United States Patent [19]

Shapiro

[11] **3,742,825**

[45] **July 3, 1973**

[54] **CHARACTER SPACING SYSTEM FOR PHOTOTYPESETTING**

[75] Inventor: **Eliezer Y Shapiro**, New York, N.Y.

[73] Assignee: **Harris-Intertype Corporation**, Cleveland, Ohio

[22] Filed: **June 26, 1970**

[21] Appl. No.: **50,025**

[52] **U.S. Cl.** **95/4.5**

[51] **Int. Cl.** **B41b 13/10**

[58] **Field of Search** 95/4.5; 350/22, 26

[56] **References Cited**

UNITED STATES PATENTS

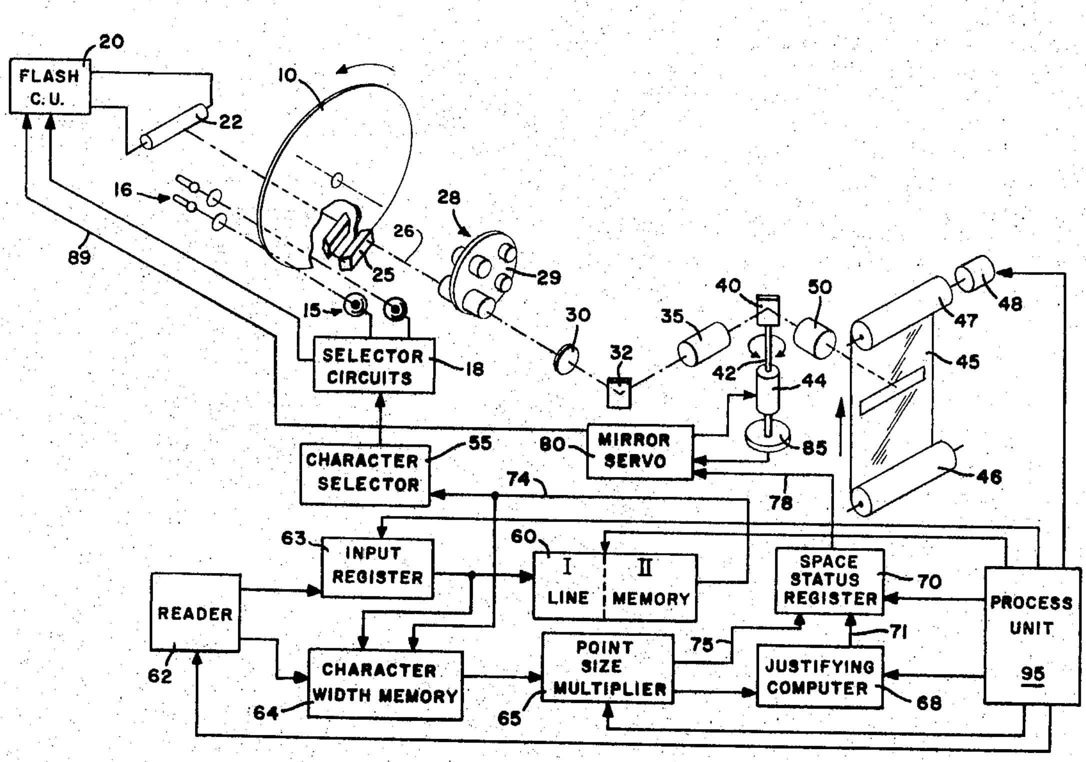
3,539,256	11/1970	Ables	95/4.5 R
3,543,657	12/1970	Rosenblum	95/4.5 R
3,434,402	3/1969	McCall	95/4.5
3,224,349	12/1965	Schumann et al.	95/4.5
2,787,654	4/1957	Peery	95/4.5

