection coil. A line deflection coil is to be understood to mean in this connection a combination consisting of two diametrically oppositely arranged line coil portions for deflecting an electron beam in a first (horizontal) direction, and a field deflection coil is to be understood to mean in this connection a combination consisting of two diametrically oppositely arranged field coil portions for deflecting an electron beam in a (vertical) direction transverse to the first direction. The line and field coils may both be of the saddle type and surrounded collectively by the annular member of soft magnetic material (the core), or the line coil may be of the saddle type and be surrounded by the core, while the coil portions of the field coil are wound toroidally on the core, this latter case being a hybrid system.

For displaying (colour) television pictures, certain electron-optical requirements are imposed upon the combination of the display tube and the electron beam deflection unit.

It holds, for example, that the raster reproduced on the display screen must be rectangular and undistorted within certain narrow limits. Furthermore the definition of the picture from the centre towards the edge of the screen may decrease only to a restricted non-disturbing extent.

For the colour display tube having a shadow mask there are two additional requirements.

The colour selection in a shadow mask tube is obtained by an eccentric arrangement of the three electron guns in such manner that the phosphor dots of a given colour are hit only by the electrons of the corresponding beam through the holes in the mask. In order to obtain a colour-pure image it is required that the relative colour selection angles of the three beams should remain unvaried upon deflection. This is the landing requirement. When this condition is not satisfied, it is possible that colour spots will occur.

A second equally important requirement is that the target of the three electron beams should coincide with each other throughout the screen so that the pictures in the three primary colours fully converge. This is the convergence requirement. When this condition is not satisfied, disturbing colour edges at brightness and colour transitions occur.

Of great importance in the further development

of colour television display systems was the introduction of the "in-line gun" display tube in which the electron guns are arranged in one plane. The basic idea of this design is that it is possible with this arrangement to obtain automatic convergence (self-convergence) throughout the display screen while using astigmatic deflection fields. A correct level of astigmatism for the field deflection coil will be described hereinafter.

For a good level of astigmatism for the field deflection coil its magnetic field should show a barrel-shaped variation in the centre and at the end facing the display screen of the deflection unit. If this variation is realised with a known (straight-wound) toroidal field deflection coil or with a known saddle-shaped field deflection coil (having a constant average window opening), then this means necessarily that the produced magnetic field has a barrel-shaped variation everywhere, and so also on the side of the deflection unit adjacent the electron gun. Since it is usual to position the three electron guns in the sequence red, green, blue, this results in the green beam lagging behind the centre of the red beam and the blue beam during deflection. This resulting deflection error is termed coma.

It is possible to mitigate coma by winding the field deflection coil in a special manner: for this purpose, a toroidal field deflection coil should be wound "obliquely" and saddle-shaped field coil should be wound so that the average window opening varies in the axial direction. However, the disadvantage of this solution is that, apart from the more complicated winding process, it introduces East-West raster distortion.

The invention provides a deflection unit for a colour television display tube of the type in which the electron beams lie substantially in a single plane on which plane the longitudinal axis lies, the central one of said beams, when undeflected, substantially coinciding with said longitudinal axis, and having a display screen for providing a rectangular display and an electron gun assembly for producing said electron beams, said deflection unit comprising a saddle shaped line deflection coil consisting of two diametrically oppositely arranged line coil portions for deflecting the electron beams in a first direction when the unit is mounted on a display tube, a field deflection coil surrounding said line deflection coil, said field deflection coil consisting of two diametrically arranged field deflection coil portions for deflecting the electron beams in a direction transverse to said first direction when the unit is mounted on a display tube, an annular core member of soft magnetic material surrounding at least the line deflection coil, a first and a second end such that when said unit is mounted on a display tube with the longitudinal axis of said unit substantially coinciding with that of said display tube the said first end faces said display screen whilst the said second end is adjacent said electron gun assembly, and two soft-magnetic segments located diametrically opposite to each other between the line and field deflection coils

adjacent the centre of the field deflection coil, the deflection unit being arranged such that when energised the magnetic field resulting from said field deflection coil in planes perpendicular to said longitudinal axis is barrel shaped about the deflection centre adjacent the centre of the field deflection coil.

