United States Patent

Ammann

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[54] METHOD AND APPARATUS FOR THE FORMATION OF ALPHA-NUMERICAL CHARACTERS ON LIGHT SENSITIVE SURFACES

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[52] **U.S. Cl.** **178/15,** 95/4.5

[51] **Int. Cl.** **H04l 15/34**

[58] **Field of Search** 178/15; 350/19; 355/3, 18, 355/43; 346/107, 108, 110; 95/4.5

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[57] **ABSTRACT**

A high speed line printer for recording computer outputs and the like on light sensitive materials. A light source capable of blinking at high frequencies is provided for each character space on the print-out line and is projected onto a corresponding character field on the material. The material is moved in the X-direction and the projected image of the light sources is moved in the Y-direction across the width of the corresponding character field by a mirror to form scan lines which are spaced in the X-direction. The light sources are selectively energized whenever the projected images are at predetermined X, Y positions to thereby simultaneously form all characters in a given print-out line. The apparatus provides means for moving the light sensitive material, mounting the light sources, projecting the light source images onto the film and moving the projected images in the Y-direction while projecting light flashes emitted by the light sources to form 35-bit character matrixes in each character field.

19 Claims, 5 Drawing Figures

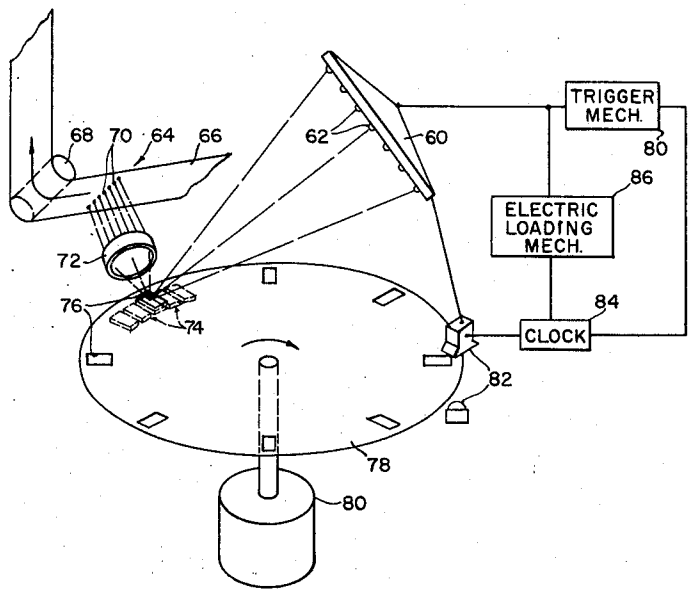


FIG. 1

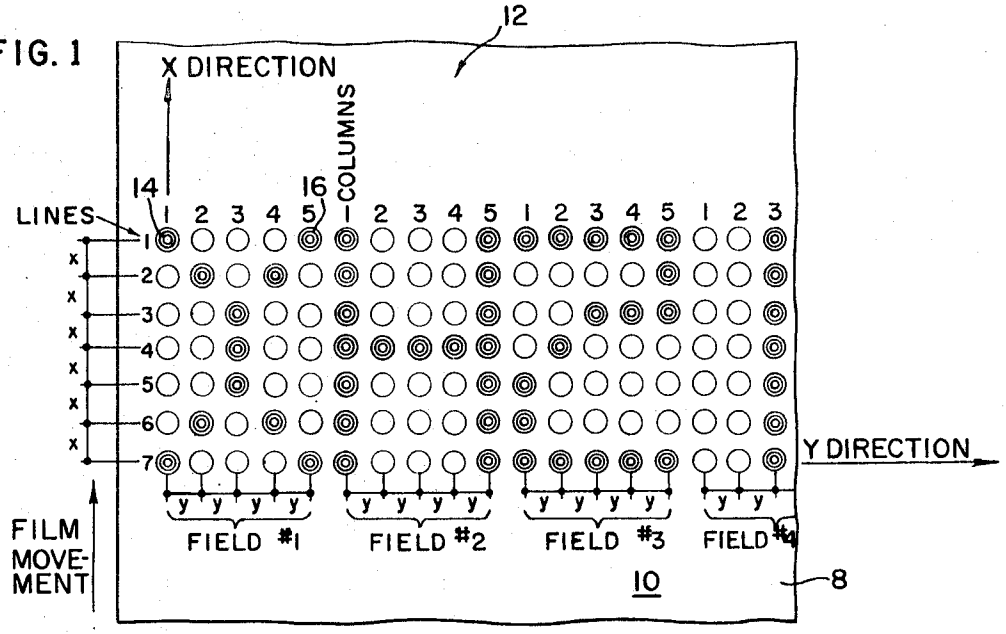
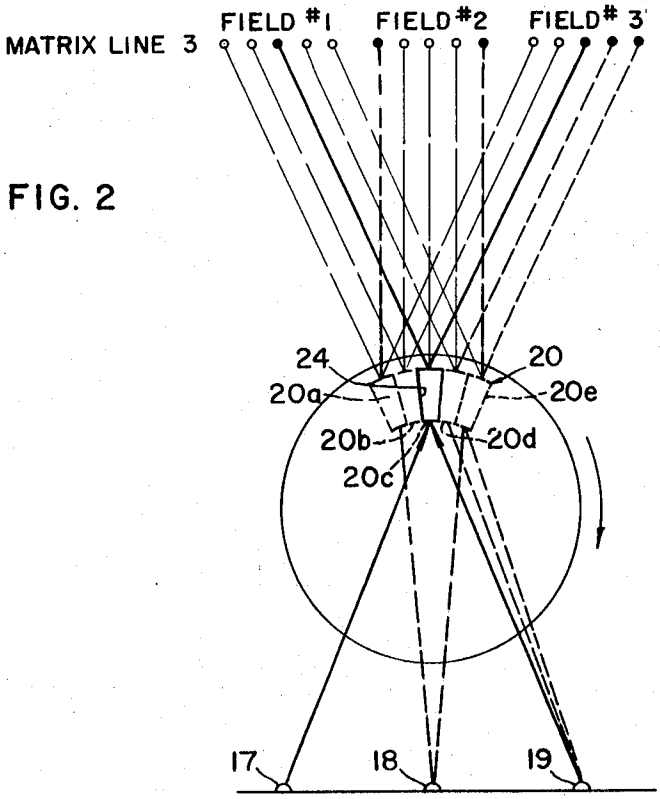