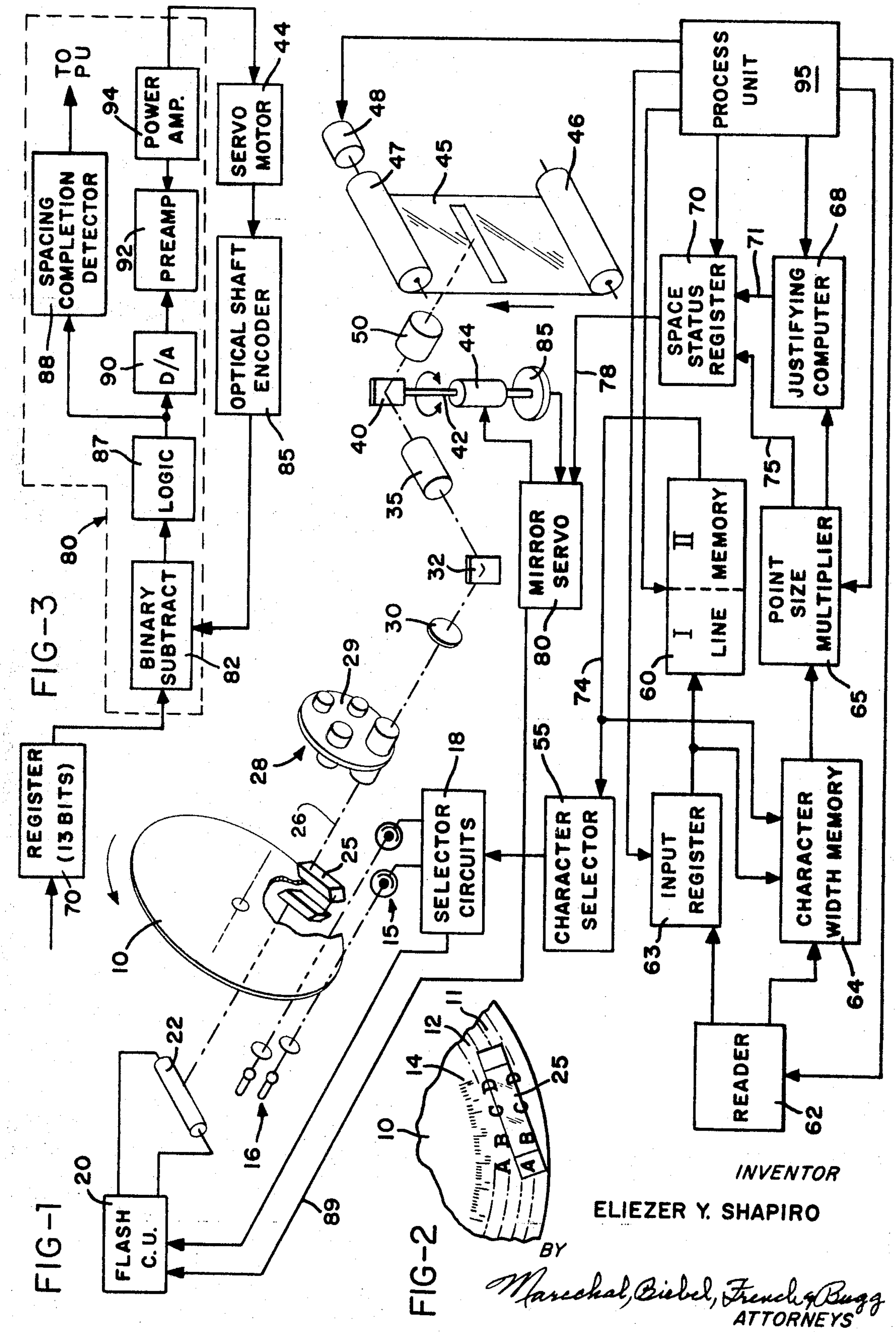
Primary Examiner—Joseph F. Peters, Jr.
Assistant Examiner—Russell E. Adams, Jr.
Attorney—Marechal, Biebel, French & Bugg

[57] **ABSTRACT**

A character image projection system successively projects image bearing light beams along a common optical axis toward a photosensitive surface. The images of the individual characters are spaced on the photosensitive surface to form lines of composition. Spacing is accomplished by collimating the image bearing light beams, then diverting the collimated beam by means of a movable reflecting surface into a refocusing and scanning lens assembly from which the light beams emit onto the photosensitive surface. The position of the reflector is controlled by a servo mechanism which responds to character image space information from a computer. The servo mechanism incorporates a closed loop with positional feedback derived from an encoder driven synchronously with the reflecting surface. Each subsequent position of the reflecting surface is defined by a unique address code finding correspondence in the encoder.

8 Claims, 3 Drawing Figures





INVENTOR
ELIEZER Y. SHAPIRO

BY Marechal, Biebel, French & Bugg
ATTORNEYS

CHARACTER SPACING SYSTEM FOR PHOTOTYPESETTING

RELATED APPLICATION

This application is related to copending U. S. application Ser. No. 34,300, filed May 4, 1970, now U.S. Pat. No. 3,668,984 entitled OPTICAL CHARACTER SPACING SYSTEM FOR PHOTOTYPESETTING and assigned to the same assignee.

