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APPARATUS FOR CONTROL OF ELECTRON BEAM CROSS SECTION

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FIG. 1.

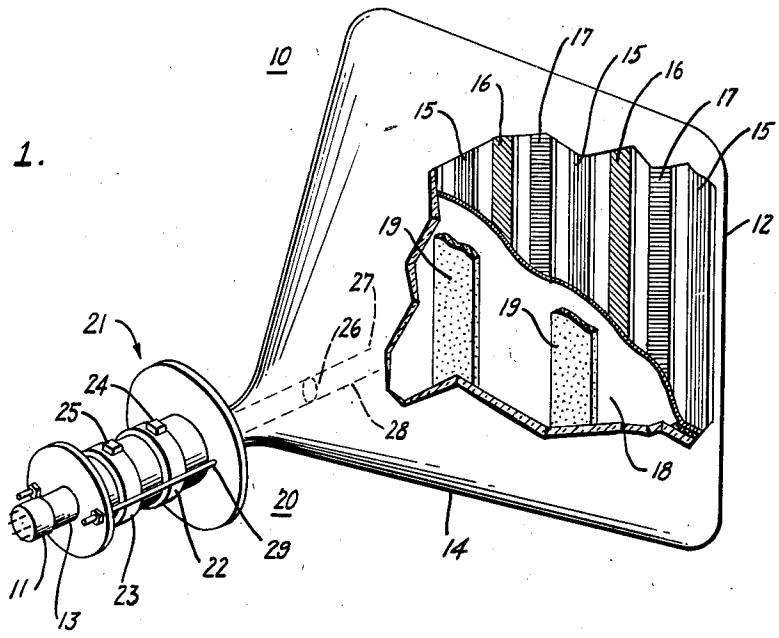
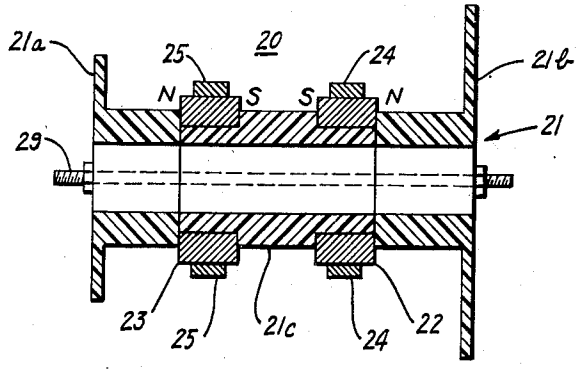


FIG. 2.



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APPARATUS FOR CONTROL OF ELECTRON BEAM CROSS SECTION

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The invention relates to improved apparatus for controlling the cross-section of the electron beam within a cathode ray tube.

In most applications of cathode ray tubes, it is of importance to have some measure of control over the cross-section of the electron beam. As a practical matter, however, it sufficed until recently to impart to the beam a cross-section which was only very approximately of the desired size and shape. With the advent of color television, on the other hand, and particularly in view of current efforts to utilize a single cathode ray tube as the image reproducing device of a color television receiver, precise control of every parameter of the cross-section of the electron beam has become of the most vital practical importance.

As is well known, one form of cathode ray tube suitable for use as a color television image reproducer has a screen structure which comprises a large number of narrow phosphor strips, different ones of which are emissive of light of different colors in response to electron beam impingement. These strips are disposed with their longitudinal axes transverse to the horizontal scanning lines, and strips emissive of light in different colors recur in a predetermined sequence across the screen structure. It is apparent that, under these circumstances, it is extremely desirable to provide a beam whose cross-section, at impingement upon the phosphor strips has a width no greater than the width of any individual phosphor strip, for otherwise there exists the danger that the beam will excite simultaneously several different phosphor strips emissive of light in different colors. If this happens, undesired coloration and desaturation of the reproduced image may result.

In certain embodiments of such screen structures the width of each phosphor strip is approximately 10 mils. While it is difficult, under any circumstances, to provide an electron beam whose width is of that order of magnitude, the problem is further complicated, in the case of the color television tubes under consideration, by the fact that the height of the electron beam (i. e. its dimension transverse to the horizontal scanning lines) is preferably much greater than 10 mils. This is because it has been found that a considerable increase in light output from the screen structure can be realized, and visual merging of successive horizontal scanning lines (which is subjectively pleasant), can be achieved by providing an electron beam whose height is approximately 30 mils. Thus the beam which is best suited for use with the form of screen structure under consideration should have a cross-section in the general shape of an ellipse whose major axis is about three times as long as its minor axis, and whose minor axis is only about 10 mils long.