The construction of the segments from soft-magnetic sheet material makes it easy to assemble them in a simple manner between the line and field deflection coils.

The above and other features of the invention will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a diagrammatic longitudinal sectional view of a colour television display tube having a deflection unit according to the invention,

Figure 2 is a diagrammatic elevation of a cross-sectional view of the colour display tube and deflection unit shown in Figure 1 taken on the line II-II;

Figure 3 is a perspective view of the soft-magnetic segments shown in Figures 1 and 2;

Figure 4 is a view corresponding to that of Figure 3 but showing an alternative construction,

Figure 5 shows diagrammatically the deflection fields at the display screen end of a conventional "in-line gun" deflection unit;

Figures 6 and 7 are graphic representations of the value of the parameter H_z along the Z-axis of display tubes having conventional deflection units;

Figure 8 shows diagrammatically the value of the parameter H_z along the Z-axis of a display tube having a deflection unit according to the invention; and

Figures 9, 10 and 11 show the field deflection magnetic fields generated by the deflection unit according to the invention.

Figures 1 and 2 show a colour display tube 1 having a display screen 2, a neck 3 and an electron gun assembly 4. An electron beam deflection unit 5 is mounted on the display tube 1. The deflection unit 5 comprises an annular core member 6 of soft-magnetic material which encloses a line deflection coil 7 and a field deflection coil 8. The deflection coils 7 and 8 in the present case consist of a pair of coil portions 11, 12 and 13, 14, respectively, of the shell type, that is to say that their ends (flanges) adjacent the electron gun assembly extend parallel to the longitudinal axis Z of the display tube 1. However, the invention is not restricted to the use of this type of coil.

Segments 9 and 10 of soft-magnetic material are arranged between the deflection coils 7 and 8 in such manner that segment 9 is associated with field deflection coil portion 11 and segment 10 is associated with field deflection coil portion 12. As a result of this, the segments 9 and 10 extend substantially parallel to the magnetic field generated by the field deflection coil 8. While Figure 3 shows segments 9 and 10 each consisting of one piece (in which the dimension of the segments in the Z direction is, for example, 14

mm for a deflection unit for a 100° display tube having a 26 inch display screen), it has been found possible to separately influence certain field gradients if each segment 9 and 10 is divided into an equal number of separate sections, for example, 9A, 9B, 9C and 10A, 10B, 10C as shown in Figure 4. The segments 9A, 9C and 10A, 10C and the segments 9B and 10B, respectively, have the same shape and are positioned symmetrically. If desired, only the segments 9A, 9C and 10A, 10C may be used, while omitting the sections 9B and 10B, so that only correction of higher order errors takes place. A further possibility in this connection is to move the segments in the Z-direction relative to each other. The segments may in general be manufactured from any soft-magnetic material having a permeability > 100 . The effect of the segments will be explained in detail hereinafter.

When a color display tube of the type having in-line electron beams is combined with a deflection unit of the astigmatic type which has a magnetic field distribution in which, as shown in Figure 5, that due to the field deflection coil is barrel-shaped and that due to the line deflection coil is pin-cushion-shaped, automatic convergence without any form of dynamic correction is possible in principle.

In order to obtain an acceptable level of astigmatism for the field deflection coil, the magnetic field generated by that deflection coil should have a barrel-shaped variation at the centre of the deflection unit and on the end of the deflection unit facing the screen. In the case of a straight-wound toroidal field deflection coil i.e. where the turns lie in radial planes which pass through the longitudinal axis of the core this means necessarily that the magnetic field has a barrel-shaped variation everywhere, hence also at the end of the deflection unit adjacent the electron gun assembly. This results in the green beam lagging behind the centre of the red beam (R) and the blue beam (B) during deflection (Figure 5). This deflection error is termed coma. Figure 6 is a graph which represents the variation along the Z-axis of the parameter H_z known from the technical literature for a straight-wound toroidal field deflection coil. Where H_z is positive the field configuration in a plane perpendicular to the Z-axis is cushion-shaped and where H_z is negative it is barrel-shaped. For the description and the measurement of H_z reference is made to the article by R. Vonk in Philips Technical Review, Volume 32, 1971 No. 3/4, pp. 61-72. For a coma-free magnetic field the value of H_z integrated in the axial direction must be small. For straight-wound toroidal field deflection coils, however, this value is considerable.

