United States Patent

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[54] **DISTORTION REDUCTION OF CHARACTER APERTURE MASK IN SHAPED BEAM TUBES**
1 Claim, 4 Drawing Figs.

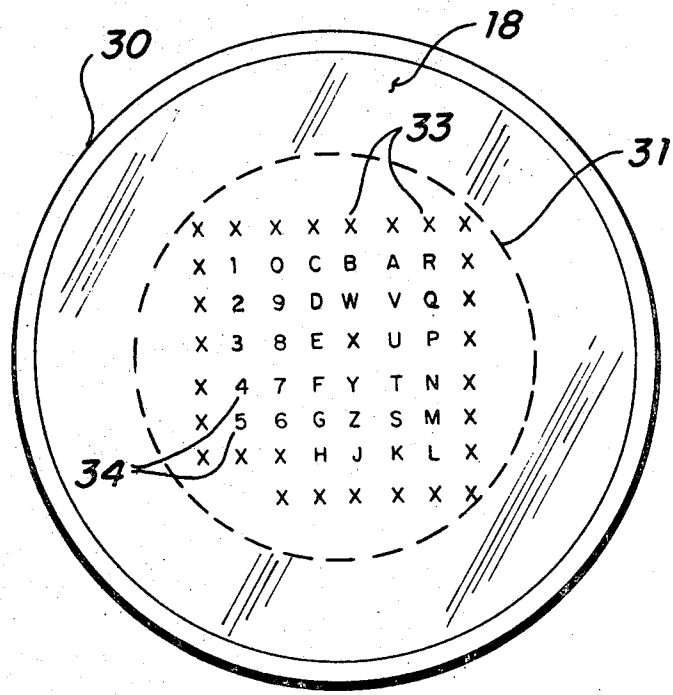
[52] U.S. Cl. 313/86, 313/83
[51] Int. Cl. H01j 29/56, H01j 31/16
[50] Field of Search ..... 313/86 KM

[56] **References Cited**
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ABSTRACT: A shaped beam cathode-ray tube having an improved character-bearing matrix is disclosed. The character shaping matrix consists of a thin sheet having a plurality of shaped apertures therethrough corresponding to the desired character shapes, grouped in an active character area. The quality of images produced by a tube using such a matrix is improved when a row of similar apertures is added surrounding the active character area. The areas and spacing of these outer apertures is important in achieving optimum distortion reduction.



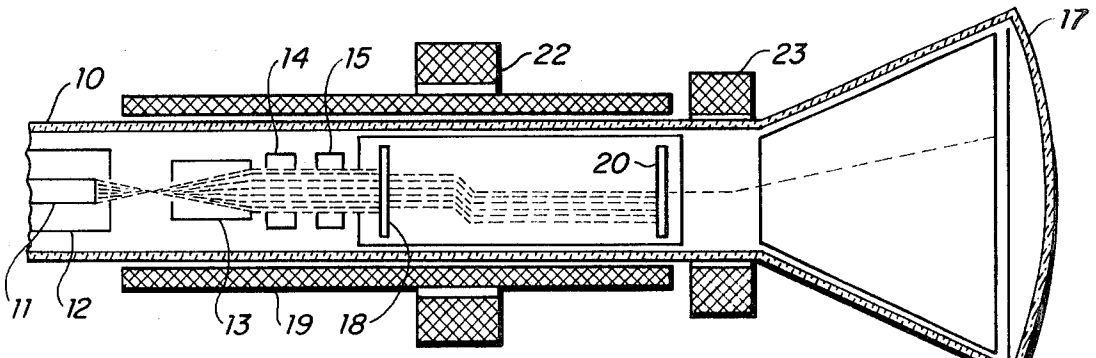
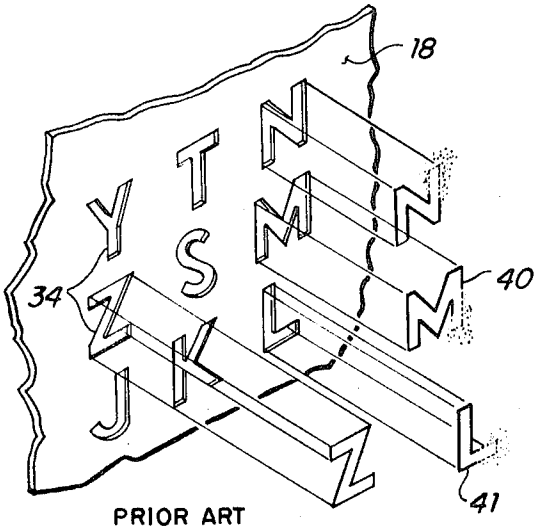
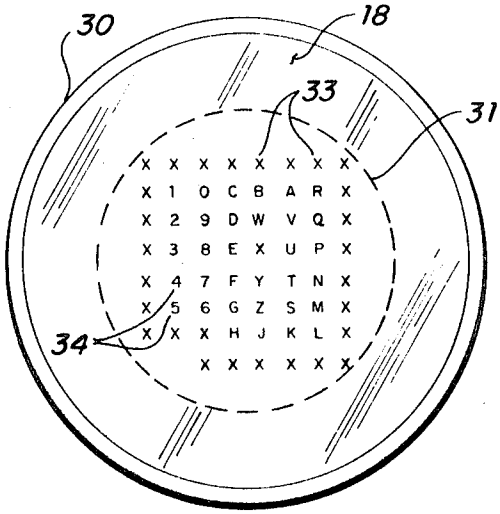


