June 10, 1952 B. H. KLYCE 2,600,168

PHOTOPRINTING DEVICE

Filed March 26, 1949 2 SHEETS—SHEET 1

FIG. 1.

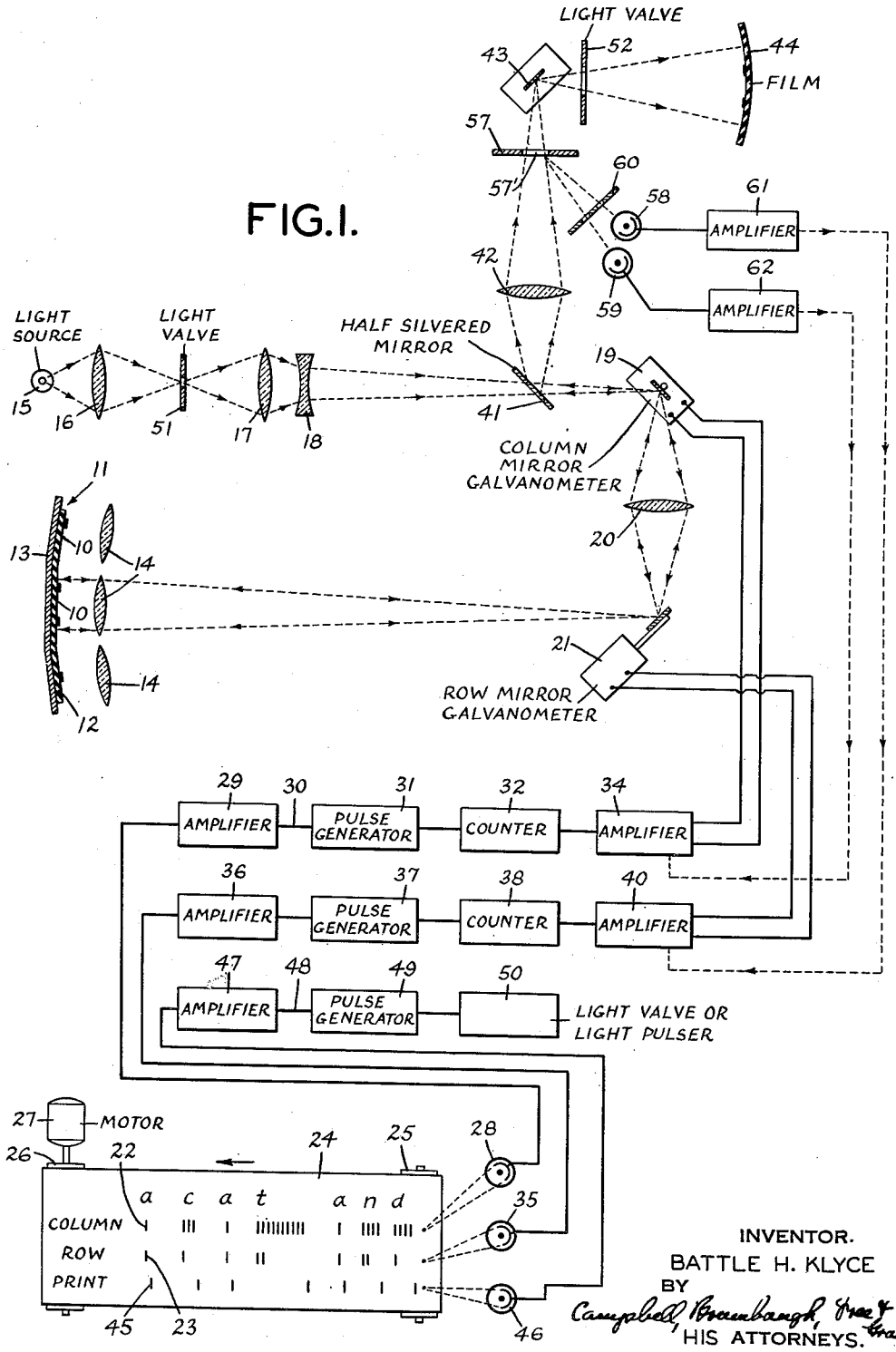

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FIG.3.