The raster defects as they are generated by a deflection unit are determined in particular by the shape of the deflecting magnetic fields at the screen end of the unit.

A barrel-shaped variation of the magnetic field of the field deflection coil in this area stimulates a pin-cushion shaped East-West raster distortion. In

the case of a straight-wound toroidal field deflection coil the extent of barrel-shape of the magnetic field is comparatively low so that the resulting East-West pin cushion distortion turns out to be comparatively low (8% is typical).

A possible way of correcting the frame coma is to wind the toroidal field deflection coil "obliquely". It can then be achieved that the magnetic field at the electron gun end of the field deflection coil becomes pin-cushion shaped so that the coma is pre-corrected as it were for the coma influence of the barrels-shaped magnetic field farther on at the display screen end of the deflection unit. The variation of the magnetic field parameter H_z will then be as indicated in Figure 7. The zero crossing of H_z lies near the deflection point P. The integrated value is now small. In order to arrive at a good level for astigmatism in these coils the magnetic field at the display screen end of the deflection unit is much more strongly barrel-shaped than in the case of the straight-wound field deflection coils. This is the reason why these coils produce a greater pin cushion-shaped East-West raster distortion (in this case 14% is typical).

As regards the magnetic field shapes which can be generated and the results with respect to astigmatism, coma and raster defects, roughly the same conclusions hold for field deflection coils of the saddle type (including also the so-called shell type coil) as described for the toroidal field deflection coils.

At a given axial position the configuration of the produced magnetic field is determined by the distribution of the conductors of the coil in the corresponding part of the coil between the front end and the rear end. A measure for this distribution is the "average window opening". The window opening is expressed as the opening angle θ with respect to the axis of the deflection unit. A saddle coil having an average window opening which is constant along the Z-axis generates an H_z function which is analogous to a straight-wound toroidal coil. A saddle coil having an average window opening which varies along the Z-axis may generate an H_z function which is analogous to that of an "obliquely" wound toroidal field deflection coil. This means that for a saddle-shaped field deflection coil with varying window opening it also holds that since the field deflection coil is made coma-free a larger East-West raster distortion will be the result than when coma is permitted.

An acceptably small frame coma error, a good level of astigmatism and a promotion of a less pin-cushion shaped East-West raster distortion can be obtained, as disclosed in Application No. 7903717 (Serial No. 2013973) by a variation of the magnetic field H_z as shown in Figure 8. The average value of H_z is small so that the coma error can be acceptably small. The strongly negative value (hence a strongly barrel-shaped field) in the middle of the deflection field, that is to say about the deflection centre, produces in the first instance an astigmatism level which is too high, but a relatively weak positive variation of H_z (hence a

weak pin-cushion shaped field) at the display screen end of the field, as denoted by the solid line in the right-hand part of Figure 8, can reduce the astigmatism to a favourable level. This weak positive variation of H_z stimulates a weakly barrel-shaped East-West raster distortion. Therefore, with the variation of the parameter H_z of the field deflection magnetic field denoted by the solid line the resulting East-West raster distortion of a complete deflection unit designed for an "in-line gun" display system can be considerably less pin-cushion shaped than the raster distortion which, in otherwise the same circumstances can be achieved with the variation of H_z shown in Figure 7.

A variation at the display screen side as denoted by the broken line in Figure 8 is slightly less optimum but still more favourable than the variation shown in Figure 7. In that case H_z is not positive but slightly negative (or even zero) which is inherent in a weak barrel-shaped (or undistorted) field, respectively. This, too, results in a less pin cushion-shaped raster distortion than that to which the H_z variation of Figure 7 give rise.

The desired variation of H_z can be realised in a very practical manner by means of magnetic field conducting means formed by the segments which are shown in Figures 3 and 4 and which are provided between the line deflection coil and the field deflection coil and which may be constructed as flat or slightly curved segments of soft-magnetic material. By accommodating them adjacent the centre of the field deflection coil, the level of astigmatism level of the field deflection coil is mainly influenced and the coma error is influenced to a smaller extent. The strong negative peak in the variation of the parameter H_z in which a barrel-shaped distortion of the field deflection magnetic field is inherent (Figure 10), is obtained by the orientation of the segments parallel to the magnetic field of the field deflection coil. Figures 9 and 11, respectively, show the small amount of pin-cushion shaped magnetic field generated at the screen end of the deflection unit and the pronounced pin-cushion shaped magnetic field generated at the electron gun end of the deflection unit. The influence on the level of astigmatism of the field deflection coil is expressed as less "overfocusing" or more "underfocusing" of the two outermost beams relative to each other.