BACKGROUND OF THE INVENTION

This invention relates to high speed phototypesetting machines of the kind in which characters for the formation of lines of composition are selected from input selection codes, and image bearing light beams of the individual characters are directed in order to different positions on a photosensitive surface, such as photographic film or paper. Various arrangements have been provided for directing of the image bearing light beams successively to the correct positions for spacing of the images formed on the photosensitive surface. These include moving film carriages and translating reflector systems. These prior art arrangements form a major limitation upon the total speed and capacity of the system, due primarily to inertia of the moving parts and consequent speed limits on the associated controls.

Suggestions have been made in the prior art for spacing of characters on the photosensitive surface through the use of rotatable reflecting members, such as a mirror, which is moved to different angular positions and therefore reflects the image bearing light beams to different regions of the photosensitive surface in order to achieve character spacing. U. S. Pat. No. 1,175,685, issued Mar. 14, 1916, discloses a system wherein the photosensitive surface is mounted in a flat image plane, and a movable optical system is incorporated in conjunction with an angularly moving mirror in order to maintain proper focus of the character images. Other suggestions have been made using angularly movable or rotatable mirrors or reflectors, in which the film is mounted along an arc which has the center of rotation of the mirror as its focus, but this results in some distortion in the character images, since they are being focused onto the photosensitive surface along a short arc, rather than over a flat plane. Furthermore, accurate positional control of an angularly movable member is compounded by the fact that small angular errors will magnify appreciably as the beam deviates farther from center, when using a flat film.

SUMMARY OF THE INVENTION

In accordance with the present invention, successive image bearing light beams of the characters to form lines of composition are produced by equipment which is known per se, and the size of the images may be controlled by known means. The path of the image bearing light beams is directed through the collimating lens system (in some cases part of the size control) which collimates the image bearing beam into parallel rays and the collimated beam is directed to a rotating reflector such as a mirror. The angular position of the reflector is controlled by a servo motor system which holds the mirror in selected different angular positions with the accuracy necessary for phototypesetting quality. The servo motor is controlled in accordance with the image width information derived in selection of the character, from a width memory and point size multiplier. The collimated beams are thus reflected toward the correct preselected locations, and a scanning and refocusing lens assembly receives these beams, at the different angular locations, from the rotatable reflector, and directs the beams onto the photosensitive surface. This surface, such as photographic film or paper, is mounted in an image plane and the scanning lens assembly focuses the image bearing beams in this plane, to form successive properly sized images of the individual characters, in the proper succession.

The scanning lens assembly thus is of a special construction which compensates for distortion of the image at the extreme angular positions of the rotatable reflector to either side of a mid position in which beams reflected from it would intersect the photosensitive surface at right angles. The scanning lens assembly also has designed into it compensation for changes in focus due to the increase in length of the optical path as the light beams intersect the photosensitive surface at angles decreasing from 90°, at either ends of the lines being composed. Therefore, the scanning lens assembly operates as a passive element which provides the necessary compensation for distortion and/or change in focus due to deviation of the light beam from direct right angle intersection with the image plane.

The angular position of the reflecting member is controlled by a servo system which responds to direct address information pertaining to the desired location of this member as each character image is projected. A unique selection code for each character is also used to look up the relative width of that character from a memory. This memory is loaded according to the font being used. The relative width is then multiplied by the point set factor, which represents the image enlargement or reduction in the optical system, and the product thus represents the actual character width.

These width values are accumulated in a register as the characters are photographed, thus the sum in this register represents the position the reflecting member should attain for the next character. A servo motor controls the position of the reflecting member, receiving its input from a D/A converter which is driven by the information in the register. The servo motor also drives a position encoder which is connected to feed back position code information to the servo control system. Thus the reflecting member is moved directly, by address, from one position to the next, and is accurately located at all times when characters are being photographed.

The encoder has the capability of representing any possible position of the reflecting member, to a small fraction of a pica, by unique address codes. Thus, the character spacing servo system can be characterized as a direct address control, as distinguished from prior devices using stepping motors which merely add or achieve their next desired position from the preceding position. Therefore, in the present invention, cumulative spacing errors do not occur. If there is an error, as due to noise or a slightly incorrect code, this has no effect on the subsequent positions so long as the output space register accurately totals the products of the selection and size multiplication devices.