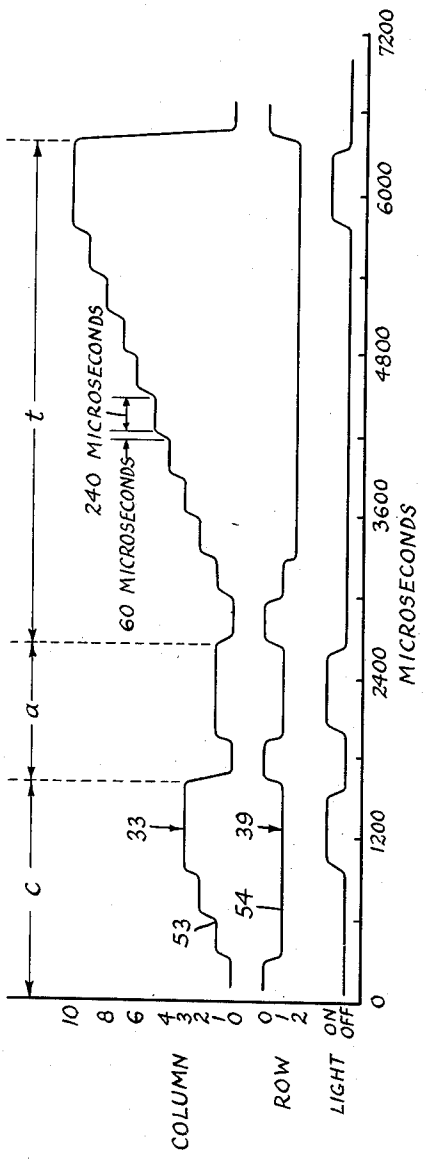


FIG.2.

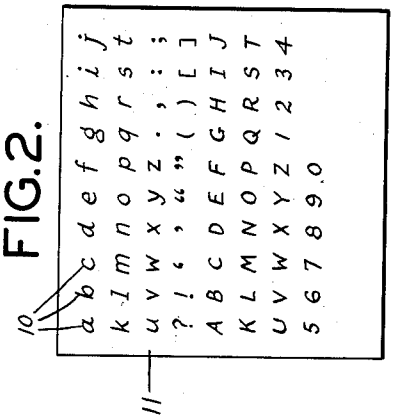


FIG.5.

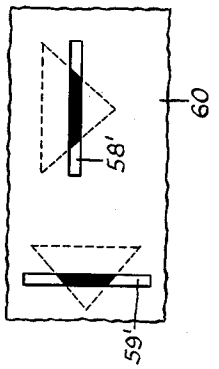
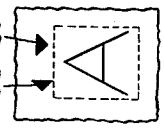


FIG.4.



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UNITED STATES PATENT OFFICE

2,600,168

PHOTOPRINTING DEVICE

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Application March 26, 1949, Serial No. 83,620

18 Claims. (Cl. 95—4.5)

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The present invention relates to photo-printing devices and more particularly to new and improved apparatus for printing characters on a photographic record strip in a rapid and effective manner.

The copending application of Walter E. Peery, Serial No. 41,318, filed July 20, 1948, for "Electronic Photo-Typecomposing System," discloses an electronic photocomposing system in which selected characters on a rotating disc are printed successively on a photographic record strip. Since only one character is printed for each revolution of the disc, this apparatus has a relatively low duty cycle and the exposure must be made with a special form of high speed printing lamp if relatively high operating speeds are to be achieved.

The principal object of the present invention is to provide new and improved photo-printing apparatus having a relatively high duty cycle and which is capable of relatively high printing speeds with a printing lamp of conventional type.

Another object of the invention is to provide new and improved photo-printing apparatus of the above character which includes means to insure proper positioning of characters to be printed on a photographic strip.

These and other objects of the invention are attained by providing a character bearing member on which are formed a plurality of characters to be printed. The characters are preferably disposed at different points of a suitable two dimensional coordinate system and they are adapted to be illuminated selectively by an optical system having moving parts of relatively small size and mass so as to be capable of very rapid movement.

