April 26, 1966 WU CHEN 3,248,554

UNIFORM INTENSITY ILLUMINATION SYSTEM

Filed Dec. 13, 1961

FIG. 1.

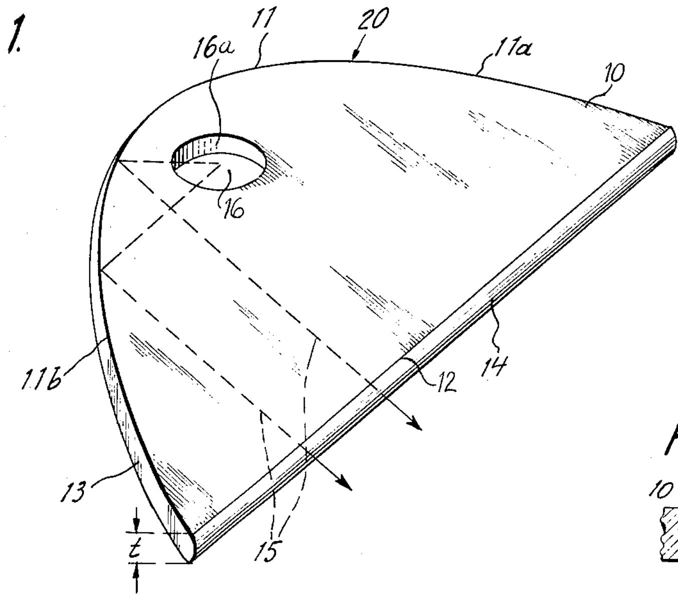


FIG. 2.

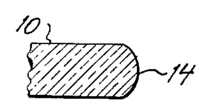
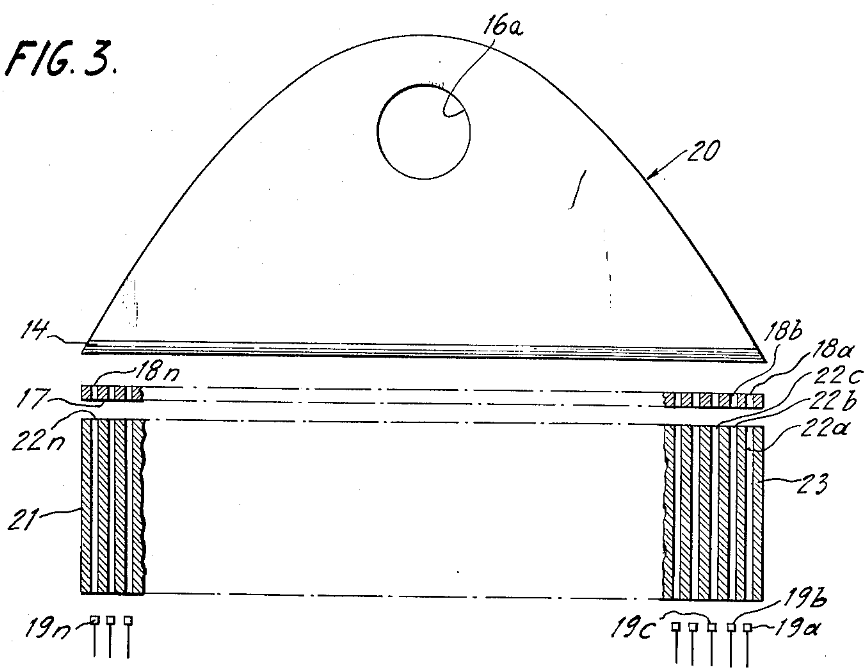


FIG. 3.



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UNIFORM INTENSITY ILLUMINATION SYSTEM

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This invention relates to the field of illumination systems. More particularly, it relates to apparatus for producing a zone of light of uniform intensity having a predetermined length and width from a primary light source having other dimensions.

This invention finds use, for example, in photo-electric document readers where a light source is required to affect or not affect photo-responsive elements depending upon the presence or absence of information on a data carrier.

In applications where light shines through holes in a data carrier to a photo-responsive element and in applications where a light is reflected from the surface of a data carrier, existing methods of providing illuminations have well known limitations.

One such approach is the use of a long filament lamp. Such lamps are expensive, produce a substantial amount of heat, and the light provided is not uniform, the lack of uniformity increasing with age.

Another approach is to use an individual point source of light for each possible location of a data bit from a selected grouping of locations on the carrier to be sensed. This, of course, is quite expensive in addition to the maintenance and servicing problems created, and introduces the likelihood of error caused by component degradation or failure.

Finally, it has been suggested that floodlamps placed some distance from the light responsive elements can be used but here there is obviously and necessarily a large amount of space and light wasted. This is particularly true where only a portion of the data carrier, normally substantially smaller than the area illuminated, is to be read at one time.

