May 23, 1961 E. W. ANTHON 2,985,873

LUMINOUS CHARACTER DISPLAY UNIT

Filed May 21, 1957 2 Sheets-Sheet 1

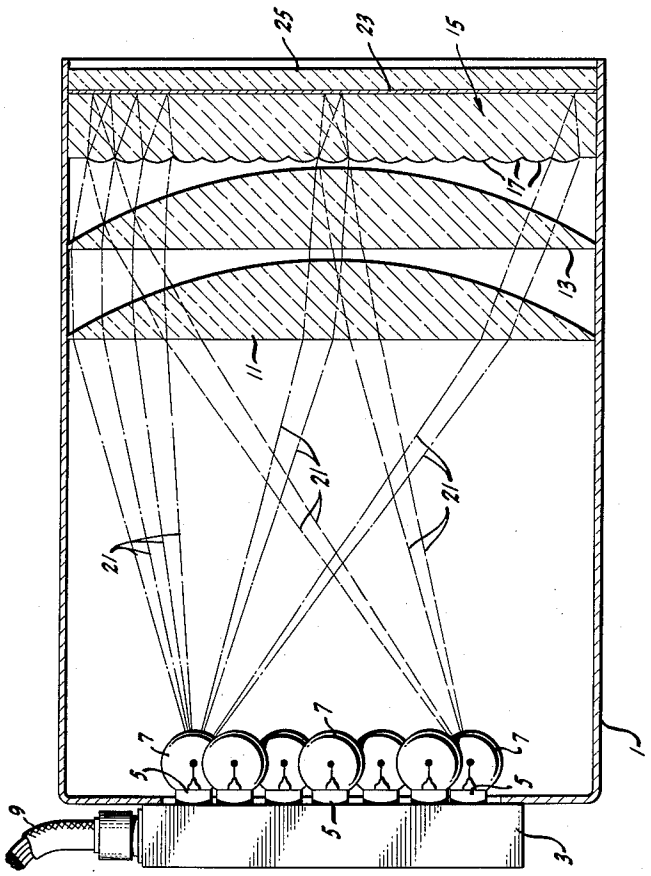

FIG-1

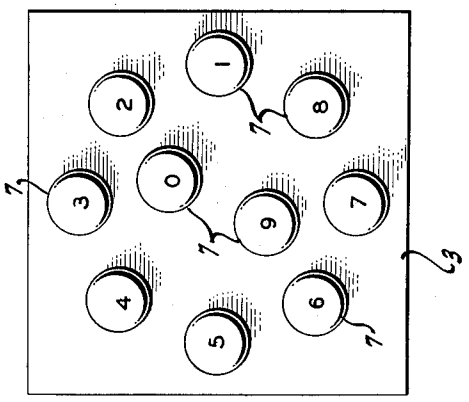

FIG-2

INVENTOR.
ERIK W. ANTHON

BY Lippincott & Smith

ATTORNEYS

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LUMINOUS CHARACTER DISPLAY UNIT

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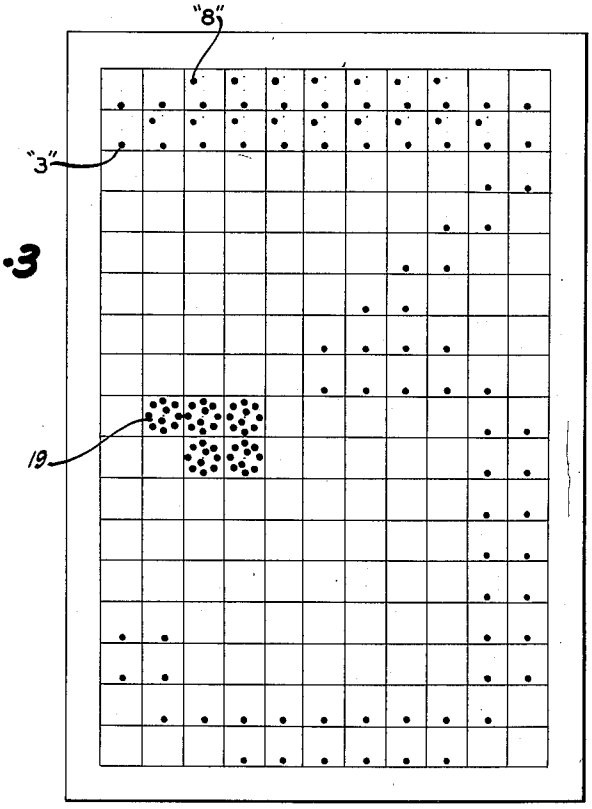