FIG. 2



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FIG. 3

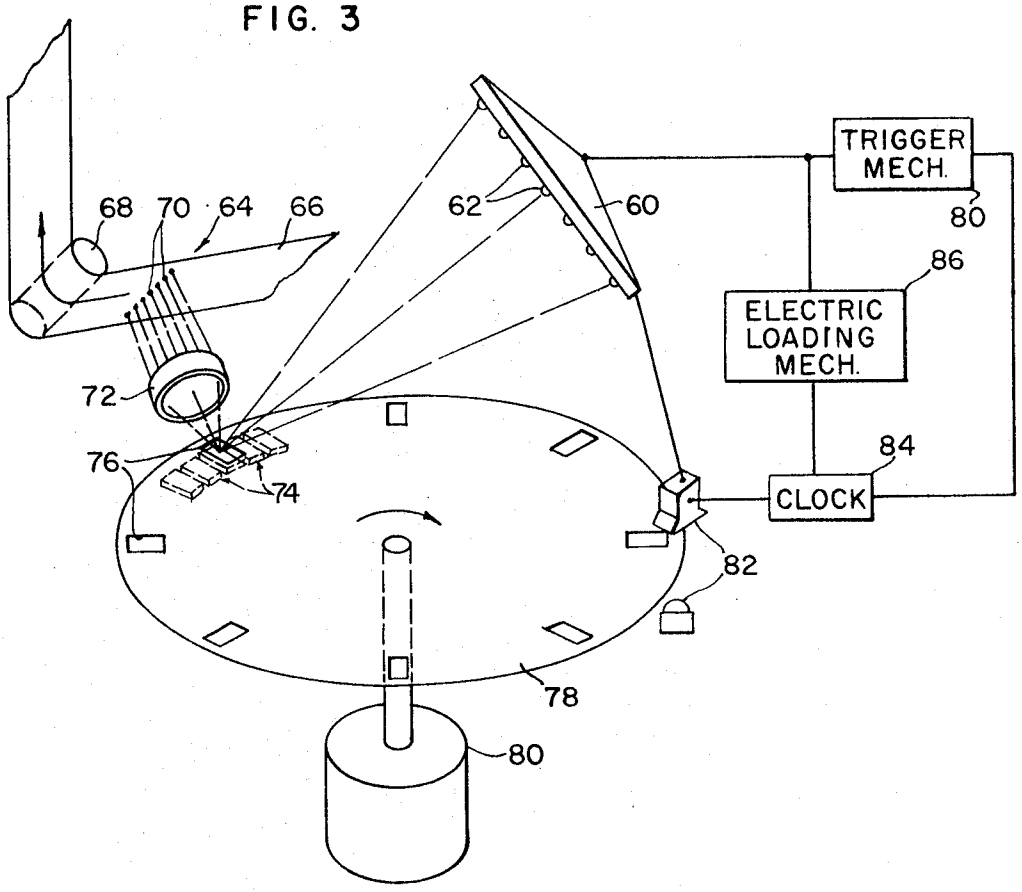
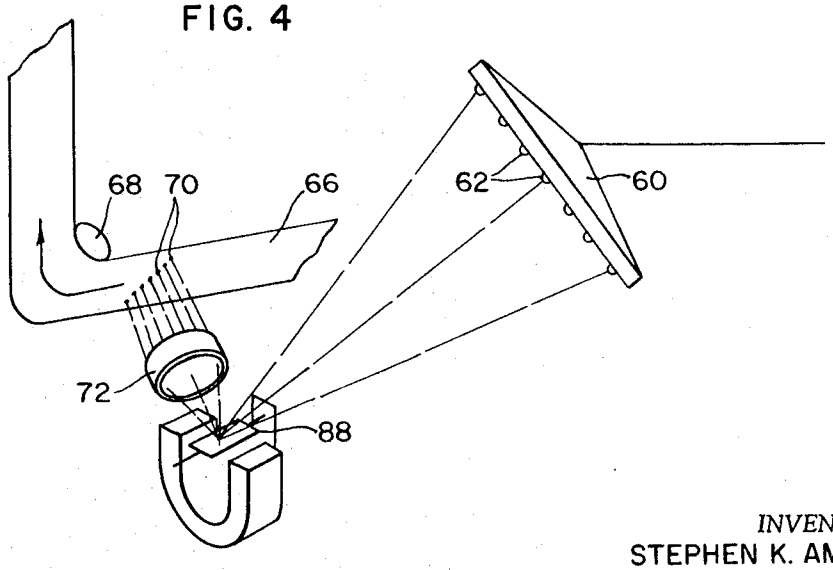