In a typical embodiment, electric signals representative of the position coordinates of a character are applied to corresponding mirror galvanometers which control the point of impingement of a beam of light upon the character bearing member. Light from the illuminated character is then directed to a photographic strip on which the character may be printed, suitable means being provided for printing successive characters in a line.

According to another embodiment of the invention, positioning indicia are associated with each character on the character bearing member and they are adapted to be illuminated simultaneously with the respective characters to which they correspond. The illumination of the positioning indicia causes signals to be generated which modify the action of the mirror galvanometers in such fashion as to position the corresponding character accurately on the photographic strip.

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Additional objects and advantages will become apparent from the following detailed description of several typical embodiments, taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic diagram of photo-printing apparatus constructed according to the invention;

Fig. 2 illustrates schematically a typical character bearing member for use with the apparatus of Fig. 1;

Fig. 3 is a graph showing representative curves of the voltages applied to the mirror galvanometers as a function of time, together with a curve showing the exposure time;

Fig. 4 is a view in elevation of part of the character bearing member, showing positioning indicia associated with a character thereon; and

Fig. 5 is a view in elevation showing how the images of the positioning indicia appear when seen through the viewing slits.

In the illustrative form of the invention shown in Figs. 1 and 2, a plurality of characters 10 on a character bearing member 11 are adapted to be selectively illuminated by controlling the point of impingement of a beam of light upon the character bearing member 11. While the characters 10 may be disposed on the character bearing member 11 in any suitable two dimensional coordinate system, they are disclosed herein, by way of example, in horizontal rows and columns as shown in Fig. 2.

The character bearing member 11 may be formed in any desired manner and it may comprise, for example, a photographic negative 12 on which the characters 10 appear as transparencies, mounted upon a suitable specular reflecting surface 13 such as a mirror, for example. Preferably, the mirror portion underlying each character should be a plane mirror, the adjacent plane mirrors being disposed on a spherical surface. Preferably, a lens 14 is disposed in front of each of the characters 10 on the character bearing member 11. With this construction, parallel light rays passing through a lens 14 will strike the corresponding plane mirror portion and will return along the same lines whence they came.

The beam for illuminating the characters on the character bearing member 11 may be produced in any desired manner, as, for example, by an approximate point source 15 such as a West-

ern Union crater lamp. Light from the point source 15 is directed through a lens system comprising the lenses 16, 17 and 18 to a mirror galvanometer 19 which is mounted for rotation about the vertical axis to select the column in which a character to be printed appears. From the column mirror galvanometer 19, the beam of light is directed through another lens 20 to another mirror galvanometer 21 which is mounted for rotation about a horizontal axis to select the row in which the character to be printed appears. If the galvanometers 19 and 20 can be placed near one another, the lens 20 may be omitted.

The column and row galvanometers 19 and 21, respectively, are adapted to be actuated by electric signals generated in response to column and row code markings 22 and 23, respectively, on a record strip 24. The record strip 24 is adapted to be moved continuously in the direction indicated by the arrow from a supply spool 25 to a take-up spool 26 which may be driven by any suitable motor 27, for example.

In the code system shown on the tape 24 (Fig. 1), the number of code markings 22 indicates the number of the column in which the letter to be printed appears while the number of code markings 23 indicates the row in which the character appears. Thus, the lower case letter *a* is represented by one code mark 22 and one code mark 23, since it is in the first column and first row on the character bearing member 11. Other suitable code systems may be employed as will be apparent to those skilled in the art.

The column code markings 22 are adapted to be scanned by a suitable photoelectric cell 28 which is connected to an amplifier 29. The output of the amplifier 29 is connected by conduit means 30 to a pulse generator 31 which produces a pulse each time a code mark 22 is scanned by the photoelectric cell 28. The pulses produced by the pulse generator 31 are counted by a conventional pulse counter 32 which produces a stair-step type of voltage, as shown in the curve 33 of Fig. 3. The stair-step voltage output of the counter 32 is amplified by suitable amplifier means 34, the output of which is connected to energize the mirror galvanometer 19.