Prior attempts to produce an electron beam with this kind of cross-section have taken the form of passing the beam through apertures having the shape which it was desired to impart to the cross-section of the beam. Because of the distorting influence which such apertures have upon the paths of electrons traveling through them,

they have been incapable of producing beams of elliptical cross-section having the desired ratio of major to minor axes without also defocusing the beam and thereby causing its minor axis to exceed substantially the aforenoted 10 mil limit. Furthermore the shaped apertures used in the prior art for controlling beam cross-section have invariably produced beams which exhibit a substantial amount of astigmatism. This, in turn, made it necessary to control very precisely the distance between the beam shaping apertures and the screen structure, for any variation in this distance would produce not only a change in the over-all size of the impinging beam but also a variation in the ratio of the lengths of its major and minor axes.

It has also been known how to produce an electron beam which was unusually free from astigmatism but not with the elliptical cross-section required for my purposes nor with the required minute minor axis.

Accordingly it is a primary object of the invention to provide new and improved apparatus for controlling, in a cathode ray tube, the cross-sectional shape and dimensions of the electron beam at impingement upon the screen structure.

It is another object of the invention to provide improved apparatus for imparting, to the electron beam of a cathode ray tube, an elliptical cross-section having major and minor axes whose lengths are in a ratio of approximately three to one.

It is still another object of the invention to provide apparatus for imparting to the electron beam of a cathode ray tube an elliptical cross-section whose minor axis is unusually short at impingement upon the screen structure.

It is a still further object of the invention to provide apparatus for imparting to the electron beam of a cathode ray tube an elliptical cross-section without, however, introducing substantial astigmatism into the beam.

These and other objects of the invention which will appear are achieved by surrounding a portion of the cathode ray tube traversed by the undeflected beam with at least one ring of ferromagnetic material, magnetized in a direction parallel to the beam path, and having applied to its outside surface at least one additional piece of initially unmagnetized, ferromagnetic material. This piece of additional material is of such size as to extend over only a small fraction of the circumference of the magnetized ring. I have found that, if this additional material is appropriately positioned along the circumference of the magnetized ring, the desired cross-section will be imparted to the electron beam. It is recognized that, in the past, it was known to place, near the electromagnetic focusing coil of a cathode ray tube, small pieces of ferromagnetic material to produce a beam of more nearly circular cross-section. Such an arrangement, however, differs completely from that disclosed herein, and is incapable of producing an anastigmatic beam of elliptical cross-section, and particularly one having the minute minor axis achievable in accordance with the teaching of the present disclosure.

The details of construction and operation of apparatus embodying my invention will be better understood from the following discussion considered in conjunction with the accompanying drawings wherein:

Figure 1 is a perspective view of a color television cathode ray tube equipped with apparatus embodying my invention; and

Figure 2 is a cross-sectional view of that portion of the apparatus of Figure 1 which embodies my invention.

As has been pointed out previously, my invention is particularly useful in connection with certain types of cathode ray tubes used in the reproduction of color television images. One form of such a cathode ray tube is

illustrated in Figure 1 to which more particular reference may now be had. This tube comprises a conventional envelope **10** terminating in a conventional base **11** at one end and in a faceplate **12** at the opposite end. The envelope **10** comprises a neck portion **13** which may be of conventional cylindrical cross-section and further comprises a flared portion **14** which connects the faceplate **12** to that end of the neck portion which is closer to the faceplate. Upon the interior surface of the faceplate **12** there is deposited the screen structure whose particular geometrical configuration gives rise to the problem which is solved by my invention. As shown in Fig. 1 this screen structure comprises a plurality of parallel phosphor strips **15**, **16** and **17**, of which those designated **15** are responsive to electron impingement to emit red light while those designated **16** are similarly responsive to emit green light and those designated **17** are responsive to emit blue light. These phosphor strips are shown disposed in recurrent sequence across the screen structure and are arrayed with their longitudinal axes in a vertical direction.