FIG. 4



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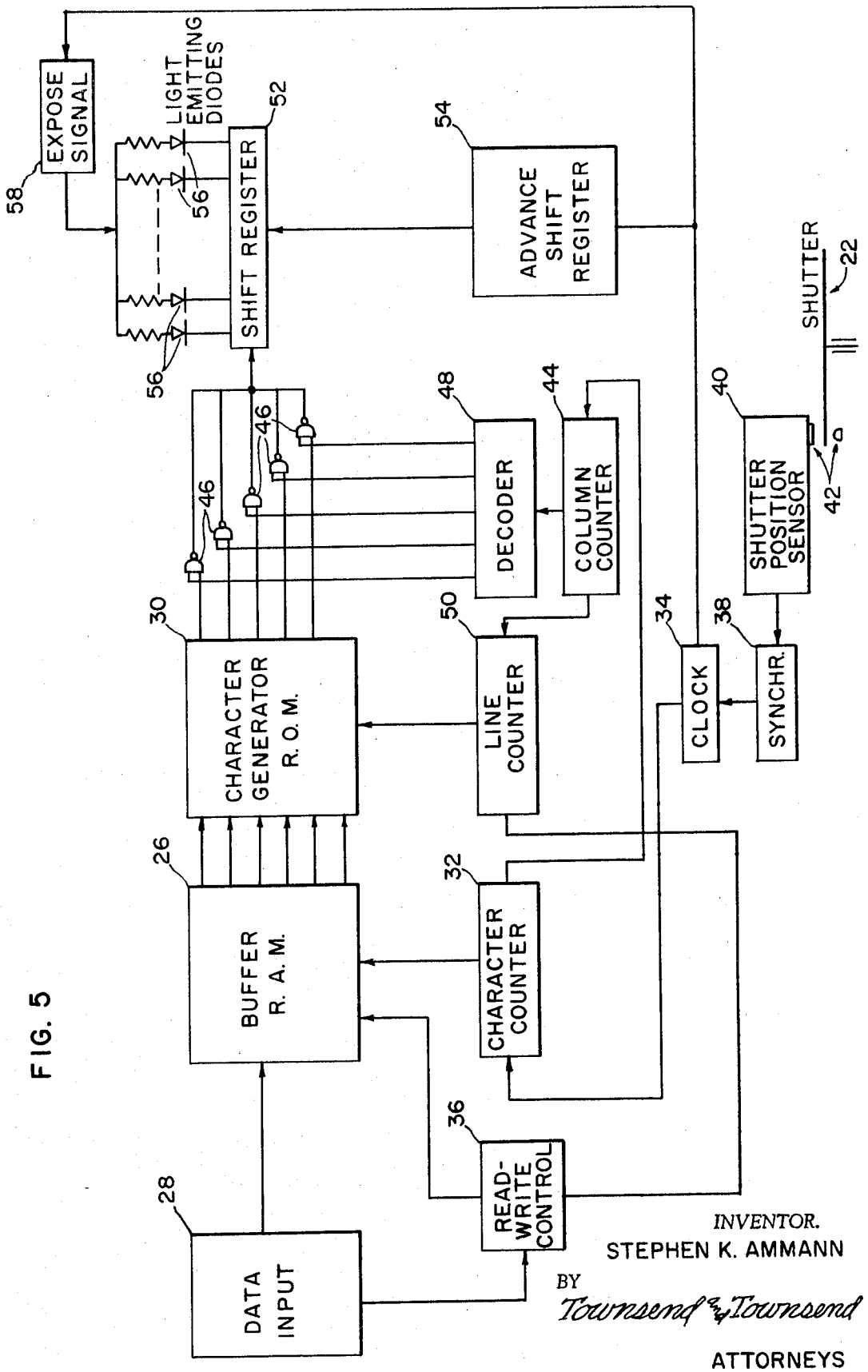