In similar fashion, the row code markings 23 are adapted to be scanned by a suitable photoelectric cell 35 connected to an amplifier 36, the output of which is supplied to a pulse generator 37. The pulse generator 37 produces a pulse each time a code mark 23 is scanned by the photoelectric cell 35 and these pulses are counted by a conventional type counter 38 which produces a stair-step voltage of the type illustrated by the curve 39 of Fig. 3. The stair-step voltage output of the counter 39 is amplified by a suitable amplifier 40, the output of which is connected to energize the row galvanometer 21.

As each group of code marks 22 and 23 on the tape 24 is scanned by the photoelectric cells 28 and 35, respectively, it will be understood that the column and row galvanometers 19 and 21, respectively, will be moved to the proper positions to direct the beam from the source of light 15 to the corresponding character 10 on the character bearing member 11. Light transmitted through the character 10 and reflected by the mirror 13 is directed by the row and column galvanometers 21 and 19, respectively, to a half-silvered mirror 41. A portion of the light reflected from the mirror 41 is directed through a lens 42 to a mirror galvanometer 43 from which it is reflected to a photographic film 44, for example, on which the character is to be printed. The mirror galvanometer 43 may be moved by means like that disclosed in the above-mentioned application Serial No. 41,318, so that successive characters are printed on the film 44 in justified lines.

The film 44 may be exposed in any desired manner, as by pulsing the light source 15 after the column and row galvanometers 19 and 21, respectively, have been moved to the proper positions to direct light to the selected character 10 to be printed. For this purpose, a plurality of code marks 45 are formed on the strip 24, which are adapted to be scanned by a photoelectric cell 46. Preferably, the code marks 45 should be positioned slightly behind the last code marking for any character, so as to provide sufficient time for the galvanometers to move to the required positions before exposing the film 44. The signals from the photoelectric cell 46 are amplified in a suitable amplifier 47, the output of which is fed by a conduit 48 to a pulse generator 49 which produces a pulse each time one of the code marks 45 is scanned by the photoelectric cell 46. The output of the pulse generator 49 may be connected to energize a suitable light pulser 50 for pulsing the light source 15.

Alternatively, the exposure of the film 44 may be controlled by means of conventional light valves which may be suitably disposed in the optical system. Thus, a light valve 51 might be interposed between the lenses 16 and 17 or a light valve 52 might be interposed between the mirror galvanometer 43 and the film 44. In either case, the light valve would be connected so as to be operated by the light pulser 50.

In operation, assume that the character *c* is to be printed. As shown on the record strip 24, this character is designated by three column code marks 22 and one row code mark 23. As these code marks are scanned by the photoelectric cells 28 and 35, respectively, stair-step voltages of the type indicated at 53 on the curve 33 and 54 on the curve 39 (Fig. 3) appear at the output terminals of the amplifiers 34 and 40, respectively. These voltages are impressed upon the column and row galvanometers 19 and 21, respectively, which move to the proper positions to focus the character *c* accurately on the film 44. Shortly after the last code mark 22 for the character *c* has been scanned by the photocell 28, the printing code mark 45 is scanned by the photocell 46. This pulses the light source 15 and exposes the film 44 to the character *c*. Other characters are printed in essentially the same manner.

Ordinarily, the characters can be accurately positioned on the film 44 despite slight variations in the voltage or in the mechanical characteristics of the several galvanometers employed in the system. If a high degree of accuracy is desired, however, each of the characters 10 on the character bearing member 11 may be provided with horizontal and vertical positioning indicia 55 and 56, respectively, as shown in Fig. 4. The indicia 55 and 56 may be, for example, transparent triangles having their apices directed downwardly and leftwardly, respectively. It will be understood that when the light source 15 is on, and the galvanometer mirrors 19 and 21 are positioned to direct light to a particular character 10, images of the character and the corresponding positioning indicia 55 and 56 will be reflected from the half silvered mirror 41.

According to the invention, a suitable reflecting screen 57 is interposed between the lens 42 and the mirror galvanometer 43, having an aperture 57' therein to permit the image of the character to pass therethrough to the galvanometer 43. The rays corresponding to the indicia 55 and 56 are intercepted by the screen 57 and directed to an opaque member 60 having slits 58' and 59' therein. Images of the indicia 55 and 56 are thus formed in the plane of the slits 58' and 59', respectively, which images are adapted to be scanned by suitable photoelectric cells 58 and 59, respectively.