FIG-3

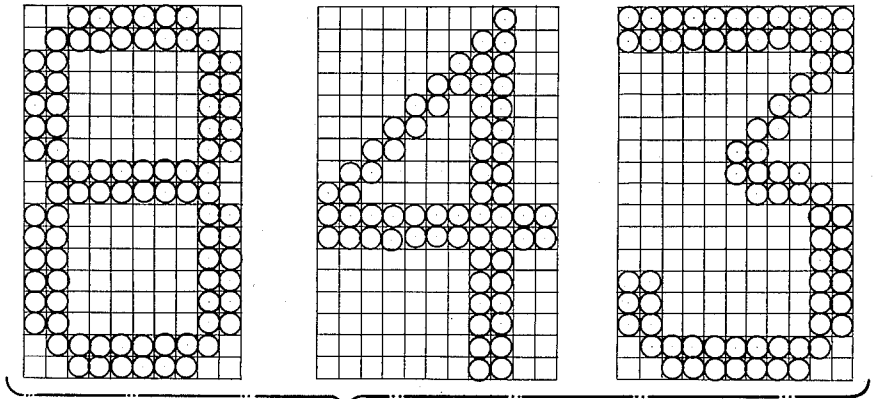

FIG-4

INVENTOR.
ERIK W. ANTHON

BY Lippincott & Smith

ATTORNEYS

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LUMINOUS CHARACTER DISPLAY UNIT

Erik W. Anthon, El Cerrito, Calif., assignor to Beckman Instruments, Inc., Fullerton, Calif., a corporation of California

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1 Claim. (Cl. 340—378)

This invention relates to devices for displaying in luminous form on a common display area any selected one of a plurality of characters. A single such device may display single characters, such as figures, letters, or arbitrary designs in any desired order. A row or bank of such devices may display words, multidigit numbers or symbols. In the form particularly to be described herein each individual unit may be arranged to display the ten arabic digits, 0 through 9 and a row of such units can be used to exhibit numbers developed by electrical computers or similar devices.

Display units for accomplishing the general result here contemplated have been made in various forms. Many such devices have been developed which use a plurality of light sources which are energized in different combinations to form the characters which it is desired to display. With such devices the large number of light sources required to show even a limited number of characters and to show them in rather crude form, has resulted in rather large display units; much larger than really required to enable the characters to be read at a distance from which they would normally be viewed. Furthermore, exciting the different sources in many different combinations has required elaborate and consequently expensive relay matrices for selecting the sources associated with the display of any individual character and the larger the number of characters to be displayed the more complex such a relay matrix becomes.

Among the objects of the present invention are to provide a display unit of the type mentioned that can be manufactured in very small sizes, the area on which each character is exhibited being of the order of magnitude of one square inch or even less. Another object of the invention is to provide a display unit of the type mentioned wherein the number of light sources used does not exceed the number of characters to be displayed, the illumination of any individual source resulting in the display of a complete character which may differ entirely from the other characters to be displayed, thus avoiding the necessity for complex and expensive relay matrices. A still further object of the invention is to provide a unit wherein the set of characters to be displayed can be changed to any other set of characters (not exceeding in number the number of light sources provided) easily and in minimum time. An additional object is to provide a type of display unit that can be manufactured reproducibly and in quantity and which does not demand highly critical adjustments in either manufacture or maintenance.