FIG. 1



PRIOR ART
FIG. 3

FIG. 2



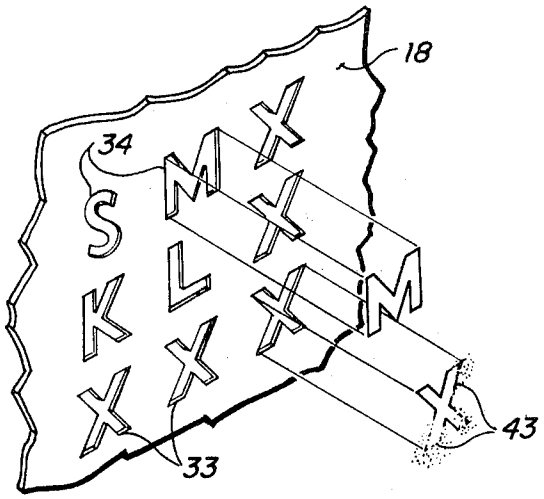


FIG. 4

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DISTORTION REDUCTION OF CHARACTER APERTURE MASK IN SHAPED BEAM TUBES

BACKGROUND OF THE INVENTION

Cathode-ray tubes utilizing character-shaped apertures in a matrix sheet to shape an electron beam, such as are described by Joseph T. McNaney in U.S. Pat. Nos. 2,761,988 and 2,824,250 are now well known. In such a tube, a thin electron-opaque sheet bearing a plurality of character-shaped apertures is located across the electron beam path within the tube. After the electron beam passes through the matrix it will consist of a plurality of beams having cross-sectional shapes conforming to the desired character shapes. A selected shaped beam is then directed to the tube face, where it typically impinges on a phosphor coated screen whereby an area is energized or illuminated corresponding to the selected character aperture through which the beam passed. In this manner, a great many characters may be rapidly formed on the tube face to provide a visible display for viewing or for copying with any suitable photosensitive system. Such shaped beam tubes have proved to be highly effective in producing displays at high character printing rates with excellent character quality and resolution. Such tubes have come into wide commercial use.

Problems, however, remain in achieving consistent high character quality. The character images formed on the tube face may be distorted in many ways. For example, the thin matrix sheet may be warped or distorted by differential thermal expansion across the sheet during operation of the tube. The matrix sheets tend to be very thin, generally having a thickness of about 0.001 inch. The characters may have heights of no more than about 0.008 inch. Thus, it can be seen that even slight warping, bulging, or distortion of the matrix can adversely effect the quality of the characters generated on the tube face.

Also, any undesired slight unbalanced electrostatic or electromagnetic fields in the tube or adjacent the tube may adversely effect the image formed by the electron beam. Careful design of the tube and the surrounding equipment tends to substantially eliminate these undesired electrostatic and electromagnetic effects. The inclusion of carefully designed slits in the matrix near the active character area tends to relieve the warping and distortion problems resulting from differential thermal expansion. Such thermal distortion elimination systems are described in copending U.S. Pat. applications Ser. No. 838,621, filed July 2, 1969 and Ser. No. 658,009, filed Aug. 2, 1967 While these various techniques have served to improve the quality of the character images produced by the tubes, the images do not yet have the desired uniform high sharpness and resolution.