Accordingly, it is an object of this invention to provide an improved illumination system.

It is a further object of this invention to provide apparatus for producing a zone of light of relatively high uniform intensity from a primary light source.

It is a further object of this invention to provide an improved reading station for a photo-electric card reader.

Other and further objects and advantages of this invention will become apparent when the following description is read in conjunction with the accompanying drawings and the scope thereof will be pointed out with particularity in the appended claims.

In the drawing:

FIG. 1 is a perspective view of an embodiment of the reflecting portion of the invention.

FIG. 2 is a detail of a portion of the reflecting element of FIG. 1.

FIG. 3 is a diagrammatic representation of a portion of a photo-electric read station.

Briefly stated, the invention provides an apparatus for producing a relatively uniform zone of light. This apparatus comprises a disk-like solid or shell of light transparent material which has one edge in the shape of a parabola and a second edge connecting the two legs of the parabola or other appropriate curve and parallel to the directrix of the curve. At least some of the surface of the parabolic edge is coated with a light reflective coating. Finally, there is an aperture through the structure at the focus of the curve to allow the installation of the light source.

Further, the invention provides means for transmitting light reflected from the parabolic surface to the photo-

responsive elements with increased uniformity of intensity.

Referring now to FIG. 1, a surface **10** is bounded by edges **11** and **12**. Edge **11** is a section of a parabolic curve chosen so that its legs, **11***a* and **11***b*, extend an equal distance along each side of the curve from the axis of symmetry. Edge **12** connects legs **11***a* and **11***b* and, as a result of the equality of these legs, edge **12** is necessarily perpendicular to the axis of symmetry and parallel to the directrix of parabola **11**.

In the embodiment shown there is a second surface coextensive with and parallel to surface **10** directly beneath plane **10** (hereinafter referred to as **10***a*), the two surfaces being joined by surfaces **13** and **14**. Surface **13** is coated with a light reflective material such as silver and is the reflecting or mirror surface of the apparatus. Surface **14** is the emitting surface from which rays, indicated at **15**, emerge. If desired, surface **14** may be made convex to focus the light source along the plane vertical to surface **10**, as is more clearly shown in FIG. 2. Also, if desired, reflecting surface **13** may be appropriately curved to obtain the same advantages. For example, surface **13** could be made parabolic between surfaces **10** and **10***a*.

An aperture indicated at **16** is formed in surface **10** and may extend through surface **10***a*. Aperture **16** has a wall **16***a* of light transmitting material joining planes **10** and **10***a*, and has its center at the focus of the parabola. A primary light source (not shown) may be mounted in this aperture, preferably with its filament at the focus, and extending generally perpendicular to the surface **10**. The means of mounting the light source and the particular light source used do not form a part of this invention. If desired, wall **16***a* may be curved to focus light from the source.

It is clear that rays of light from the light source located at aperture **16** will be reflected from surface **13** and be emitted as parallel beams from surface **14** because surface **13** is parabolic. It is further true that the length of the path traveled by each of these beams is equal. This follows from the nature of the parabolic curve and from the fact that the light origin is at the focus of the parabola and the emitting surface is parallel to the directrix of the parabola.

In the embodiment thus far described there is some slight variation in light intensity along emitting surface **14** though this variation is well within the limits of tolerance of existing photo-responsive elements and is significantly less than with existing illumination systems. The reason for this variation is that the intensity of light along reflecting surface **13** is not linearly uniform but rather angularly uniform. That is, the intensities of light along two separate but equal intervals of surface are different but the intensity of light along two sections of that surface subtended by pairs of lines from the focus having equal angular displacements are equal.

Since rays reflected from surface **13** to the emitting surface **14** are parallel, it follows that to obtain equal average intensities along two segments of surface **14**, unequal segments must be chosen. Phrased differently, the intensity at a point on surface **14** tends to decrease as the point becomes more remote from the axis of symmetry (along which the primary light source is located).

By placing he primary light source equidistant between the extremities of emitting surface **14** it is clear that a band of light of any given length can be provided with less variation in intensity due to the above, than would be possible if the primary light source were located elsewhere. The light rays **15** are parallel when reflected from the parabolic surface **13**. However, until they strike the parabolic surface **13** these rays **15** diverge angularly from each other. Therefore, the shorter the distance these rays have to travel from the light source to the parabolic surface **13**, the less they will diverge and the closer together the reflected parallel rays will be. The closer together the parallel rays are, the smaller is the decrease in light intensity which occurs toward the extremities of the surface **14**. The best way to reduce the decrease in light intensity at these extremities is, therefore, to reduce the divergence of the light rays by minimizing the distance from the light source to all parts of the parabolic surface **13**. This, in turn, is best done by locating the aperture **16** and the light source centrally between the extremities of the parabolic surface **13**.