In accordance with this invention there is provided an optical system which includes, as its essential element, a raster-lens formed of a multiplicity of positive elementary lenses in abutting relationship, each elementary lens being adapted to form an individual real image of a common field of view, so that the resultant image, formed by the raster-lens as a whole, is a mosaic of repeating individual images of the field. The raster-lens may be either larger or smaller than the area upon which the various characters are to be projected, but conveniently it is substantially

the same size and shape. Upon conjugate focal surfaces of the optical system there are disposed, on the first, a group of light sources equal in number to the number of characters that may be displayed; on the second focal surface, conjugate to that of the light sources, there is a predominately opaque mask provided with apertures located at the positions of the images of certain individual light sources formed by certain selected ones of the elementary lenses, the mask therefore occulting the light of the images formed by the elementary lenses not so selected while it transmits the light forming the images of that source formed by the selected elementary lenses. The lenses selected to form unocculted images of each of the various light sources are those so arranged on the raster-lens as to form a different character. The light sources are excited one at a time. Therefore when viewed from the front of the device, facing the mask, only a single character is seen, formed of the bright spots of light passed by apertures in the mask positioned to coincide with the images of that particular source. Preferably a light-diffusing plate is positioned immediately in front of and substantially in contact with the mask, causing the spots to diffuse and blur and reducing their intrinsic brilliancy in the process, causing the dots corresponding to adjacent elementary lenses to merge and the character to appear as substantially continuous lines instead of as sharply defined dots. The whole arrangement is preferably enclosed in a case that is light-tight except for a display window occupied by the diffusing screen on which the characters are exhibited, thus to prevent the escape of any confusing light rays that would reduce the contrast when the characters are viewed.

The detailed description of a preferred embodiment of the invention which follows is illustrated in the accompanying drawings, wherein:

Fig. 1 is a semi-diagrammatic longitudinal vertical section through a device embodying the present invention;

Fig. 2 is a vertical sectional view, taken on the line 2—2 of Fig. 1, showing a preferred disposition of the light sources as grouped in a device for showing the arabic numerals 0 to 9 inclusive;

Fig. 3 is a diagrammatic view illustrating the arrangement of the elementary lenses in one form of raster-lens as well as the positions of the images as formed thereby and the arrangement of the apertures in the mask as disposed to display certain specific characters; and

Fig. 4 is a diagrammatic showing of the form of certain typical digits as displayed by the device of the present invention.

The general construction of a display unit built in accordance with the present invention is illustrated in Fig. 1. As there indicated, the entire equipment is enclosed in a housing or casing 1, conveniently made of sheet metal. While the shape of the housing is not material to the broad concept of this invention, for the display of arabic numerals it is preferably of rectangular cross-section. Thus the units may be closely stacked side-by-side the relative proportions, vertically and horizontally are appropriate to the shape of the figures if about those of the diagram of Fig. 3. As in optical equipment generally, the interior of the housing is preferably dead black in order to avoid the formation of any spurious images or general illumination due to reflections from its interior.

At its rear end the housing is closed by a connection box 3, through which project sockets or receptacles 5 for holding the various light sources. In the present instances these sources are shown as incadescent lamps 7. The sizes used will, of course, depend upon the area of the display surface and the size of the characters to be displayed. For very small units they may be flashlight bulbs, miniature neon lamps, or switchboard lights such as are used in telephone installations. The lamps are

adapted for individual excitation, the exciting circuits being brought out through a cable **9** in the present instance.

The arrangement of the light sources is of some importance. Preferably they are so grouped that the minimum distance between any two adjacent lamps is approximately constant, and for the display of arabic characters the generally octagonal arrangement shown, with two lamps within the outline of the octagon, is a suitable one. With the particular type of raster-lens herein employed it is desirable that no two lamps of the group be arranged in the same horizontal or vertical line; the roughly octagonal group of lamps is therefore canted at a slight angle, somewhere in the neighborhood of 22½ degrees with respect to the vertical plane longitudinal of the housing. This is a desirable but not a necessary feature and the reason for it will be explained in connection with a description of the raster-lens hereinafter.