FIG. 5

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METHOD AND APPARATUS FOR THE FORMATION OF ALPHA-NUMERICAL CHARACTERS ON LIGHT SENSITIVE SURFACES

BACKGROUND OF THE INVENTION

High speed line printers are widely used for printing computer outputs. Mechanical line printers are employed for the printing of hard copies. Frequently, it is also desired to provide microfilm copies of the output for subsequent use and/or storage.

An optical readout system is necessary to obtain a direct microfilm readout from the computer. In the past, alpha-numeric characters have been generated in various ways as with 35-bit matrix printers. Such printers employ an array of 35 light sources for each character field across the width of the printout line. The light sources are arranged in five columns and seven rows and the full image of each matrix is projected onto the corresponding character field on the film to thereby form the desired characters in a printout line. Thus, the common 132 character space printout line requires 132 35-bit light matrixes to obtain the desired optical readout.

The light matrixes are relatively expensive to install and maintain. Moreover, they render the readout mechanism bulky. Space limitations frequently represent formidable difficulties in accommodating the many light matrixes so that the use of optical readout mechanisms might be foreclosed.

Other prior art optical line printers employ laser or flying spot cathode ray tubes for generating characters. Such line printers generally suffer the same shortcomings and are, moreover, perhaps even more costly than light matrix printers.

SUMMARY OF THE INVENTION

The present invention provides an optical line printer for use with light sensitive materials such as photographic film and enables the simultaneous printout of all characters in the line. The characters can be formed with a single light source per character in fields defined by columns and rows extending in perpendicular X- and Y-directions. The fields are arranged side-by-side in the Y-direction across a light sensitive surface.

Briefly, the method comprises the steps of providing a light source for each field, deflecting light emitted by each source to a different field and changing the angle of deflectance for each light to scan the light from each source across the corresponding fields in the Y-direction. Each light source is selectively energized when the light is deflected at predetermined positions or matrix points of the scan paths while relative displacements in the X-direction between a light sensitive surface and the deflected light are caused. The deflecting and energizing steps are repeated to fully form the characters. The light sources simultaneously scan across the fields to simultaneously form all alpha-numeric characters in a given printout line. Preferably, the light sources are fixedly mounted and reflectors or mirrors are disposed between the light sources and the light sensitive surface to scan the deflected light flashes in the Y-direction across the width of the character fields.

In one presently preferred embodiment of the invention, the reflector is defined by a plurality of angularly inclined mirror segments, the number of which equals the number of columns in the alpha-numeric character field, e.g., five. The segments are so positioned that light flashes from the respective light sources are projected exactly to the corresponding matrix points on the character field. For that purpose, a rotatable shield or masking disc is provided to prevent emitted light flashes from reaching all mirror segments except the one which, at that moment, is in a projecting position. The masking disc is, of course, synchronized with the actuating means for the light source energizer so that each time a character being printed in a given field requires the exposure of a small area in that field, a light flash occurs and is reflected onto the field by the respective mirror segment, while, at that instant, all other areas in that field remain dark.

In another preferred embodiment of the invention the light flashes emitted by the light sources are reflected by a movable or Galvanometer reflector which is so positioned that its movements scan the light source images over the light sensitive surface in the Y-direction. Whenever the projected light source image is at a matrix point that requires exposure, the light source is energized.