Light passing through the slits 58' and 59' to the photocells 58 and 59 causes the latter to generate electric signals which are amplified in the amplifiers 61 and 62, respectively. The outputs of the amplifiers 61 and 62 are fed back to the amplifiers 40 and 34, respectively, in such fashion as to generate voltages tending to cause the column and row galvanometers 19 and 21, respectively, to move until the indicia 55 and 56 are so positioned that the amount of light reaching the photocells 58 and 59 is midway between the minimum and maximum amounts of light that may reach them. This is the condition shown in Fig. 5. When this condition obtains, it will be understood that the character to be printed will be accurately positioned for proper exposure on the film 44.

In this embodiment, the light source 15 must be on all the time so that the positioning system can operate properly. Exposure of the film 44 to the character to be printed should preferably be accomplished by means of the light valve 52 which is interposed between the mirror galvanometer 43 and the film 44.

It will be apparent, from the foregoing, that the invention provides a novel photographic printing device which enables high printing speeds and a relatively high duty cycle to be attained with conventional components. Thus, with a light source 15 comprising a conventional printing lamp which has an exposure time of, say, 600 microseconds, it can be shown that the character *a* can be printed with the apparatus at the rate of about 1,000 per second. On the other hand, the character T can be printed at the rate of about 250 per second. An average printing speed for the apparatus under these conditions, therefore, might be around 400 or 500 characters per second. These figures are based on the assumption that the galvanometers employed have a uniform frequency response up to about 5,000 cycles per second, and that the time of rise of the circuits interposed between the photoelectric cells and the mirror galvanometers is of the order of 53 microseconds.

It will be further understood that the several embodiments described above by way of illustration are susceptible of numerous changes in form and detail within the spirit of the invention. The amplifiers, pulse generators and counters employed may be of any conventional type suitable for the purpose. Also, the coordinate system in which the characters 10 are arranged on the character bearing member 11 need not be rectangular, as shown in Fig. 2, but may be of any suitable type. The specific embodiments described and illustrated herein, therefore, are not to be regarded as limiting in any way the scope of the following claims.

I claim:

1. In a projection system, the combination of a member carrying a plurality of rows and columns of characters thereon backed by specular reflecting means, a source of light, means forming an optical path between said light source and said character bearing member for directing light in one direction from said source to a selected character and for transmitting an image of said character in the opposite direction thereover, said path forming means including a pair of reflector members, and means for adjusting the positions of said reflector members with respect to said character bearing member to direct light from said source to a character to be projected.

2. In a projection system, the combination of a member carrying a plurality of rows and columns of characters thereon backed by specular reflecting means, a source of light, means forming an optical path between said light source and said character bearing member for directing light from said source to a selected character and for transmitting an image of said selected character thereover in the opposite direction, said path forming means including a pair of reflector members, means for adjusting the positions of said reflector members with respect to said character bearing member to enable them to direct light from said source to a character to be illuminated by said source, an image receiving element, and reflector means in said optical path for directing said image of a selected character on said character bearing member to said image receiving element.

3. In a projection system, the combination of a member carrying a plurality of mutually perpendicular rows and columns of characters thereon, said characters being backed by specular reflecting means, a source of light, means forming an optical path between said light source and said character bearing member for directing light from said source to a selected character and for transmitting an image of said selected character thereover in the opposite direction, said path forming means including a pair of reflector members mounted for rotation about mutually perpendicular axes, code controlled means for adjusting the positions of said reflector members with respect to said character bearing member to direct light from said source to a character to be illuminated by said source, an image receiving element, and reflector means in said optical path for directing said image of a selected character on said character bearing member to said image receiving element.

4. In a projection system, the combination of a member carrying a plurality of rows and columns of characters thereon, said characters being backed by specular reflecting means, a source of light, means forming an optical path between said character bearing member and said light source for directing light from said source to a selected character and for transmitting an image of said selected character thereover in the opposite direction, said path forming means including a pair of reflecting members, a record strip bearing row and column code indicia corresponding to characters to be projected and other code indicia, means responsive to said row and column code indicia for adjusting the positions of said reflecting members relatively to said character bearing member so as to enable them to direct light from said source to a selected character to be projected, means responsive to said other code indicia for rendering said light source effective to illuminate said selected character on said character bearing member, and reflector means

in said optical path for directing said image of a selected character to image receiving means.