An optical system for projecting the images of the group of lamps occupies the forward portion of the housing, opposite to that wherein the lamps are mounted. Preferably this system includes a collimating lens or lenses, shown here as a pair of plano-convex, spherical lenses **11** and **13** respectively, mounted with their convex faces away from the light sources. Other well-known collimating or condensing lens systems may be used. The purpose of the collimaters is to render the rays of light proceeding from each of the sources parallel, or very nearly so, as they leave the collimating system. This removes the virtual source of the light, as viewed from the front of the device, substantially to "infinity," with the result that the image of the entire field of view of the system, as formed by each of the elementary lenses of the raster-lens, occupies an area substantially identical in size, shape, and relative position with the elementary lens that forms it.

The raster-lens in the present instance is formed of a single block of glass **15** that occupies the entire cross-sectional area of the housing immediately in front of the collimating system. In this lens the elementary lenses that form it are molded in the surface of the glass. Each is a positive or convex lens and as indicated at **17** in the figure, their surfaces are spherical and they are arranged in rectangular formation so that each elementary lens occupies a square area. In the diagrammatic showing of Fig. 3 each of the individual squares corresponds to the area within which an image is formed of the field of view of the optical system as a whole and therefore defines the size and arrangement of the elementary lenses. As shown, the raster which they form is 11 elements wide by 17 high.

It is because of the rectangular conformation of the raster that it is desirable to tilt the axis of the group of lamps that form the light sources. Between each pair of elementary lenses there is necessarily a transitional area that forms no part of either of the lenses, and some small amount of light, unfocused, passes through these areas. If both the lamps and the elementary lenses are alined vertically and horizontally, faint streaks of light sometimes appear across the viewing surface, which display, very faintly, characters not intended to be shown. Tilting the axis of the source-group avoids this difficulty.

Preferably the raster-lens is made quite thick and with a plane rear surface, the curvature of the individual elementary lenses being such that their focal length is equal to the thickness of the lens. As a result, the substantially parallel rays from each of the sources are brought to a focus at the plane surface of the lens, thus forming, in this plane, a multiplicity of reversed real images of the field of view of the lens, including, in particular, the images of the sources themselves. In the case of the incandescent lamps these sources are, of course, the filaments; an image of the entire field is formed by each elementary lens when any one of the sources is excited to illuminate the others, but the image of the light-emitting source is so much brighter than the others that the contrast is so high as to make only its own image visible to the eye.

It will thus be seen that there is formed, in the plane of the rear surface of the raster-lens, a mosaic-like pattern of images of the group of sources, the images being equal in number and corresponding in position to number and position of the elementary lenses in the raster-lens. A small portion of the mosaic is illustrated by the dotted squares indicated by the reference character **19** in the diagram of Fig. 3. Each dot is positioned to indicate the position of the images of one of the sources in the group.

It has already been stated that each source in the group illustrated in Fig. 2 corresponds to one digit that may be exhibited. While the choice of which source corresponds to any digit is arbitrary, it will be assumed for purposes of explanation that the figures on the lamps shown in Fig. 2 indicate the digit to which it corresponds, it being understood that no such marking will ordinarily appear on the sources used in an actual device. As is well understood, each of the real images formed by the raster lens is reversed, as is shown by the construction "rays" **21**, extending diagonally across the space within the housing as shown in Fig. 1. Therefore, since the source representing the digit 3 is the one located nearest the top of Fig. 2, the dots that show the position of the image of this source in the various squares of Fig. 3 is the one located at the bottom of the group. There is a similar transposition from left-to-right, as viewed from the front of the device.