Thus, the present invention provides a simple optical readout mechanism for the high speed line printing of computer outputs and the like which merely employs a single light source for each required alpha-numeric light matrix. Preferably, the light source is a light emitting diode so that relatively simple integrated printed circuits can be employed to reduce installation costs to a level not heretofore attainable. Substantial space savings and less maintenance costs are thereby realized. As a consequence of the economics provided by the present invention, optical line printers and the printout and use of computer outputs on microfilm becomes substantially more attractive and will result in further savings from storage space reductions, lesser transportation charges and a reduction in the paper consumption.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a grossly enlarged portion of microfilm and illustrates part of a printout line;

FIG. 2 is a schematic illustration of the manner of exposing areas located on row 3 of character fields 1 through 3 illustrated in FIG. 1;

FIG. 3 is a schematic, perspective view illustrating one embodiment of the present invention;

FIG. 4 is a schematic, perspective view illustrating another embodiment of the present invention; and

FIG. 5 is a block diagram schematically illustrating the electronics provided by an apparatus constructed in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, a typical computer printout line is fragmentarily shown and is defined by a plurality of character fields or spaces that are horizontally spaced and aligned in the Y-direction. The character fields extend over substantially the full width of a sheet 8 which, for the present invention, comprises photographic film or the like having a light sensitive surface 10. Each character field is defined by a standard 35-bit matrix 12 comprising seven horizontal rows that are equally spaced in the X-direction a distance "x" and five columns that are equally spaced in the Y-direction a distance "y". Exposure of various matrix bits or points results in the formation of alpha-numeric characters such as the letters X and H in character fields 1 and 2, the numeral 2 in character field 3, and the letter I in field 4.

In accordance with the present invention, characters are formed as follows: Assuming momentarily that character formation takes place in character field 1 only, and that film 8 moves in the X-direction at a predetermined speed, a light source (not shown in FIG. 1) is projected onto the film at five points, all in alignment with matrix row 1. The light source projected onto matrix points 1—1 (row 1, column 1) and 1–5 flashes light rays to expose the film at areas 14 and 16 of character field 1.

To maintain exposed areas 14, 16 aligned with row 1, the light flashes are projected onto the film so that their actual relative positions offset the film travel as more fully described hereinafter. Alternatively, light flashes must occur simultaneously or within such short time interval that the continuous travel of film 8 in the X-direction is insufficient to recognizably offset the areas, or the film must be intermittently moved.

After film 8 is moved a distance "x" in the X-direction, light flashes are projected onto the film in alignment with matrix row 2. The flashes are timed so that areas at matrix points 2—2 and 2–4 are exposed. This process is repeated for all seven

matrix rows of character field 1 to form the letter X by exposing matrix points 3—3, 4–3, 4–5, 6–2 and 6–4, and 7–1 and 7–5. Other alpha-numeric characters, or any other desired symbol, can be printed as desired in each character field, or a space can be left open, as between adjacent words, by not exposing any of the matrix points in a given character field.

To obtain the desired high speed printout, all character fields in a given printout line are formed simultaneously, that is, each time any one of matrix rows 1 through 7 of field 1 is being exposed, the same matrix rows in all other character fields are exposed in the above described manner.

Referring to FIGS. 1 and 2, the simultaneous formation of 132 matrix rows is schematically illustrated with reference to the formation of matrix rows 3 in character fields 1, 2 and 3. Light emitting diodes 17, 18 and 19 are provided for character fields 1, 2 and 3, respectively, and for a 132 character printout line 132 light emitters are used. The diodes are positioned so that they cast a light beam onto a reflector 20 which is divided into five reflector segments or sections 20*a* through 20*e*. With respect to sections 20*a* through 20*e* the light emitting diodes are so positioned that an image of the diode is projected via an objective (not illustrated in FIGS. 1 and 2) onto a corresponding character field on film 8 in such relative positions that the five possible projections define the five matrix points on a given matrix row. Thus, mirror sections 20*a* through 20*e* reflect the image of diode 17 onto character field 1. In the assumed relative position of the film the projected diode images form matrix row 3. Similarly, diodes 18 and 19 are projected onto the film to form matrix rows 3 of character fields 2 and 3.

To prevent a simultaneous light emitting diode projection onto the film, which would cause the exposure of all or none of the matrix points on the matrix row, a shutter 22 is provided to mask all reflector sections 20*a* through 20*e* at any given moment except the one which corresponds to the matrix point that is subject to exposure. Thus, a full image of the light emitting diodes can only be projected by one reflector section at a time to assure the sequential exposure of the matrix points of each matrix row.

The shutter rotates at a given rate and suitable electronic circuitry, more fully described hereinafter, is provided to momentarily energize the light emitting diodes as follows. When aperture 24 fully overlies reflector segment 20*a* (not illustrated in FIG. 2), diode 18 is energized to emit a light pulse which is deflected by section 20*a* and exposes a film area covering matrix point 1—1 of row 3 of character field 2. Light emitting diodes 17 and 19 remain deenergized so that the first matrix points on rows 3 of character fields 1 and 3 remain unexposed, As aperture 24 moves in a clockwise direction, it will cover reflector segment 20*b* (not illustrated in FIG. 2). At that moment, none of the diodes are energized so that the second matrix points of rows 3 in fields 1, 2 and 3 remain unexposed.

