March 7, 1967 R. A. PROUD, JR., ETAL 3,307,459

SPACER CONTROL FOR PHOTOTYPESETTING SYSTEM

Filed May 7, 1965 3 Sheets-Sheet 1

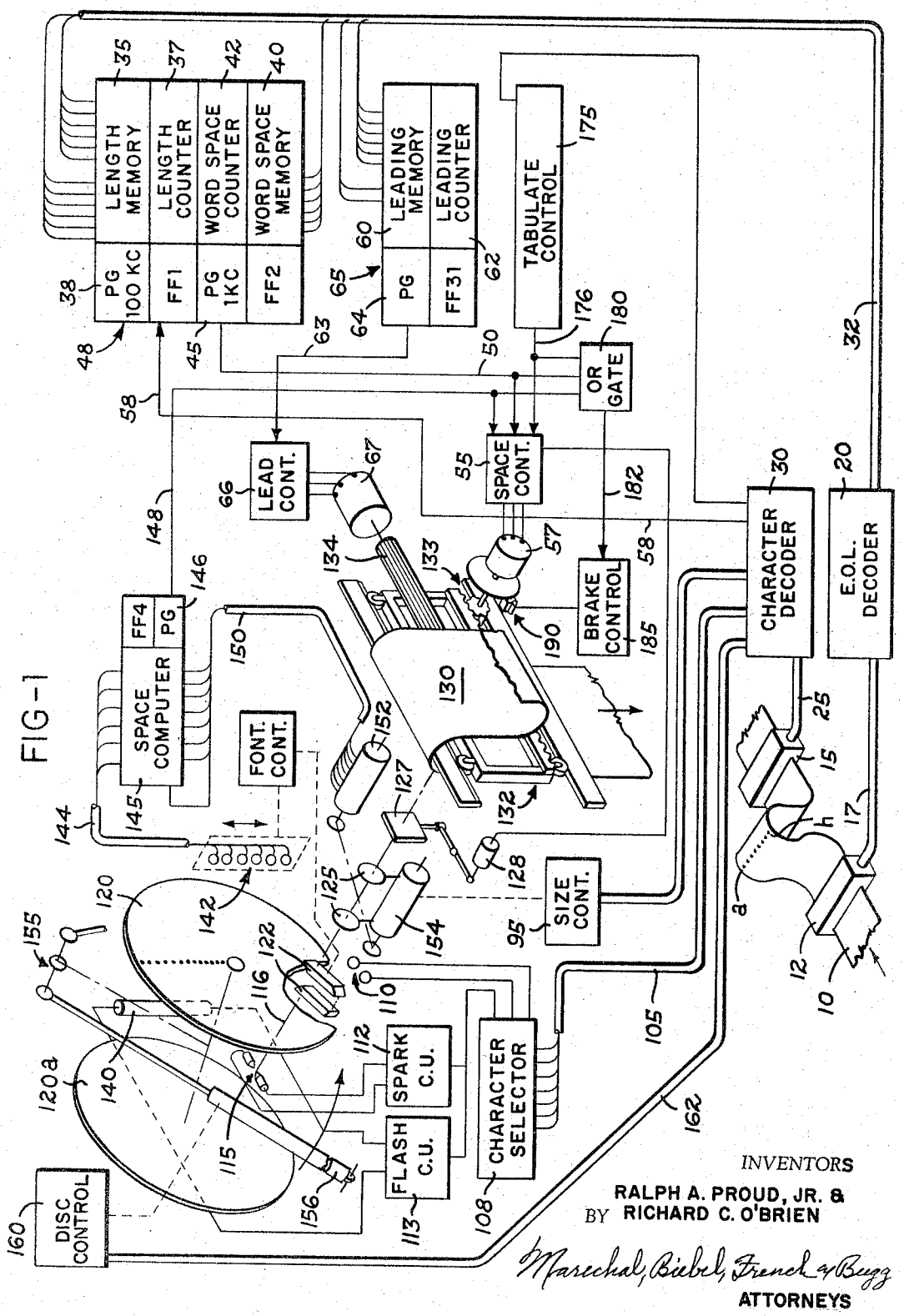

FIG-1

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SPACER CONTROL FOR PHOTOTYPESETTING SYSTEM

Filed May 7, 1965 3 Sheets-Sheet 2

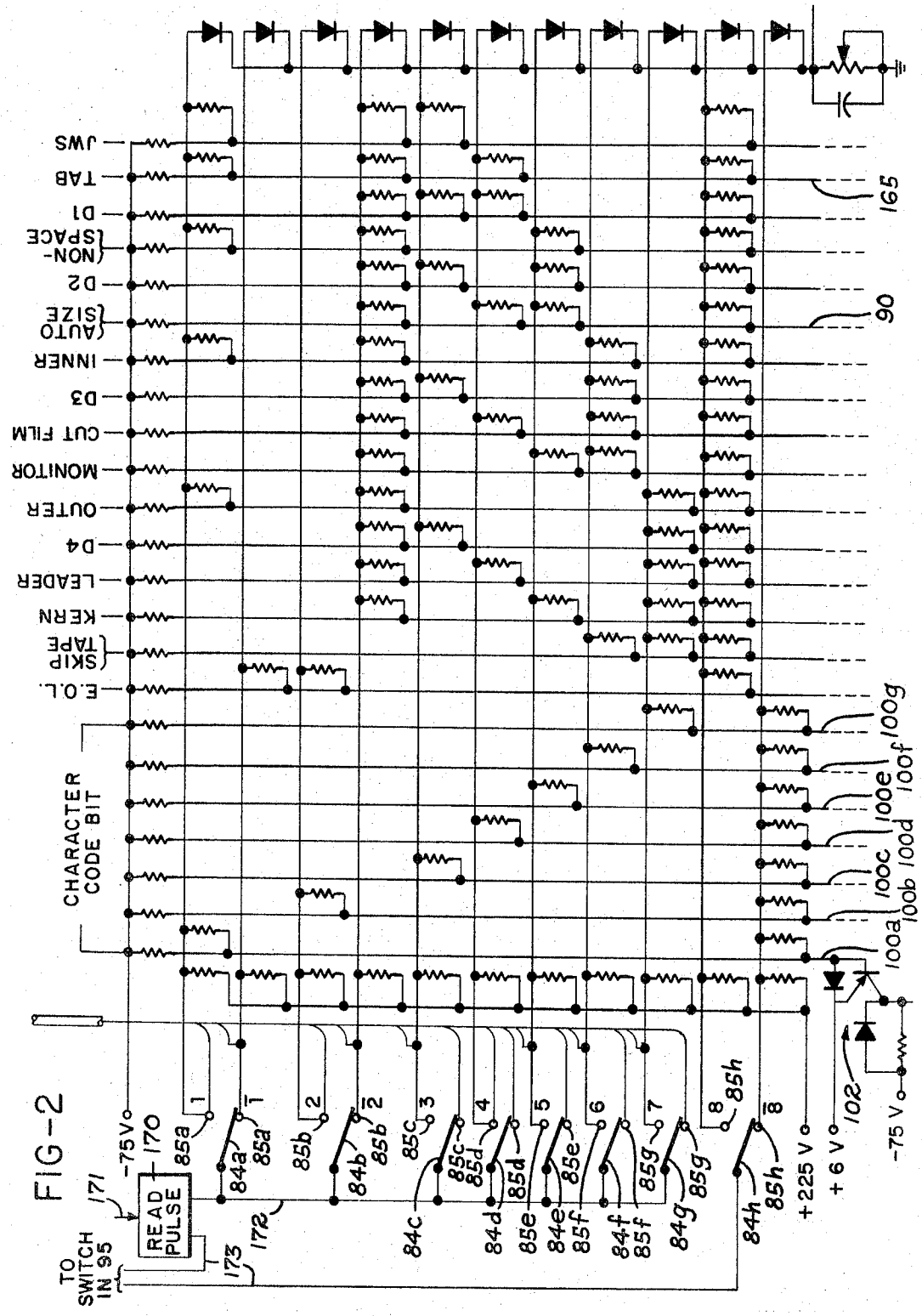

FIG-2

SPACER CONTROL FOR PHOTOTYPESETTING SYSTEM

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FIG-4

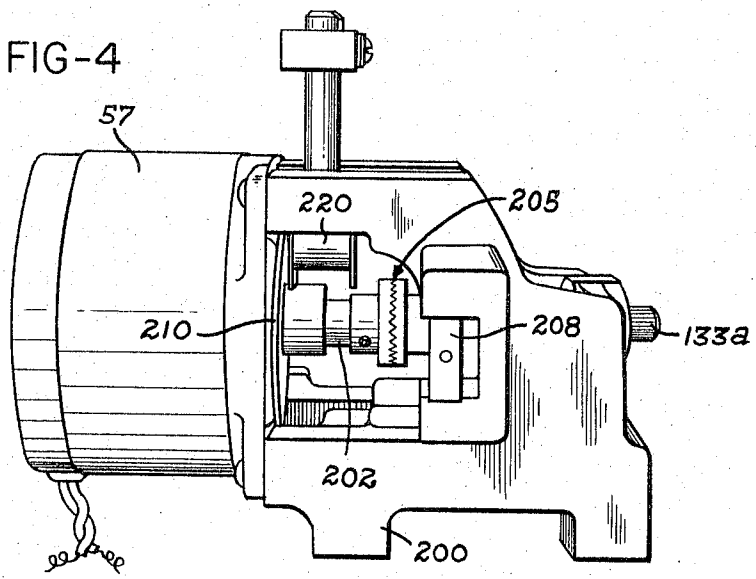


FIG-5

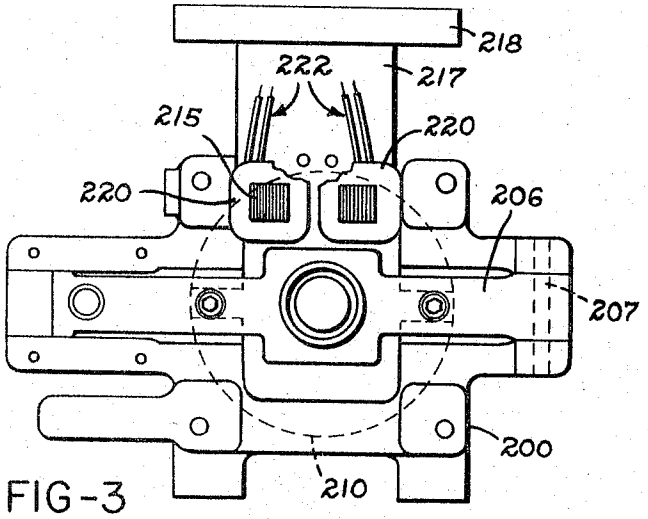


FIG-6

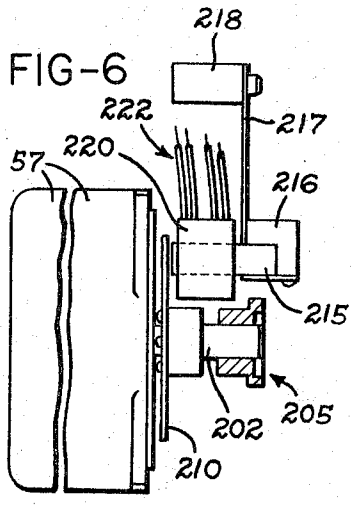
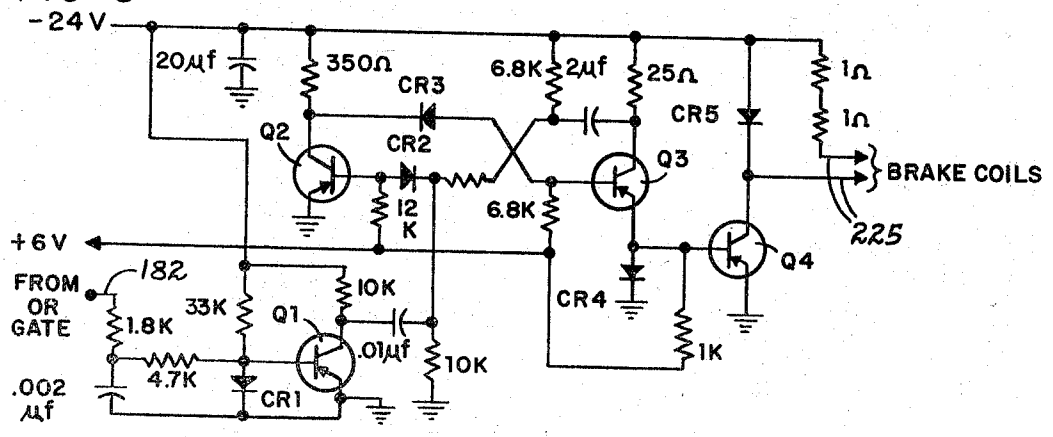


FIG-3



United States Patent Office 3,307,459 Patented Mar. 7, 1967

3,307,459

SPACER CONTROL FOR PHOTOTYPE-SETTING SYSTEM

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3 Claims. (Cl. 95—4.5)

This application is a continuation-in-part of U.S. application Serial No. 117,454, filed June 15, 1961, now U.S. Patent No. 3,183,806, issued May 18, 1965, for Photographic Type Composition.

