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PHOTOGRAPHIC RECORDING APPARATUS HAVING CATHODE RAY READOUT OF A CHARACTER MASK**Joseph T. McNaney, La Mesa, Calif., assignor to General Dynamics Corporation, Rochester, N.Y., a corporation of Delaware**

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This invention relates to apparatus for producing a display, and more particularly to apparatus for producing shaped light beams and projecting them onto a printer or a large size display.

One prior-art approach to a display comprising shaped characters—such as letters, numerals, symbols, etc., is to use a cathode ray tube known as a "Shaped Beam" tube. This tube gets its name from its mode of operation, which is to direct electrons to a "matrix" having an arrangement of stencil-like apertures whose configurations correspond to various characters. As the electrons pass through these apertures, the cross section of the emergent electron beam is shaped to correspond with various characters. The shaped electron beam is then directed to selected areas of the fluorescent screen, where it produces a visible pattern that is representative of a selected character. A plurality of juxtapositioned visible characters thus spells out a message.

In order for shaped beam tubes to produce large displays containing one or more lines of information that can be seen by a number of people, or read from afar, the faceplate of the cathode ray tube must be quite wide. In addition, in order to present an entire line or set of lines, the cathode ray tube's deflection must be of the line-by-line or frame-by-frame type. Cathode ray tubes for large displays thus require relatively complex and power-demanding circuitry, and in addition, the tube itself becomes undesirably long as the size of the display increases.

Shaped beam tubes, while extremely successful, have inherent shortcomings. For example, in the electron beam shaping matrix some character-shaped apertures—such as "O," "D," or "B"—have unsupported central portions. These center portions will fall out, unless supported by "bridges" which unfortunately are difficult to make small enough so that they do not appear in the resultant display. Another shortcoming of a shaped beam tube is that once it has been fabricated, it is impossible to display characters other than those already in the matrix.

It is therefore the principal object of my invention to provide improved apparatus for presenting a display, particularly one that comprises message characters.

A further object is to provide a simplified high-speed message character display apparatus capable of displaying characters of improved resolution, or quality.

The attainment of these objects and others will be realized from the following specification taken in conjunction with the single drawing, which shows the basic concept of my invention.

Broadly speaking, my invention contemplates apparatus that produces a character-by-character display. I use a relatively small cathode ray tube wherein predetermined positions of the electron beam produce light beams whose cross sections are shaped to correspond to various characters. The shaped light beam is projected onto a viewing screen or a printer, so that sequentially positioned characters spell out messages.

My invention will be readily understood from a study of the figure, which shows a cathode ray tube 10 having a faceplate 11 on whose inner surface is a fluorescent

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screen 12. Cathode ray tube 10 contains the usual beam producing means, electron beam deflecting means, and such electron lenses as may be necessary, and has associated synchronizing, blanking, and deflection circuits.

In the usual cathode ray tube, the faceplate is a single pane of glass. As light from a spot on the fluorescent screen on the inner surface traverses the thickness of the glass, it spreads out and produces a larger and much diffused area of light on the outer viewing surface. Therefore, the light from two closely adjacent spots on the inner surface overlap on the viewing surface to the extent that one cannot be distinguished from the other. This overlapping produces a blurring, which is intolerable for high quality displays. To prevent this effect, a cathode ray tube may have a faceplate that comprises a bundle-like array of light guides that comprises rods of materials having good light-transmitting characteristics. Light introduced into one end of a light guide is efficiently transmitted, and is emitted at the other end; the area of the emitted light having the same diameter as the light guide. For most applications it is desirable that each light guide have a very small cross section; and these are frequently called optical fibers.

Cathode ray tube 10 is therefore preferably one wherein the faceplate 11 comprises a plurality of light guides.

Referring once more to the figure, it will be seen that when electron beam 14 impinges upon a given area of the fluorescent screen 12, it produces a spot of light whose size depends primarily upon the size of the electron beam. Present day cathode ray tubes are capable of producing a very fine focussed electron beam, so that the spot of light on the fluorescent screen is quite small. The light is transmitted through the faceplate by the previously described action of a small group of optical fibers, which are much smaller than the light spot. The resultant spot of light at the outer surface of faceplate 11 is therefore substantially the same size as the one on the fluorescent screen, thus preventing blurring.

In the cathode ray tube art, electron beam deflection systems capable of precisely positioning the electron beam are well known. The indicated deflection system 17 is one that is capable of positioning electron beam 14 in a number of predetermined positions, each of which produces a spot of light, as hereinabove described. A "blanking" circuit, 29, cuts off the electron beam during deflection. The described apparatus thus produces a plurality of positionable light spots. A cathode ray tube has the advantage that the light spot may be re-positioned very rapidly, but aside from this advantage the light spots may be produced in any other desirable way. For example, light may be projected through holes in cards, tapes, or clear portions of a moving film.

External to the tube, and directly in front of the faceplate, is positioned a sheet 16 of opaque material having transparent areas whose shapes correspond to characters—such as letters, numerals, or symbols. One of these transparent areas is positioned adjacent the external ends of a group of optical fibers whose internal ends coincide with a light producing spot as determined by deflection system 17. Sheet 16 is called a light beam shaping matrix, does not require the previously discussed bridges, and may readily be produced by photographic processes.