At its central position (illustrated in FIG. 2) aperture 24 overlies mirror segment 20*c* and diodes 17 and 19 are energized for the exposure of the third matrix points on rows 3 of character fields 1 and 3. Diode 18 remains deenergized so that the third matrix point on row 3 of character field 2 remains unexposed. Similarly, at the fourth position of the aperture, overlying reflector section 20*d* and light source 19 are energized to expose matrix point 4 of character field 3. At the fifth operative position sources 18 and 19 are energized to expose matrix points 5 of character fields 2 and 3.

As is more fully described hereinafter, the preferred embodiment of the present invention contemplates the sequential loading of the light emitting diodes for each character field before they are triggered for recording the emitted light flashes on the film. For each matrix row, this must be repeated five times. Since each printout line normally has a substantial number of character fields, the resulting time interval is sufficient to cause a significant slanting of the exposed field areas from the associated matrix rows due to the continuous forward movement of the film material. To compensate for the slant, reflector segments 20*a* through 20*e* are preferably increasingly angularly offset to project the true position of the diode images for each successive matrix point on a given row further in the direction of the forward movement of the film from the true matrix rows. The film movement is thereby offset so that the final recorded matrix row appears on the film in a straight line and character slanting is avoided. During that time interval shutter aperture 24 moves across the reflector segments and again returns to reflector section 20*a*, and film 8 moves in the X-direction a distance "*x*" for the formation of the next adjacent matrix row. Now the shutter apertures sweeps across the reflector segments for the exposure of the desired matrix points in the next row of the character fields.

To obtain a proper exposure of the necessary matrix points, the rotation of aperture plate 22, and particularly the relative position of aperture 24, and the energization of the light emitting diodes is synchronized.

This synchronization is attained with the electric circuitry illustrated in FIG. 5.

Referring now to FIG. 5, a buffer random access memory 26 receives its data input from a conventional computer 28 while it is in its write mode to store, for example, 132 six-bit words for subsequent transmission to a read only memory character generator 30. A read-write control 36 responsive to computer 28 places the random access memory into its read mode for the transmission of the words. A synchronizer 38, driven by a shutter position sensor 40 which locates shutter 22 with the help of a photocell 42, actuates a clock 34 at the beginning of a printout cycle.

At the beginning of a print cycle, impulses from a character counter 32 driven by clock signals from clock 34 actuate random access memory 26 for the transfer of the first information bit to character generator 30. A column counter 44, also driven by clock signals received from character counter 32, provides first signals to AND gates 46 via a decoder 48. Spillover signals from the column counter are fed to a row or line counter 50 to release the respective information bits from character generator 30 to the gates and, from there, to a shift register 52 where 132 bits of information can be stored. Impulses from AND gates 46 are sequentially advanced by a clock signal driven shift register advance 54 until the shift register contains 132 bits of information.

During the first printout cycle, the loaded shift register determines the information that will be recorded at matrix points 1—1 of all character fields of the printout line. 132 light emitting diodes 56 are coupled with the shift register so that when a potential is applied across the diodes, certain ones, namely the ones which have been loaded in the register, will be energized to emit brief light flashes for recordation on the film. The light emitting diodes are triggered via an exposure signal trigger mechanism 58 that emits a signal after 132 clock pulses. Thus, each time shift register 52 is completely loaded, diodes 56 are energized. Synchron mechanism 38 is so adjusted that the aperture in shutter 22 overlies the proper reflector segment at that instant. That is, trigger mechanism 58 is energized each time aperture 24 (shown in FIG. 2) overlies one of the reflector segments 20*a* through 20*e* (FIG. 2) to thereby record the five information bits for each row of each character field. At the same time, aperture 24 establishes light communication between the diodes and one reflector segment shutter 22 masks all other reflector segments to prevent the simultaneous exposure of more than one print in any one matrix row of any character field.

After shift register 52 has been emptied, column counter 44 advances by one so that the shift register can be loaded with data bits for recordation of matrix points 1–2 of each character field. This process is repeated five times to cover the full length of each matrix row. Thereafter, column counter 44 spills over and advances row counter 50 by one for the recordation of data bits on matrix row 2 in the above described manner. This is repeated until row 7 has been fully printed out whereupon the row counter 50 spills over and actuates read-write control 36 to place random access memory 26 into its

write mode for acceptance of data input for the next printout line on the photographic film.