It has been found advantageous to coat surfaces **10** and **10***a* with a light reflective coating to contain more of the light and increase the intensity of light emitted from surface **14**. Further, as mentioned above, surfaces **13** and **14** may be appropriately curved to vary emitted light intensity. Still another variation is to coat surfaces **10** and **10***a* with a light scattering material to increase uniformity of output.

Referring now to FIG. 3 wherein like reference numerals refers to the same parts, the parabolic structure described in detail in FIG. 1 is indicated at **20**. A section of a data carried **17** such as a card is shown. Assuming for the sake of this description that card **17** is traveling into the plane of the drawing and that it is being read column by column, **18***a*, **18***b* and **18***n* represent holes punched at chosen ones of a plurality of possible position along the column to represent a number or a letter or some other intelligence in a manner well known to the art.

Card **17** is moved past the reflector **20** in any one of the several ways well known to the art, and passes between the reflector and a plurality of light responsive elements indicated at **19***a*, **19***b*, **19***c* . . . **19***n*, there being one such element for each possible position in the column. These elements are connected to appropriate gating, timing and utilization circuits which are not shown and which form no part of this invention.

Between card **17** and the light responsive elements **19***a*, etc., may be intensity adjusting apparatus **21**. This apparatus is optional and can be included in those applications where the variation in light intensity along surface **14** of generator **20** is unacceptable. The type of adjusting means shown consists of a structure **21** (shown in section) having a plurality of columnar apertures or channels **22***a*, **22***b*, **22***c* . . . **22***n*, formed therethrough, there being one channel for each possible data position of the group of data positions which are simultaneously sensed. In the embodiment shown, where the reading is column by column, 12 such channels could be provided. If the reading were to be row by row, then 45 or 80 channels would be provided or, if the entire card were to be sensed at one time, still more channels would be provided.

The walls **23** of each channel are preferably coated with a light absorbing material. The effect of channels **22** is to remove or greatly decrease the amount of light which reaches light responsive elements **19***a*, etc., from rays which were not orthogonal to emitting surface **14**. In this manner most of the light reaching surface **14** *directly* from the light source will be removed, permitting substantially only the reflected rays, equal in length to each other, to reach elements **19***a*, etc. Further, by varying the cross-sectional areas of the various channels, any variation of light intensity from emitting surface **14** can be still further compensated.

As was mentioned above, surfaces **10** and **10***a*, surfaces **13** and **14** and wall **16***a* may define a shell. If aperture **16** extends through from plane **10** to plane **10***a* then the shell is torroidal. This shell may be filled with a light transmitting material of the same or different characteristics as that used for surface **14** and wall **16***a*.

Surfaces **10** and **10***a*, while described as being parallel, need not be so restricted. The two surfaces, for example, could converge toward emitting surface **14** thus permitting use of a larger lamp in aperture **16**. Also, aperture **16** need not be circular, but could be irregularly shaped, for example along that portion through which rays will pass directly toward emitting surface **14**.

While what has been shown and described is presently considered the best mode and preferred embodiment of this invention it will be clear to those skilled in the art that variations and modifications may be made therein without departing from the spirit of the invention and the scope thereof is intended to be limited only by the claims.

What is claimed is:

1. In a reading station for a photo-electric reader wherein data marks are arranged in selected ones of a plurality of predetermined locations on a support and read in potentially equal groups of linear arrays, including apparatus for providing a zone of light having a length and a width substantially equal to the dimensions of each of said potentially equal linear arrays, said apparatus including a disk-like solid formed of light transmitting material, said solid having a pair of planes, said planes being bounded by a first surface defining a portion of a parabolic curve and a second surface parallel to the directrix of said curve, a light reflecting coating on at least a portion of said first surface, an aperture formed in said structure at the focus of said curve, a light responsive element for each possible unit position in said linear array; the improvement comprising: a structure including a plurality of channels located between each of said light responsive elements and said second surface, said channels being substantially orthogonal to said second surface, the interior of the walls of said channels being non-reflective, the cross-sectional area of each of said channels being less than or equal to the cross-sectional area of said data marks, the cross-sectional area of said channels increasing in the directions of the extremities of said second surface whereby to improve uniformity of the intensity of light transmitted.

2. The device defined in claim **1** wherein said channels are coated with a light scattering material.

3. Apparatus for providing a zone of light comprising a body formed of light transmitting material having a pair of substantially parallel planes bounded by a first surface defining a portion of a parabolic curve and a second surface parallel to the directrix of said curve, an aperture formed in said body at the focus of said curve substantially orthogonal to said planes, and a light reflecting coating on at least a portion of said parabolic surface, said planes having a light scattering coating thereon and said second surface and the walls of said aperture being convex.

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