The primary object of the invention, therefore, is to provide a novel character spacing system and control for a phototypesetting machine, wherein lightweight low inertia parts are accurately positioned by a servo system incorporating direct address position control and positional direct address feedback, thereby minimizing the time between character projections and still achieving spacing of typographical quality.

Other objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram showing the phototypesetting machine and its character spacing apparatus, as provided by the invention, together with block diagram illustrations of the controls therefor;

FIG. **2** is a fragmentary view of the typical character font disc which may be employed in the apparatus shown in FIG. **1**, illustrating the character selection code used in conjunction with the character selection and projecting system; and

FIG. **3** is a more detailed block diagram of the spacing servo system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, the character image projecting system includes a continuously rotating character font disc **10** which may be of the type shown in U. S. Pat. No. 3,223,017, although the character width information may be omitted from the disc in this particular instance. As shown in FIG. **2**, the disc includes at least two font circles **11** and **12**, each of which includes a full font of type, different from the other, as a transparency throuh an opaque background. The character selection code, unique for each character in the font, is contained within a separate zone **14**. Further details regarding the selection code and its use are described in U. S. Pat. No. 3,059,219.

The selection code in zone **14** cooperates with a pair of photocells **15** and cooperating light sources **16** to generate character selection pulses which are directed to selector circuits **18** that in turn control a flash control unit **20**. This unit drives a high speed flash lamp **22** (or a corresponding spark gap) which creates an intense beam of light, having a short time duration in the order of a microsecond. This light passes through the font selector prisms **25** which are located on either side of the disc **10**, and exits from these prisms along an optical path **26** which is common to the successively connected images. Details of the construction and operation of the font prism system are disclosed in U. S. Pat. No. 3,099,945.

The image bearing light beams then proceed through one of a plurality of sizing lenses **28** carried for example in a turret **29** such that any selected one of these lenses is movable into the optical path, thus changing the size of the resultant image. Alternatively, adjustable character sizing lenses could be employed. In any event, the sizing lens which is in the operating position produces a real image of the character at a field lens **30**, which is essentially operative to gather the light rays for the further operation of the optical system. The image bearing beams proceed from the field lens **30** to a reflector system shown schematically at **32**, in which the light is redirected as necessary. This sytstem may include prisms with multiple reflecting surfaces for orienting the character images as necessary, however, for simplification there is shown merely a single reflecting surface.

The light beams then pass to a collimating lens system **35**. This collimating lens preferably has some adjustment of its focal length, sufficient for initial set-up and precise focusing, but once this adjustment is made, ordinarily the collimating lens is not further adjusted. The collimated light beams emitted from the collimating lens **35** are directed onto a rotatable reflector or mirror **40** which is connected to the shaft **42** of a servo motor **44** which functions as a means for selectively changing the angularity of the reflection of the collimated beams. This directs the collimated light beams to different portions of a photosensitive surface **45**, which may be for example photographic film or paper from a supply roll **46**, passing to a take-up roll **47** under the control of a motor **48** that functions as a leading or line spacing control for the spacing of successive lines of composition. The reflector **40** directs light to the plane of the photosensitive material **45** in such a way that the center of a line to be formed on the material **45** is at a point at right angles to the beam of light coming from the reflector **40**. Thus, the reflector displaces the beams to either side of this center path.

Between the reflector **40** and the image plane defined by the position of the photosensitive material **45**, there is a scanning or refocusing lens **50** which functions to focus the collimated light beams and thus produce a real image at the image plane and on the photosensitive material. At the same time, this scanning lens provides compensation for the angularity of light beams striking the photosensitive surface at some angle less than 90°, as when the light beams are displaced to either side of the center. Obviously, the farther the light beams are displaced in either direction, the more acute this angle will become, and in an ordinary optical system this would produce blurring of the images due to change in optical path, and would also produce a distortion of the image, with the character image tending to become wider as it is displaced farther from the center mark.

The scanning lens **50** thus functions as a passive element which provides for proper focus and sizing and spacing of the character images, while permitting the photosensitive material to be supported in a plane. This scanning lens is of a special design, and is more fully described in the above-mentioned U. S. application Ser. No. 34,300.

Thus, in this system the only member which moves for spacing of characters while composing an entire line, is the relatively lightweight, low inertia, mirror or reflecting member **40**. With the servo motor **44**, it is possible to achieve angular movements and positioning of the mirror **40** at very high speeds and with accuracy that is acceptable for typesetting standards of quality.