It will be understood that the illustration of these phosphor strips in Fig. 1 is diagrammatic and that, in practice, the screen structure of the cathode ray tube includes many more phosphor strips than have been illustrated (the actual number is approximately 1200 for a 21" tube) and that the individual phosphor strips are much narrower than shown in Fig. 1 (i. e. approximately 10 mils wide).

Superposed upon the phosphor strips **15**, **16** and **17** is an electron-permeable layer **18** of a conductive material, such as aluminum, for example, which has been shown partly broken away to show the underlying phosphor strips. This aluminum layer serves the usual purpose of reflecting light emitted by the phosphor strips toward the interior of the tube back toward the faceplate and through that faceplate toward the observer, thereby increasing the effective light emission efficiency of the screen structure. In addition, in the particular tube illustrated, this conductive layer **18** serves to provide a surface of uniform secondary electron emissivity, upon which are disposed additional strips **19** of a material (such as magnesium oxide, for example) which has a secondary electron emissivity considerably higher than that of the aluminum. These strips **19** are disposed in a predetermined geometrical alignment with the phosphor strips. For example, in the case illustrated, successive ones of these magnesium oxide strips are aligned with successive red light emissive phosphor strips **15**. The purpose of providing these strips **19** is not material to the present invention. Briefly, however, they serve to provide distinctive electrical indications of beam impingement upon red light emissive phosphor strips, thereby also providing indications of the instantaneous position of the electron beam during its scanning of the screen structure. These distinctive indications are useful in controlling the rate of scanning of the electron beam and/or the rate at which picture intelligence is utilized to control the intensity of the beam.

In the operation of a tube such as that illustrated in Figure 1, the electron beam is generated in an electron gun (not shown) of conventional form disposed within neck **13** near the base end thereof and traverses this neck substantially without deflection. The beam is then deflected, at or near the transition between the neck and the funnel, by means of conventional electrostatic or electromagnetic deflecting apparatus (not shown) so as to scan a conventional raster upon the screen structure of the tube. In accordance with my invention that portion of the neck **13** which is traversed by the undeflected beam is surrounded by an assembly **20** which comprises a non-magnetic supporting sleeve **21** provided with flanges at each end. Spaced along this sleeve are two rings, **22** and **23**, of ferromagnetic material magnetized in a direction parallel to the direction of travel of the electron beam. More particularly each of these rings may be of the conventional form employed for focusing the electron beam of a cathode ray tube. For example each ring may be formed of a ferrite material molded into an annular shape of rectangular cross-section. As has been noted, each of these rings is magnetized in a direction parallel to the direction of propagation of the electron beam, but this magnetization is of opposite sense for the two rings—that is, ring **22** may be oriented with its north pole nearer the tube base **11**, in which case ring **23** will be oriented with its north pole farther from the base. Mounted upon, and in direct contact with the outer surface of each of these rings, are additional pieces of magnetic, but initially unmagnetized material. In Figure 1 the additional piece of material shown mounted on ring 22 is designated by reference numeral **24** while that mounted on piece **23** is designated by reference numeral **25**. In addition, similar pieces of ferromagnetic material are preferably mounted at diametrically opposed points on the circumference of each of these rings, but these latter pieces are not visible in Figure 1. I have found that each of these additional pieces of ferromagnetic material **24** and **25** should be mounted upon the outside surface of its respective magnetic ring in such a position that a line passing through the center of that piece and through the axis of the electron beam is substantially parallel to the major axis of the ellipse into which it is desired to shape the electron beam. In the case of the tube structure illustrated in Figure 1 it may be desirable to shape the electron beam into an ellipse having its major axis extending vertically, i. e. parallel to the phosphor strips of the screen structure. This desired shape of the beam is diagrammatically illustrated in Fig. 1 by the broken line ellipse **26** which represents the cross-section of an electron beam whose outer boundaries are indicated diagrammatically by broken lines **27** and **28**. I have also found that all of the additional pieces of ferromagnetic material applied to any given magnetized ring in accordance with my invention should occupy, together, not more than approximately 10 percent of the circumference of this ring.

The reasons for the effectiveness of the aforedescribed arrangement in producing an elliptical beam which does not suffer from substantial astigmatism, which has a minor axis of unusually small dimension and which has an unusually high ratio of major to minor axis length, are not fully understood at this time. However, the existence of the phenomenon has been fully established experimentally and has, in fact, given a new impetus to the use of a cathode ray tube of the form illustrated in Figure 1.