It has been found that in the usual matrix, that the characters around the outer edge of the active character area tend to be distorted to a greater degree than those towards the center of the active character area. This distortion generally takes form of a "flaring" of character lines in a direction along a line drawn outwardly from the center of the matrix active character area. Also, a general decrease in sharpness of the outer active characters has been noted. It had been thought that this distortion was caused by the fact that the electron beam had to be deflected to a greater extent to direct the shaped beam from the outer characters in the required manner than would be necessary with the inner characters which are significantly closer to the optical axis of the electron beam and of the tube. Therefore, it was thought that elimination of this distortion would not be possible.

However, it would be highly desirable if this nonuniformity in image quality could be eliminated so that all of the characters displayed on the tube face would have uniform high resolution and sharpness.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide a distortion correcting system for shaped beam cathode-ray tubes which overcomes the above-noted problems.

It is another object of this invention to provide a matrix for a shaped beam tube of improved quality character generating capability.

It is still another object of this invention to provide an improved shaped beam tube system providing images of higher resolution and sharpness.

The above objects, and others, are accomplished in accordance with this invention by providing an improved matrix for use in shaped beam cathode-ray tubes which has in addition to the plurality of character-shaped apertures grouped in an active character area, one or more additional row of apertures surrounding the active character area. Preferably, each of the apertures in the outer row has an aperture area approximately corresponding to the average individual active character aperture area and are spaced from each other and from the outer active characters about the same distance as the active characters are spaced from each other. Preferably, this outer row of apertures is with the area on the area on the matrix sheet flooded by the electron beam during tube operation. This improved matrix shows much less distortion in the outer row of active characters than do prior art matrices. Of course, the apertures in the row outside the active area are never imaged on the tube screen, so that distortion in these apertures is immaterial. The outer row of apertures may have any desired shape. Typical shapes which have been found to work well include the letters "O" and "X." Characters such as these are preferred since their aperture areas are substantially equal to the average character aperture area and they tend to have the same maximum dimensions as most of the active characters.

While the mechanism by which this invention reduces distortion in the outer row of active characters is not fully understood, it is thought to be a result of electron repulsion phenomena. In shaped beam tubes of the aperture selection type, the electron beam floods the entire matrix. Thus, the electrons which pass through the matrix are in the form of a plurality of parallel electron bundles or beams each having a character-shaped cross section. The outer shaped beams have adjacent shaped beams on the side toward the center of the matrix, but no shaped beams on the outer side. Since electrons tend to repel each other, the beams toward the center of the matrix are subject to repulsion forces from all directions substantially uniformly. This results in little distortion. However, the outer beam is repelled only by electrons from one side. This causes the electrons to move slightly outwardly away from the center of the matrix as they pass down the tube. This results in distortion in character lines in these outer areas. The electrons are moving at relatively low velocity in this area, so that the unbalanced forces have an especially great influence. Also, secondary electrons released from the matrix are affected to a greater extent by these unbalanced forces, since they are moving at a very low velocity. In addition, differential thermal expansion in the matrix area which is heated by the electrons which strike the matrix may cause distortion which will tend to wrinkle the outer row of apertures to a greater extent than in other areas. Thus, the outer row of added apertures may add some flexibility to the matrix and decrease the distortion in the active character area. This theoretical explanation of the presumed mechanism by which the invention operates is further detailed in FIGS. 3 and 4.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, and certain preferred embodiment thereof, will be further understood upon reference to the drawings wherein:

FIG. 1 is a schematically represented longitudinal section through a shaped beam cathode-ray tube of the sort in which the improved matrix of this invention is useful;

FIG. 2 is a plan view of the matrix of this invention;

FIG. 3 is a perspective view of an enlarged portion of a matrix according to the prior art showing the formation of a plurality of shaped electron beams; and