A predominantly opaque mask **23** is mounted immediately in front of and in contact with the plane surface of the raster lens **15**, and hence substantially in the focal surface conjugate to that occupied by the light sources. The mask is provided with light-transmitting apertures which coincide in position with the images of certain of the sources as formed by certain selected ones of the elementary lenses, the lenses so selected being arranged to form the characters to be displayed by the individual sources whose images fall upon the apertures. In Fig. 4 there is shown a typical arrangement within the raster-lens of the elementary lenses that might be selected to form the digits 8, 4, and 3, each circle in Fig. 4 representing the relative position of one of the elementary lenses selected. Since the raster-lens is 17 elements high by 11 wide it will be noted that each of the digits shown corresponds to these measurements and that each stroke of the digits is two units wide.

The diagram of Fig. 3 is intended to represent the relative position of the raster-lens elements and the images formed thereby as viewed from the front of the device. On the diagram there are shown the positions of the apertures in the mask which are formed to display the digit 3 in the formation shown in Fig. 4. As the position of the "3" lamp is at the top of the group, the black dots showing the position of these selected apertures is located at the bottom of each of the squares of the mosaic. The squares bearing the dots in this position are the only ones that are apertured at the position of the image of the source representing the digit 3.

It will be noted that many of the same elementary lenses employed to depict the digit 3 are also employed to depict the digit 8, namely lenses in the upper and lower rows of the raster. In the two top rows of the diagram of the raster in Fig. 3 there are also shown the position of the apertures in these two rows employed to depict the digit 8. Apertures are formed in the mask arranged to depict each of the digits displayed. There will be several apertures corresponding to the images of light sources in some of the elementary lens fields, in others there will be few or none at all. To show in the diagram the positions of all the apertures in the mask would merely be confusing, but it is to be understood than in practice such apertures exist for depicting each character.

Most conveniently the mask is formed photographically, and the mask itself can be formed of a piece of the usual flexible, transparent photographic film or, if desired, a photographic plate. A master negative can be made by exposing a film positioned, with respect to the optical system, as the mask will be in use. A stencil representative of the digit to be exposed can be placed between the negative film and the lens and the source that is to represent the stencilled character is lighted. When exposure is complete the stencil character is replaced by another, the corresponding source is lighted, and the process is repeated until latent images have been formed on the film for all of the sources of the group, after which the negative is developed. From this negative any desired number of densely exposed positives can be made.

A master negative, formed as described, can also be used to form a metallic mask. A metal film can be coated with a photosensitive resist, exposed and the apertures etched through, forming actual holes instead of merely light-transmitting apertures in the opacity of a photographic film. This latter process is more expensive and the film will ordinarily be the material chosen.

It has been found that the use of a single master negative to form a mask of the kind here described is entirely practical and introduces no real problem of registration between the images formed by one raster-lens and the apertures photographed with another. The raster-lenses used can be molded of glass in a common mold and are therefore substantially identical. The mask can be contact printed. The holes in the connection box **3** within which the sockets **5** are mounted are formed simultaneously in a punch press and therefore their positioning in different units is identical. Registration is therefore almost automatic; when the connection box is assembled to the unit only a very slight adjustment of its position is ever necessary. The most that is required is to excite the lamp representative of one character; if that character is displayed the registration of the others is assured.

The housing is finally closed by a window **25**. This could be of clear glass, but a much more pleasing display is produced if it is of ground glass or is otherwise light-diffusing. The intrinsic brilliancy of the images as viewed directly is very high and they are visible through only a rather narrow angle. The use of a diffusor makes the display visible through a wide angle, reduces the apparent intrinsic brilliancy, and softens the outline so that the displayed characters appear as substantially continuous lines instead of a succession of very bright dots.

It will be understood that the display units of this invention are not limited to the exhibition of numerical digits. There is no reason why the number of sources cannot be increased so as to display, for example, an alphabet, provided smaller sources are used and they are placed closer together. The registration in this case must of course, be more exact.