A practical embodiment of the present invention is perspectively illustrated in FIG. 3. It comprises a holder **60** for a number of light emitting diodes **62** which equals the number of character fields in a printout line **64** on photographic film **66**. The film is moved longitudinally by a transport mechanism **68** and images **70** of the light emitting diodes are projected onto the film by an objective or lens **72** via a five-segment reflector or mirror **74** as the segments come into light communication with the objective and the diodes in the above described manner through apertures **76** of a rotatable shutter disc **78** driven by a motor **80**. The shutter disc includes a plurality of apertures **76** which are equally spaced about its periphery to reduce the necessary r.p.m. of the shutter.

A shutter position photo-sensor-synchronizer **82** provides the initiating impulses for a clock **84** to initiate an electronic loading mechanism **86** and diode trigger **80** for the recordation of data bits at the matrix rows and columns of the character fields. To prevent a slanting of the matrix lines recorded on the photographic film, the segments of mirror **74** are angularly offset in the above referred-to manner to compensate for the forward feed of the film during the recordation of the matrix bits.

Another embodiment embodying the present invention is illustrated in FIG. 4. It again comprises a holder **60** for the necessary number of light emitting diodes **62**, photographic film **66** moved forwardly by a transport mechanism **68** and images **70** of the light emitting diodes projected onto a film by lens **72** and a movable mirror or galvanometer deflector **88**. The galvanometer reflector pivots back and forth through an arc scanning the projections **70** of the light emitting diodes **62** through the length of matrix rows on film **66**. The angular position of the reflector **88** is sensed to emit the earlier referred-to synchron signals initiating a clock cycle so that the light emitting diodes are energized and emit light flashes at the desired points for recordation of the characters in the character fields on film **66**.

For adequate exposure of the light sensitive material on film **66**, a light flash lasting for only a few micro-seconds is sufficient. Moreover, to assure maximum utilization of the available light energy, synchronizer **38** (illustrated in FIG. **5**) is set so that trigger mechanism **80** (illustrated in FIG. **3**) energizes the light emitting diodes only when the aperture **76** of disc **78** permits the projection of the full area of the effected mirror segment without blocking part thereof. Similarly, in the embodiment illustrated in FIG. **4**, the synchronizer and trigger mechanism are so set that the light emitting diodes are energized when and for substantially so long as the galvanometer reflector **88** is in its angular position which causes the projection of the diode images at the intersection of the respective matrix rows and columns.

I claim:

1. A method for forming a symbol on a light sensitive surface in a character field extending in perpendicular X- and Y-directions comprising the steps of: providing a single light source for the field, imaging the light source on the character field, scanning the light source projection across the field in the Y-direction, selectively energizing the light source when the projections are at predetermined points spaced in the Y-direction to form brief light flashes and sequentially expose the predetermined points to light, moving the surface in the X-direction, and repeating the scanning and energizing steps to form the complete symbol.

2. A method according to claim **1** wherein the step of scanning comprises the steps of deflecting the light-beam from the light flashes to change the position of the image of the light flashes striking the surface.

3. A method according to claim **2** wherein the step of deflecting comprises the steps of positioning a plurality of reflector segments between the source and the surface, arranging a plurality of light sources so that each source is imaged at a different character field and a plurality of points spaced across its field in the Y-direction, and sequentially projecting the light sources on each segment, and wherein the step of energizing comprises the steps of determining when the sources are imaged on the predetermined points, and energizing the light sources while imaged on the predetermined points.

4. A method according to claim **2** wherein the step of deflecting comprises providing a movable reflector between the source and the surface, arranging a plurality of light sources so that the reflector images each source in a different character field, adjusting the angular position of the reflector with respect to incoming light flashes to scan the source images across the fields in the Y-direction, and wherein the step of energizing comprises the steps of determining the Y-position of the source images in the fields, and energizing the light sources when the source images are located at a predetermined point.

5. A method for the simultaneous formation of a plurality of alpha-numeric characters in fields defined by columns and rows extending in perpendicular X- and Y-directions, the fields being arranged side-by-side in the Y-direction across a light sensitive surface, the method comprising the steps of: providing a light source for each field, deflecting light emitted by each source to a different field, changing the angle of deflectance for each light to project the light from each source and scan across the corresponding fields in the Y-direction, selectively energizing each light source when the light is projected at predetermined positions of the scan paths, causing relative displacements between a light sensitive surface and the deflected light in the X-direction, and repeating the deflecting and energizing steps to form characters extending in the X- and Y-directions.

6. A method according to claim **5** including the step of providing a single point light source for each field capable of emitting brief light flashes at high frequencies.

7. A method according to claim **6** wherein the step of changing the angle comprises providing a plurality of mirror segments, positioning each segment to project light from the respective source to the corresponding fields and onto areas spaced across the fields in the Y-direction, sequentially projecting all sources onto a single mirror segment at a time, wherein the step of energizing comprises the steps of determining when the light sources are projected onto a segment, determining the predetermined positions in the fields, and energizing the sources imaged at the predetermined positions while the sources are projected onto substantially the full reflecting surface of the mirror segment.