FIG. 4 is a perspective view of an enlarged portion of the matrix of FIG. 2 showing the formation of a plurality of shaped electron beams according to this invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1, there is seen a schematic representation of a shaped beam tube of the aperture selection type. The cathode-ray tube comprises an evacuated envelope **10** which may be made of glass, plastic, metal, etc. Within envelope **10** is mounted an electron source **11**, control grid **12**, accelerating electrode **13**, first anode **14** and second anode **15**. In operation, a beam of electrons is emitted from source **11** and directed through first grid **12** to the target which is generally a phosphor layer on the inner surface of faceplate **17**. Grid **12** is spaced from source **11** and may be in the form of a cylinder having an aperture therein through which the electron beam may pass. As is well known, grid **12** performs the same function as a control grid in an ordinary vacuum tube. Electrode **13**, first anode **14**, and second anode **15** in cooperation with grid **12** function as an electrostatic lens which causes the electron beam generated by the source **11** to be initially shaped and collimated as it passes along the predetermined path. Beam shaping matrix **18**, which may be in the form of a thin sheet having letter, numeral, or symbol-shaped openings therein, is positioned in the path of the electron beam. The electron beam floods or overlays the entire active character area on matrix **18**. Thus, electrons pass through all character openings forming a plurality of substantially parallel electron beams each having the shape of the aperture through which is passed. Coil **19** which extends along the length of the neck of envelope **10** such that electrode **13** and anodes **14** and **15** are substantially within the magnetic field of the coil establishes lines of force parallel with the longitudinal axis of envelope **10**. This causes the parallel electron beams passing through matrix **18** to maintain their parallel trajectories. Unhindered, these parallel beams eventually strike aperture plate **20**. Plate **20** has a single aperture therein through which a single selected character beam may be passed. Selection of different shaped beams may be accomplished by suitable horizontal and vertical selection signals applied to a pair of mutually perpendicular coils **22** mounted on the envelope **10**. This causes the desired character beam to pass through the aperture in plate **20**. Since aperture plate **20** is mounted with the aperture aligned with the longitudinal axis of envelope **10**, the selected electron beam will be directed along a path essentially coaxial with the optical axis of the tube. In the absence of a control signal, none of the individual character beams strikes the aperture in plate **20**. When a suitable signal is introduced into coils **22** a selected character beam passes through the aperture in plate **20**. Character positioning means **23** associated with envelope **10** serves to direct the selected electron beam to a predetermined position on the phosphor layer on faceplate **17**. Also, electromagnetic means are shown for selecting the desired character. It is, of course, possible to use electrostatic means such as horizontal and vertical deflection plates to accomplish the same result. Anodes **25** and **26** are provided to serve in a conventional manner as acceleration anodes and may be aquadag coatings on the interior surface of envelope **10**, if desired. Suitable operating potentials are impressed on anodes **25** and **26** and the other element in a conventional and well-known manner.

While the shaped beam tube assembly shown in FIG. 1 is especially suitable for use with the improved matrix of this invention, other aperture selection tube arrangements may be used if desired, such as those described by McNaney in U.S. Pat. No. 2,761,988. While the tube shown schematically in FIG. 1 uses magnetic deflection, electrostatic deflection may be used if desired. Also, while the electron beam is shown focused at a point adjacent grid **12**, the beam may merely be initially shaped and collimated without point focusing, if desired.

Details of the matrix of the present invention will be further understood upon reference to FIG. 2 which shows the matrix **18** mounted within support rings **30**. The character apertures **34** are grouped together in an active character area, generally near the center of matrix **18**. The characters **34** are generally reasonably evenly spaced from each other. Of course, any arrangement of characters and symbols may be used, that shown in FIG. 2 being for illustration only. The electron beam which impinges on the matrix **18** floods the entire active character area. Broken line **31** illustrates the approximate boundary of the electron beam. In this illustration the active characters include numerals zero through nine and the alphabet, with the numerals "1" and "0" serving both as numerals and letters. In the embodiment illustrated, the active area is surrounded by an outer row consisting of the letter "X." The outer row characters are spaced from each other and from the active characters about the same distance as the active characters are spaced from each other. While any other suitable aperture shape may be used in outer row **33**, the letters "X" and "O" are especially desirable since they have an aperture area and overall dimensions about equal to the average active character aperture. The outer row **33** comes substantially within the area covered by the electron beam **31**. Thus, the plurality of individual parallel character-shaped beams extruded from this matrix will include a row of X-shaped beams surrounding the active character beams. Thus, all of the active character beams will have an adjacent electron beam on each side. The beams on each side of each active character will be substantially equal in size and spacing. Of course, an additional "outer row" of characters could be included, although a single row generally is as beneficial as multiple rows, and is simpler and more economical to produce. The arrangement of characters shown in FIG. 3 is entirely arbitrary, since a circular, rectangular or other arrangement may be used, as desired. As illustrated in FIGS. 3 and 4, this added uniformity substantially reduces distortion of letters produced by the outer row of active characters.