Various controls and devices can be used for the selection of the characters to produce justified lines of composition. By way of example the selector circuits **18** may be of the type described and shown in U. S. Pat. No. 3,339,470 issued Sept. 5, 1967. These circuits are controlled through a character selector **55** receiving character codes from a line memory or register **60**. This memory preferably is divided into parts I and II, such that one part can be controlling an output or photographing operation while the other part is being loaded with information for the next line, and vice versa.

A reader **62**, which may be a conventional paper tape reader or any equivalent device for handling input code information, is connected to transmit character identification and control codes to an input register **63**. The reader is also connected alternatively to load relative width codes into a character width memory **64**, into which is loaded all of the unique typographic widths for the various characters on the font **10**. A point size multiplier **65** receives the width information for each character, from the width memory **64**, multiplies by the point size which is a factor related to the optical size change afforded by the selected lens **28**, and transmits the product to a justifying computer **68**. These products are summed in the computer, subtracted from a specified line length which is preset into the computer, and the difference is divided among the number of interword spaces in the line. Any remainder from this division is later placed in selected ones of the interword spaces, generally according to the system described in U. S. Pat. No. 3,339,470.

The resultant figure is an absolute justified interword space value that is to be used for each interword space as the corresponding line is produced on the film. This value is stored in computer 68, preferably as the aforementioned difference and the number of interword spaces in the line, so that the division, and placement of any remainder, can occur as the value for a justified interword space is needed. This is transmitted to a space status register **70** via an input **71** from the justifying computer.

After one line is prepared in a part of the line memory **60**, that part is transferred to an output mode and the line is photographed. Meanwhile the reader **62** feeds information for the next line into input register **63**, and this information is transferred to the other part of the line memory while the character widths are looked up from the memory **64** and justification computation proceeds for this next line.

As photography of the line begins, the character identification codes are read one at a time from the part of line memory **60** which is in the output mode. These are directed via cable **74** to the character selector **55**, and also back to the width memory where the relative width again is looked up, processed through the point size multiplier **65** to determine the code value of the actual character width, which is now added through connection **75** into the space status register **70**.

Thus the value or code number stored in register **70** represents the desired position of reflector **40** at the time the next character is to be photographed. As a character is photographed, its actual width is determined by the above process, the change in output register **70** is transmitted over cable **78** to the mirror servo control **80** which immediately begins to advance the mirror to the next position as identified by the actual location code in the space status register **70**.

A sub-diagram of the control **80** is shown in FIG. 3. The information from the register **70** is supplied to a binary subtractor unit **82**. This unit functions to subtract actual position code information from an optical shaft encoder **85** from the desired location code in the register **70**. In a typical embodiment, the encoder is an absolute thirteen bit natural binary optical shaft encoder with a resolution of 8,192 parts per revolution or 2.6 minutes of arc, and the binary subtractor has a like capacity.

The output of the subtractor unit **82** is supplied to a logic circuit **87** which converts the information to a form more convenient for digital to analog conversion, and also extracts the information indicating that the spacing operation is complete. This latter information is sent to the detector circuit **88**, which in turn generates an output that indicates photography, or whatever operation is called for by the next code in the memory **60**, can proceed. The output from the logic circuit also functions as an inhibiting signal sent through line **89** to the flash control uint **20** to prevent its operation until the spacing is completed.

The converted digital information from the logic circuit **87** is sent to a digital to analog converter **90**, and its analog output is sent to a preamplifier and compensation circuit **92**, which supplies the required gain for static and dynamic performance of the servo system and ensures stable closed loop performance. The output from this circuit is to the power amplifier **94**, which may typically have a gain in the order of 20V./V., and which drives the servo motor **44** to rotate the reflecting member **40** and the encoder **85**. A typical motor type is a permanent magnet low inertia D.C. motor delivering 30 ounce-inches torque, available from Honeywell Manufacturing Company as type HSM-30.

The entire system is under control of a processing unit **95**, which controls the timing of the various operations and sends appropriate switching and control signals to the reader, input register, memory, to direct the outputs of the multiplier **65** to the appropriate place, to start and stop the justifying computer **68** and when needed have it supply space information to the register **70**. The processing unit **95** can also provide appropriate spacing information to the leading motor **48** for line spacing and other film advance requirements.