The influence on the astigmatism error of the field deflection coil is such that segments having a length in the axial direction of 10 to 15 mm, and dimensions in the circumferential direction of 20 to 30 mm, accommodated within a saddle/shell field deflection coil for a 26 inch display tube (thick neck) may give rise to an astigmatism correction of 5 to 10 mm if they are positioned to substantially surround the field deflection centre.

For good operation of the segments it is essential that they be placed in the field deflection magnetic field in an axial position where the electron beams have already experienced some deflection. As a result of this, the beams will also be influenced by field components which are of a

higher order than those described with the parameter H_z . On the other hand, these higher-order field components near the segments are greatly influenced by the segments. In other words: in addition to the influence of what is known as the "third-order behaviour" of the field deflection coil by these members, there is also an influence on the higher order behaviour. Notably there is an influence on errors which are known as anisotropic coma and anisotropic astigmatism. The sensitivity of the behaviour of the deflection coil to the detail structure of the members increases with increasing order of the behaviour. For adjusting a correct "higher order" behaviour, several embodiments are therefore realisable of members which affect the magnetic field which nevertheless always give the same influence of the "third order" behaviour. It is feasible *inter alia* to split up the members into several parts, both in the direction of the Z-axis and in the circumferential direction. Furthermore, variations of shape on the rectangular basic form are possible.

CLAIMS

1. A deflection unit for a colour television display tube of the type in which the electron beams lie substantially in a single plane on which plane the longitudinal axis lies, the central one of said beams, when undeflected, substantially coinciding with said longitudinal axis, and having a display screen for providing a rectangular display and an electron gun assembly for producing said electron beams, said deflection unit comprising a saddle shaped line deflection coil consisting of

- two diametrically oppositely arranged line coil portions for deflecting the electron beams in a first direction when the unit is mounted on a display tube, a field deflection coil surrounding said line deflection coil, said field deflection coil consisting of two diametrically arranged field deflection coil portions for deflecting the electron beams in a direction transverse to said first direction when the unit is mounted on a display tube, an annular core member of soft-magnetic material surrounding at least the line deflection coil, a first and a second end such that when said unit is mounted on a display tube with the longitudinal axis of said unit substantially coinciding with that of said display tube the said first end faces said display screen whilst the said second end is adjacent said electron gun assembly, and two soft-magnetic segments located diametrically opposite to each other between the line and field deflection coils adjacent the centre of the field deflection coil, the deflection unit being arranged such that when energized the magnetic field resulting from said field deflection coil in planes perpendicular to said longitudinal axis is barrel shaped about the deflection centre adjacent the centre of the field deflection coil.
2. A deflection unit as claimed in Claim 1, in which each segment is either flat or curved and formed of sheet material, one segment being provided at a previously determined distance from the other.
3. A deflection unit as claimed in Claim 2, in which each segment is formed by a plurality of members of sheet material radially spaced from each other.

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higher order than those described with the parameter H_2 . On the other hand, these higher-order field components near the segments are atly influenced by the segments. In other words: in addition to the influence of what is known as the "third-order behaviour" of the field deflection coil by these members, there is also an influence on the higher order behaviour. Notably there is an influence on errors which are known as anisotropic coma and anisotropic astigmatism. The sensitivity of the behaviour of the deflection coil to the detail structure of the members increases with increasing order of the behaviour. For adjusting a correct "higher order" behaviour, several embodiments are therefore realisable of members which affect the magnetic field which nevertheless always give the same influence of the "third order" behaviour. It is feasible *inter alia* to split up the members into several parts, both in the direction of the Z-axis and in the circumferential direction. Furthermore, variations of shape on the rectangular basic form are possible.

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2. A deflection unit as claimed in Claim 1, in which each segment is either flat or curved and formed of sheet material, one segment being provided at a previously determined distance from the other.

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