5. In photoprinting apparatus, the combination of a member carrying a plurality of rows and columns of characters thereon, said characters being backed by specular reflecting means, a photosensitive element, a source of light, means forming an optical path between said light source and said character bearing member for directing light from said source to a selected character and for transmitting an image of said selected character thereover in the opposite direction, said path forming means including a pair of reflecting members mounted for rotational adjustment about axes at an angle to each other, means for adjusting the positions of said reflecting members relatively to said character bearing member so as to enable them to direct light to a selected character to be printed, and optical means including reflector means in said optical path for directing an image of a selected character to said element.

6. In photoprinting apparatus, the combination of a member carrying a plurality of rows and columns of characters thereon, said characters being backed by specular reflecting means, a photosensitive element, a source of light, means forming an optical path between said light source and said character bearing member for directing light from said source to a selected character and for transmitting an image of said selected character thereover in the opposite direction, said path forming means including a pair of reflecting members mounted for rotation about mutually perpendicular axes, a record strip bearing row and column code indicia representing characters to be printed, means responsive to said code indicia for adjusting the positions of said reflecting members relatively to said character bearing member so as to enable them to direct light from said source to a character to be printed and optical means including reflecting means in said optical path for directing said image of a selected character to said photosensitive element.

7. In photoprinting apparatus, the combination of a member carrying a plurality of rows and columns of characters thereon, said characters being backed by specular reflecting means, a photosensitive element, a source of light, means forming an optical path between said light source and said character bearing member for directing light from said source to a selected character and for transmitting an image of said selected character thereover in the opposite direction, said path forming means including a pair of reflecting members mounted for rotation about mutually perpendicular axes, a record strip bearing row and column code indicia representing characters to be printed and printing code indicia, means responsive to said row and column code indicia for adjusting the positions of said reflecting members relatively to said character bearing member so as to enable them to direct light from said source to a character to be printed, optical means including reflecting means in said optical path for directing said image of a selected character to said photosensitive element, and means responsive to said printing code indicia for rendering said light source effective to expose said element to said image.

8. In a projection system, the combination of a member carrying characters and character positioning indicia thereon, a reflecting means, a record strip bearing code indicia thereon representing characters to be projected, means responsive to said code indicia for adjusting the positions of said reflecting means relatively to said character bearing member to select a character to be projected, and electrical means embodying photosensitive means responsive to the character positioning indicia corresponding to said selected character for further adjusting the positions of said reflecting means to control the accuracy of positioning of the projection of said selected character.

9. In a projection system, the combination of a member carrying characters and corresponding character positioning indicia thereon, a photoelectric element, means forming an optical path between said character bearing member and said element, said path forming means including a pair of reflecting members mounted for rotation about mutually perpendicular axes, a record strip bearing row and column code indicia corresponding to characters to be projected, means responsive to said code indicia for adjusting the positions of said reflecting members relatively to said character bearing member to select a character to be printed, reflecting means for directing to said photoelectric element an image of the positioning indicia corresponding to a selected character, and electrical feedback means including said photoelectric element responsive to said positioning indicia image for modifying the adjustment of said reflecting members to render the selection of a character more accurate.

10. In photoprinting apparatus, the combination of a member carrying a plurality of rows and columns of characters and corresponding character positioning indicia thereon, said characters and character positioning indicia being backed by specular reflecting means, a photosensitive element, an image receiving element, a source of light, means forming an optical path between said light source and said character bearing member for directing light from said source to a selected character and for transmitting an image of said selected character thereover in the opposite direction, said path forming means including reflecting means rotatable about mutually perpendicular axes, a record strip bearing row and column code indicia thereon representing characters to be printed, means responsive to said row and column indicia for adjusting the positions of said reflecting means relatively to said character bearing member so as to enable them to direct light from said source to a character to be printed, optical means including second reflecting means in said optical path for directing an image of a selected character to said image receiving element and an image of the corresponding positioning indicia to said photosensitive element, and electrical feedback means including said photosensitive element responsive to said positioning indicia image for modifying the operation of said adjusting means to render the selection of a character more accurate.