FIG. 3 illustrates the effect of plural individual character electron beams passing through a matrix according to the prior art. The portion of a matrix shown in FIG. 3 is similar to the lower right-hand corner of the matrix shown in FIG. 2 except that the outer row of apertures **33** around active character apertures **34** have not been included in the matrix shown in FIG. 3. As is well known, electrons moving in parallel closely spaced paths exert repulsion forces upon each other. As illustrated in FIG. 3, the electron beam making up the character "S" has adjacent electron beams above and below and on both sides thereof. Thus, repelling forces on the electrons making up the "S" beam are approximately balanced. However, the electrons making up the letters "M" and "L" are not centrally located and have shaped electron beams only on one side. Since the repelling forces are not quite in balance, electrons making up these letters are urged to the right. This unbalanced force tends to be approximately along a line drawn outwardly from the center of the active character area. Thus, a scattering or "flaring" effect is seen along the outer leg **40** of the letter "M" and portion **41** of the letter "L." While this flare effect is difficult to illustrate, it results in a definite blurring and loss of sharpness in the image produced on the tube screen. Of course, the distortion is exaggerated in FIG. 3 since the short distance shown in the drawing would cause less distortion. However, in the actual tube where the electron path is considerably longer, the distortion is easily seen.

Much of the distortion due to repulsion occurs in the region where the electrons are traveling slowly, that is, where they have been accelerated through only a small potential difference. The velocity of electrons in a vacuum is proportional to the square root of the potential difference through which the electrons have been accelerated, as is well known. In a typical tube, the matrix sheet is operated at about +120 volts, the focus electrode about +250 volts and the accelerating anode at about +4,000 volts. Thus, the electrons travel from the

cathode through the matrix at relatively low velocities and then are accelerated by the high potential of the accelerating anodes. Since the electrons travel at a substantial distance at low velocity, significant distortion can occur.

Distortions of the sort shown in FIG. 3, can be substantially eliminated by the inclusion of the outer row of apertures as provided by this invention. The effect of the outer row of apertures is illustrated in FIG. 4. As seen in FIG. 4, the outer row of active characters each have a shaped individual beam above and below and upon each side thereof. Only the outer row of individual beams are significantly affected by the unbalanced electron forces. Since the outer row, in this example the letter "X," is not utilized for display purposes, distortion therein is of no consequence. For clarity, the schematic appearance of the projected letters "M" and the lower right-hand "X" only are represented. Of course, similar shaped beams are produced by each of the outer active character apertures **34** and outer characters **33**. The shaped beam produced by the "M" aperture will now be undistorted since there will be similar parallel shaped beam on each side. The shaped beams produced by the outer apertures **33** may be distorted, as indicated at **43**, but this will be of no consequence since these beams are not used for display. Thus, distortion in the active characters is substantially eliminated.

Although specific character arrangements and specific characters have been shown in the above descriptions of preferred embodiments, these may be varied within the scope of the disclosure with similar results. For example, the outer row of characters may be apertures of any shape having the above-described characteristics and need not have a conventional alpha-numeric shape.

Other modifications and ramifications of the invention will become apparent to those skilled in the art upon reading the present disclosure. These are intended to be included within the scope of this invention as defined in the claims.

I claim:

1. In a shaped beam cathode-ray tube having an electron beam source at one end and a target at the other, a matrix sheet having an active character area having spaced active character apertures therein, arranged in the electron beam path so that said electron beam covers an area including but larger than said character area, means for directing an electron beam from said source through the apertures in said matrix toward said target, and selection means for directing selected character shaped beams to selected locations on said target, the improvement wherein at least one additional row of character apertures is provided around the active character area and located substantially within the area on said matrix sheet flooded by the electron beam during operation, each of said additional apertures having an area approximately equal to the average active character aperture area and being spaced from the outer active character apertures and from each other a distance approximately equal to the average active character aperture separation, said selection means preventing shaped electron beams from the additional character apertures from reaching the target.