It will be noted that the builder of beam shaping apparatus embodying my invention has considerable latitude in the choice of the exact dimensions of the pieces of ferromagnetic material applied to the magnetic rings. No precise directions governing these dimensions can be given because they depend upon a great many variables, such as the cross-sectional shape and size of the beam prior to passage through the apparatus embodying my invention, the intensity of this beam and the relative positions and field strengths of the ferromagnetic rings. As a practical matter, however, the proper dimensions can conveniently be determined, for any actual case, by first adjusting the magnetic rings, without the additional pieces of material, in accordance with entirely conventional principles to produce the best focused beam possible with circular cross-section and then applying several additional pieces of material, of varying sizes, until observation of the actual beam indicates that it has reached its desired cross-sectional shape.

The details of construction of the assembly **20** of Fig. 1 are further illustrated in Fig. 2, to which more particular reference may now be had. This figure is a cross-sectional view of this assembly taken in a vertical plane parallel to the axis of the beam. As shown therein, the non-magnetic mounting sleeve **21** consists preferably of three separate pieces, namely two flanged end pieces **21a**

and 21*b* and a center piece 21*c* having a thick central portion and thinner end portions. Upon the thin end portions of this center piece 21*c* are seated the magnetized rings 22 and 23 which are then secured in position by abutting the flanged end pieces against them. The entire assembly is held together by bolts 29 attached to the flanges of the end pieces 21*a* and 21*b* and extending lengthwise of the assembly between these flanges. The additional pieces of ferromagnetic material 24 and 25 provided in accordance with my invention are secured to the outer surface of the magnetic rings in any desired manner, e. g. by merely gluing them in place with a suitable adhesive. All three sections of the mounting sleeve are, of course, hollow so as to fit over the neck of the cathode ray tube.

It will be understood that a number of other physical arrangements of the apparatus embodying my invention can be devised by those skilled in the art without departing from my inventive concept. Accordingly I desire the scope of this concept to be limited only by the appended claims.

I claim:

1. Beam shaping apparatus for cathode ray tubes comprising a ring of ferromagnetic material magnetized in a direction parallel to the axis of said ring and a piece of initially unmagnetized ferromagnetic material applied directly to the outer surface of said ring, said piece of material having such dimensions as to occupy only a small fraction of the circumference of said surface.

2. Apparatus according to claim 1 further characterized in that the value of said small fraction is less than approximately one-tenth.

3. Beam shaping apparatus for cathode ray tubes comprising a ring of ferromagnetic material magnetized in a direction parallel to the axis of said ring and a pair of pieces of initially unmagnetized ferromagnetic material respectively applied directly to the outer surface of said ring at diametrically opposed regions thereof, said pieces of material having such dimensions as to occupy, together, only a small fraction of the circumference of said surface.

4. In combination: a cathode ray tube having means for projecting an electron beam within said tube and means for elongating the cross-section of said beam in a predetermined direction, said last-named means comprising a ring of ferromagnetic material disposed concentrically about the path of said electron beam, said ring being magnetized in a direction parallel to said path, and at least one piece of initially unmagnetized ferromagnetic material applied directly to the outer surface of said ring in such a position along the circumference of said surface that a line connecting said piece of material and said beam path is substantially parallel to said direction of elongation.

5. In combination: a cathode ray tube having a screen structure comprising a plurality of elongated, parallel phosphor strips emissive of light in different colors and having means for projecting an electron beam toward said screen structure; a ring of ferromagnetic material disposed concentrically about the path of said electron beam, said ring being magnetized in a direction parallel to said beam path; and a pair of pieces of ferromagnetic material applied directly to diametrically opposed portions of the outside surface of said ring and in such circumferential positions that a line connecting said pieces of material and said beam path is substantially parallel to said phosphor strips.

6. In combination: a cathode ray tube having a screen structure comprising a plurality of elongated, parallel phosphor strips emissive of light in different colors and having means for projecting an electron beam toward said screen structure; a pair of rings of ferromagnetic material disposed concentrically about spaced portions of the path of said electron beam, said rings being magnetized in a direction parallel to said beam path but in opposite senses; and at least one piece of initially unmagnetized ferromagnetic material applied directly to the outer surface of each said ring in such circumferential position that a line connecting each said piece of material and said beam path is substantially parallel to said phosphor strips.

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