The preferred embodiment described above is subject to variation without departing from the inventive concept. For example, the encoder **85** can be of a type which merely transmits pulses in accordance with movement of the encoder. In this event the mirror servo control would incorporate a counter driven from the encoder and operating to accumulate a position code to be compared with the location code derived from the space status register. Such an arrangement would require the need for an extra counter in the servo control, and somewhat more elaborate code comparison circuits, but on the other hand the encoder itself would be of a more simple type. However, the servo control still, in such an arrangement, functions to compare the actual location code with the position code feedback in order to achieve the desired position of the operating member, such as the mirror or reflecting member **40**.

While the forms of apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. In a phototypesetting machine having a character projection system forming image bearing light beams, a photosensitive material on which the images are recorded to form lines of composition, and a spacer operative to locate the images on the photosensitive material forming words and interword spaces making up justified lines,

the improvement comprising

a position control system including a register for storing a unique code identifying the location of the next individual character image to be formed in a line, a servo motor incorporated in said spacer and connected to said position control system to cause variable spacing movement according to location codes in said control system,

a position encoder driven by said servo motor and capable of generating unique codes within the entire line for a series of incremental servo motor positions in achieving designated locations within the limits of a line of composition,

and a feedback control from said encoder to said position control system.

2. A spacer for phototypesetting as defined in claim 1, wherein said spacer includes a rotatable reflecting means driven by said servo motor, and said encoder produces an output identifying the angular position of said reflecting means.

3. A spacer for phototypesetting as defined in claim 1, including a memory for storing character identification codes for a line of characters, a selector operated from said identification codes and driving said projection system to form character images in the proper sequence, a character width memory, and means oooperative in conjunction with said selector to add an appropriate width value to said register whereby the servo motor advances to the correct position for locating the next character image.

4. In a phototypesetting machine having a character projection system forming image bearing light beams, a photosensitive material on which the images are recorded to form lines of composition, a spacer member operative to direct the images onto the photosensitive material to form words and interword spaces making up lines of composition, and means for generating digital codes representing the space occupied by each character image and the space allotted to interword spaces,

the improvement comprising

a position control system including a register receiving digital codes as the individual character images are formed in the line, said register operating to sum the digital codes into a unique location code defining the position of each character with respect to one end of the line,

a servo motor driving said spacer member to cause variable spacing movement according to location codes in said register,

a position encoder driven by said servo motor and capable of generating unique digital position codes for a series of incremental spacer member positions in achieving designated positions within the limits of a line of composition,

a subtractor circuit comparing the codes from said register and the codes generated by said encoder and functioning to produce a difference signal,

a digital to analog converter receiving said difference signal and providing a corresponding analog output to drive said servo motor,

and a detector circuit also responsive to said difference signal for indicating coincidence between the location codes and the position codes signifying completion of a spacing operation.

5. A phototypesetting machine as defined in claim 4, said spacer member being a rotatable reflector member connected to assume unique angular positions under control of said servo motor,

and an inhibiting control connection from said position control system to said character projection system to prevent projection of a character image while said reflecting member is moving to its next position.

6. A phototypesetting machine as defined in claim 5, said encoder being an optical shaft encoder rotatable in unison with said reflector member.

7. A phototypesetting machine as defined in claim 4, said means for generating space codes including a memory for storing relative width codes for each character, and

a point size multiplier receiving width codes from said memory and sending actual image width codes to said register.

8. In a phototypesetting machine having a character projection system, a photosensitive material on which images are successively recorded to form lines of composition, an optical system between said projection system and said material including a scan lens operative to focus on said material across the entire width of a line, a spacer member incorporated in said optical system and operative to direct light through said scan lens to form words and interword spaces making up lines of composition, and means for generating digital codes representing the space occupied by each character image and the space allotted to interword spaces in the lines of composition;

the improvement comprising

a register receiving digital codes as the individual character images are formed in the line and operating to sum the digital codes into a unique location code defining the position of each character with respect to one end of the line,

a servo motor driving said spacer member to cause variable spacing movement thereof according to location codes in said register,

a position encoder driven by said servo motor and generating unique digital position codes for a series of incremental spacer member positions in achieving designated positions along a line of composition,

a subtractor circuit comparing the codes from said register and the codes generated by said encoder and functioning to produce a difference signal,

a digital to analog converter receiving said difference signal and providing a corresponding analog output to drive said servo motor,

a detector circuit also responsive to said difference signal for indicating coincidence between the location codes and the position codes signifying completion of a spacing operation,

and an inhibiting circuit responsive to said detector circuit and connected to inhibit operation of said character projection system until a spacing operation is complete.

* * * * *