Neither is it necessary that the raster-lens be formed of spherical elements, rectangularly alined. One possible modification is to use spherical lenses arranged in a hexagonal or honeycomb pattern. Another modification would form the elementary lenses with surfaces defined by cylinders intersecting at right angles so that the resulting lenses might be described as "square domes." In this case the images of the sources would not be true representations of the light sources themselves but would be approximately square, since they would be the intersection of two linear images. The use of elementary lenses of this form could be advantageous for the reason that it would be very easy to make the molds for forming raster-lenses of this character.

Still another simpler form of raster lens, which may be used to advantage where only a relatively small number of characters is to be displayed, is to use cylindrical elementary lenses instead of spherical or domed lenses. A cylindrical lens has a line instead of a point focus.

In adapting such construction to a digit display such as is here shown, the axes of the cylinders could be arranged horizontally, so that in cross-section the lens would present exactly the same appearance as does the lens **15** shown in Fig. 1. With this form of the device the sources are arranged so that no two are in the same horizontal line and to secure more uniform illumination over the entire surface of the character it is of some advantage to group the sources as close as possible to the vertical axis of the field of the optical system. So arranged the image of each source is a horizontal line, extending entirely across the display surface. These lines distinguish from each other by being displaced vertically within the linear field of each of the cylindrical lenses, and therefore to distinguish between the images of the different sources the foci have to be quite sharp and the vertical registration problem is somewhat more difficult because of the accuracy required. The master negative for forming the masks can, however, be formed in the same way as has already been described. In general, the use of lenses that that focus the images in both the horizontal and vertical dimension is to be preferred, particularly where the number of characters to be displayed is relatively large, since with this arrangement the images of the sources are distinguished by their lateral as well as by their vertical displacement. This being the case the apertures can be made somewhat larger than the images themselves (as, for example, by some over-exposure of the negative so that the images fog at the edges, increasing their effective area) giving some tolerance in the registration of the mask.

Numerous other modifications of the invention will naturally suggest themselves. Other collimating systems than that shown are known and could, of course, be used. It is not necessary that the thickness of the raster-lens be made equal to the focal length of its elementary lenses; the raster-lens may be thinner and other means of support provided for the mask instead of clamping it between the raster-lens and the window **25**. An additional optical system can be added to re-project the illuminated image of the mask to give a display either larger or smaller than the raster lens itself, while still maintaining the relative sizes of the groups of images formed by the elementary lenses in correspondence with the size and position of these lenses. Numerous other modifications in size, shape, material and arrangement are possible.

The embodiment of the invention illustrated and described is therefore not intended to define the scope of the invention but rather to illustrate the form which is preferred because of its compactness, cheapness, ease of assembly, ease of reproducibility and reliability. Any intended limitations upon the scope of the invention are specifically set forth in the claim which follows.

I claim:

A display unit for exhibiting optionally any one of a plurality of different characters, comprising a casing which is substantially light tight except for a display window at the front thereof, a plurality of concentrated light sources equal in number to the characters to be exhibited disposed both in a circular array and within said circular array at the rear of said casing facing said display window, a collimating lens system for rendering the light emitted from each of said sources substantially parallel mounted within said casing between said sources and said window, a raster-lens comprising a single plate having a substantially plain rear surface and having a multiplicity of elementary positive lenses in abutting relationship formed on the front surface thereof, each of said elementary positive lenses adapted to form an individual image of the common field of said optical system within an area of one focal surface which corresponds in relative size and position to the elementary lens forming said individual image, the thickness of said plate

being substantially equal to the focal length of said elementary lenses, a predominantly opaque mask disposed substantially in said one focal surface and having formed therein light transmitting apertures located at the points where the images of certain individual sources are projected by certain selected ones of said elementary lenses, the lenses so selected with respect to each of said sources being arranged to define one of the characters to be displayed, and the lenses so selected with respect to the different sources defining different characters, and a

light diffusing plate disposed closely adjacent said mask and forming a closure for said display window.

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