8. A method according to claim **6** including the steps of forming a clock pulse responsive to the relative position in the Y-direction of light flashes striking the fields, and controlling the energization of the light sources with the clock pulse.

9. A method according to claim **8** including the steps of storing information bits in a memory bank, simultaneously energizing all selected light sources at spaced time intervals, and controlling the time intervals with the clock pulses.

10. Apparatus for generating symbols extending in perpendicular X- and Y-directions on a surface comprising: a light source, means for forming an image of the light source on the surface, means for rapidly and repeatedly scanning the image in the Y-direction, means for selectively energizing the light source to expose predetermined surface areas to light flashes, and means for causing a relative displacement in the X-direction between the surface and the light source to thereby form a plurality of exposed areas on the surface extending in the X- and Y-directions and forming the symbol.

11. Apparatus according to claim **10** including a plurality of light sources for the simultaneous formation of a plurality of symbols, and including means positioning the light sources with respect to the image forming means and the scanning means so that projections of each light source occur over a portion of the surface which is separate and independent of surface portions onto which the remaining light sources are projected.

12. Apparatus according to claim 10 including reflector means between the light source and the surface, and wherein the scanning means comprises means positioning the reflector means for changing the angle of incident of light emitted by the source striking the surface so that the projected source image is moved in the Y-direction.

13. Apparatus according to claim 12 wherein the reflector means comprises a plurality of reflector sections, wherein the means positioning the reflector means comprises means fixedly mounting each section and means positioning reflecting surfaces with respect to incoming light from the source so tat the light strikes each reflecting surface at a different angle and is projected to the predetermined surface areas, and wherein the apparatus further includes means for shielding all but at most one of the reflector sections from light emitted by the source, and means for moving the shielding means to permit emitted light to sequentially strike each reflector section.

14. Apparatus according to claim 13 wherein the shield moving means comprises disc means between the source and the sections and defining at least one aperture positioned to permit light from the source to be projected to the sections, and wherein the apparatus further includes means for moving the disc means in synchronism with the means energizing the light source.

15. Apparatus according to claim 12 wherein the reflector means comprises a movable reflector, and means for moving the reflector to change the angle of incidence of light emitted by the source striking the surface so that the source image scans in the Y-direction.

16. A line printing apparatus for simultaneously generating a plurality of alpha-numeric characters in character fields extending in perpendicular X- and Y-directions, the fields being lineally spaced in the Y-direction across the width of a movable light sensitive surface comprising: a light source for each character field mounted to a support structure, the light source being capable of emitting brief light flashes at high frequencies, means for imaging each light source on the corresponding character field, means for moving the source images in the Y-direction substantially fully across the width of the fields, means synchronized with the projected image moving means for repeatedly selectively energizing the light sources to expose surface areas of the fields at predetermined relative positions spaced in the Y-directions, and transport means for moving a sheet defining the surfaces in the X-direction so that the predetermined areas define the characters when exposed to the light flashes.

17. An optical line printer comprising a support structure, means for mounting a light sensitive sheet and moving the sheet in a first direction, a plurality of light sources fixedly mounted to the support structure, means for projecting light emitted by each source onto the sheet, means cooperating with the light source mounting means for equally spacing the projected light in a second, perpendicular direction across the width of the sheet, means for repeatedly scanning the projected light in the second direction a distance not exceeding the spacing between the light projections to obtain a plurality of scan lines spaced in the first direction as a result of the movement of the sheet, means for momentarily energizing the light sources to form brief light flashes, ad synchronizing means coupled to the light source energizing means and the scanning means, the synchronizing means including means permitting the energization of the light sources when the projected images are at predetermined relative positions in the fields, and means for selectively actuating the light source energizing means when the projected images are at the predetermined positions to sequentially expose characters defining surface areas of the fields.

18. A line printer according to claim 17 wherein the scanning means comprises a galvanometer reflector disposed between the light sources and the sheet, the light sources comprise light-emitting diodes, and including means for simultaneously projecting light flashes from all diodes via the galvanometer reflector onto the sheet, the galvanometer being positioned so that relative movements of the reflector cause the simultaneous movement of the projected light flashes in the second direction.

19. Apparatus according to claim 17 wherein the scanning means comprises a plurality of fixed, angularly inclined reflector segments, means defining an aperture and disposed between the segments and the light sources, means for sweeping the aperture past the segments, and means coupling the sweeping means and the actuating means for energizing the light sources when the aperture substantially fully overlies one reflector segment to maximize the intensity of light striking the material.

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