11. In photoprinting apparatus, the combination of a member carrying a plurality of rows and columns of characters and corresponding character positioning indicia thereon, said characters and character positioning indicia being backed by specular reflecting means, a photosensitive element, an image receiving element, a source of light, means forming an optical path between said light source and said character bearing member for directing light from said source to a selected character and for transmitting an image of said selected character thereover in the opposite direction, said path forming means in-

cluding a pair of reflecting members rotatable about mutually perpendicular axes, a record strip bearing printing code indicia and row and column code indicia thereon representing characters to be printed, means responsive to said row and column indicia for adjusting the positions of said reflecting members relatively to said character bearing member so as to enable them to direct light from said source to a character to be printed, optical means including reflecting means in said optical path for directing an image of a selected character to said image receiving element and an image of the corresponding positioning indicia to said photosensitive element, electrical feedback means including said photosensitive element responsive to said positioning indicia image for modifying the operation of said adjusting means to render the selection of a character more accurate and means responsive to said printing code indicia for rendering said light source effective to expose said photosensitive element to said selected character image.

12. In a projection system, the combination of a member carrying a plurality of characters thereon, a beam of radiant energy, first optical means forming a path for said beam between its source and said member, said path including first reflecting means, means for positioning said first reflecting means relatively to said member to select a character on said member to be projected, second reflecting means in back of said characters for reflecting an image of each selected character as formed by said beam and member in reverse direction along said path, and second optical means including third reflector means interposed in said path between said source and the first reflecting means for directing an image of each selected character to an image-receiving point.

13. In a projection system, the combination of a member carrying a plurality of characters thereon, a beam source, first optical means forming a beam path between said source and said member, said path including first reflecting means mounted for movement about mutually perpendicular axes, motive means for adjusting the angular positions of said reflecting means relatively to said member to direct said beam to a selected character on said member to form an image thereof, second reflecting means in back of said characters for reflecting each character image in reverse direction along said beam path, and second optical means including third reflector means interposed in said path between said source and first reflector means for directing the images of the successively selected characters to an image-receiving point.

14. In a projection system as set forth in claim 13 including means forming character positioning indicia on said character-carrying member adjacent each character thereon and adapted to form indicia images concurrently with the formation of each selected character image, photoelectric means, and electrical feedback means including said photoelectric means responsive to said character positioning indicia images for modifying the operation of said motive means to render selection of characters more accurate.

15. In a photo-printing apparatus, the combination of a member carrying a plurality of characters thereon, a light source, means forming an optical path between said light source and said character-bearing member for directing light from said source to a selected character and for transmitting an image of said selected character in the reverse direction thereover, said path including a first reflecting means mounted for adjusting movement relatively to said member to select a character to be projected, second reflecting means in back of said characters for reflecting images of selected characters as formed by said light in reverse direction along said optical path, optical means including third reflector means interposed in said path between said light source and said reflecting means for directing successively formed character images out of said optical path, photo-sensitive means to which images from said third reflecting means are directed, and motive means for adjusting the position of said first reflector means.

16. In photo-printing apparatus as set forth in claim 15 including means forming character positioning indicia on said character-carrying member adjacent each character thereon and adapted to form positioning indicia images concurrently with the formation of each selected character image and electrical feedback means including said photosensitive means responsive to said character positioning indicia images for modifying the operation of said motive means to render selection of characters more accurate.

17. In photo-printing apparatus as set forth in claim 15 wherein said third reflecting means comprises a partially silvered mirror for passing at least a portion of the light from said light source to said character-carrying member and for reflecting at least a portion of the light forming an image of a selected character returning from said character member in reverse direction along said light path.

18. In a projection system as set forth in claim 12, said member carrying a plurality of characters and said second reflecting means comprising a plurality of surfaces contained in angularly spaced planes, said planes being angularly arranged to reflect the character images formed thereon to a common position in said beam path.

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