It may be seen from the figure that the light from a given spot on the fluorescent screen is transmitted through the optical fibers, and is emitted in such a manner that the light traverses a single opening in the light beam shaping matrix 16. The light beam that emerges from the matrix therefore has a cross section that corresponds to the shape of the opening.

It is thus apparent that sequential positioning of the electron beam provides "bursts" of light whose cross sec-

tion periodically change to correspond to various desired characters.

In order to project the shaped light beam onto a screen, I position a lens in front of each transparent area of matrix 16. Instead of using independent lenses, I prefer to use a "lenticular" structure 18 that, once designed, can be readily molded in plastic, glass, or other materials having suitable light refracting characteristics. Each lens of lenticular structure 18 is so designed that the shaped beam of light which enters it is refracted to strike a given point 20 on the extension of the axis of tube 10. It is thus apparent that selected positions of the electron beam will image any desired character at point 20 on the axis.

Lenticular lens 18 acts differently than a single lens. For example, a single lens—such as is used in a camera—would produce an image of the entire light shaping matrix 16. In the image some of the transparent character-shaped areas would be above the axis, others would be below the axis, and still others would be to the right or left of the axis. This result is entirely different from the one obtained with the disclosed lenticular lens system.

In accordance with my invention, I position another bundle 22 of optical fibers on the axis in such a way that their input ends form a plane perpendicular to the axis through point 20. Any shaped light beam that strikes point 20 enters array 22 of optical fibers, and regardless of the angle of the incident beam, the light traverses the bundle of optical fibers and is emitted parallel to the axis. Therefore, when the light emerges from the optical bundle 22, it is collimated parallel to the axis. The emergent light now consists of an axial beam of light whose cross section corresponds to the character selected by the position of the electron beam. When the electron beam moves to another position, it produces another burst of light whose cross section now corresponds to another character. In this way, the light emerging from optical array 22 can be thought of as a series of bursts whose cross sections correspond to various characters.

In order to convert the character-by-character display from optical bundle 22 to a large size display, I image the emergent shaped light beam onto a movable reflecting surface 36, such as a pivoted or rotatable mirror or a rotating prism. The light beam is thus directed onto a light receptive area such as a viewing screen, or a light sensitive surface like a moving photographic film or a tape that may permit light images to be printed by xerography.

If a viewing screen is used, the mirror directs a burst of light onto a particular area—and during the blanked out interval between bursts, the mirror is rotated so that it directs the new burst to an adjacent area. To accomplish this result, the mirror's movements are intermittent, and are synchronized with the blanking and deflection systems of the cathode ray tube.

When the shaped bursts of light are to be applied to a moving film or tape, the mirror moves in synchronism with the film's movement—so that a given burst is always directed to the same area of the moving film. This prevents blurring from taking place on the film. When it is desired to display the next character, the mirror reverts to its original position—preferably during blackout, and the foregoing process is repeated.

It will be noted that my invention has several advantages over prior-art types of displays. First of all, the cathode ray tube is conventional. Secondly, the light beam shaping matrix can accommodate as many as sixty-four characters in an area less than 2" x 2", therefore requiring a cathode ray tube having a small faceplate. The small cathode ray tube will therefore be inexpensive,

low powered, and require relatively little space. The character forming matrix may be readily changed, since it is now positioned outside the tube, and shapes an optical beam—rather than an electron beam. This means that the light beam shaping matrix can be a photographic film that is capable of providing characters of superior quality and does not require any "bridging" structure. My invention therefore provides characters having exceedingly good resolution. My invention further produces a character-by-character display that requires relatively simpler circuitry than that necessary for equivalent presentation by the prior art. The large display resulting from my invention is furthermore produced by elements that are external to the cathode ray tube.

The particular embodiment of the invention illustrated and described herein is illustrative only, and the invention includes such other modifications and equivalents as may readily appear to those skilled in the art, within the scope of the appended claims.

I claim:

1. The combination comprising, means for producing a sequentially positionable spot of light, light beam-shaping means comprising a plurality of n apertures each of which individually defines a character or symbol, means for selectively illuminating apertures of said light beam-shaping means by positioning said spot of light upon selected characters one at a time, a plurality of n lenticulated lenses located on the opposite side of said beam-shaping means from said light producing means, one of said lenses being individually associated with each of said apertures, said lenses being located so that the optical axis of each lens intersects at a given point in space, each of said lenses being located a distance from its corresponding aperture so that the aperture is at the focus of the lens whereby the selectively created character-shaped collimated light beams converge at said given point.

2. The combination of claim 1 further comprising, means located at said given point for collimating light projected on one surface thereof to thereby produce character-shaped light beams which are projected parallel to the axis of said collimating means.

3. The combination of claim 2 further comprising, a lens positioned on the axis of said collimating means for converging said character-shaped collimated light beams, light receptive means, means for directing light from said lens onto said light receptive means, said lens being positioned with respect to said light receptive means to image the selected characters upon said light receptive means.

4. The combination of claim 3 in which said light receptive means is a movable light recording medium and said light directing means is movable in synchronism with said light recording medium so that the projected image is stationary upon said recording medium.

5. The combination of claim 3 in which said light producing means includes a cathode ray tube having optical fibers in the face thereof, said given point being upon the longitudinal axis of said tube, said collimating means comprising a bundle of optical fibers aligned with the axis of said tube.

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