This invention relates to improvements in digital stepping motors and in spacer controls for phototypesetting machines, particularly with respect to digital controls and transducers operating to produce spacing movements of photosensitive material in a phototypesetting machine.

In phototypesetting systems the characters to be reproduced are generated by photographic devices which project shaped light beams along an optical axis or path onto photosensitive material. The character images are thus formed on the photosensitive material in succession, and at the desired size, and in order to space the characters, one from another, according to typographic requirements, it is necessary to produce relative movement between the photosensitive material and the optical path according to the spacing desired for each character as it is projected. Various systems have been proposed wherein this spacing operation occurs either before or after the "flash" exposure which produces the character image. The present invention is applicable to such arrangements, but it is particularly useful in connection with phototypesetting machines where the latent photographic image is formed on the photosensitive material and the spacing movement occurs thereafter, such as described in said application Patent No. 3,183,806.

The present invention relates particularly to controls for high speed stepping motors, and to their use with phototypesetting systems where the spacing movement occurs on some type of digital basis, in other words, the spacing movement between the photosensitive material and the optical path is produced as a plurality of small spacing increments. Preferably these increments should be small enough that the difference between them is minute, for example, one system employs individual spacing increments of one-sixty-fourth of a pica (approximately 0.0026") and in order to obtain optimum speed from the machine it is desired to have the ability to produce an exact number of such incremental movements, which number will vary according to the width requirements for different characters, within a short time. For example, machines with which the present invention is concerned, can employ rotating character matrices, together with high speed light flashes and controls which will cause the exposure of a character for each revolution of the character matrix disc. With the disc rotating for example at 2,400 r.p.m., or forty revolutions per second, and allowing time for acceleration and deceleration, and time for the computation of the character width data, it will be appreciated that the time requirements on spacing controls of this type are severe, and therefore any improvement in the deceleration characteristics of the spacer controls and equipment will in particular be of great advantage in improving the speed and reliability of the system.

Accordingly, the primary object of this invention is to provide an improved spacing control for phototypesetting machines.

Another object of the present invention is to provide a novel stepping motor drive, which may be used for example, in producing spacing operations in phototypesetting machines, particularly including energy absorbing devices which will remove kinetic energy from the spacing mechanism to improve the deceleration characteristics of such mechanism to enable the photographic operations of the machine to proceed at an optimum rate.

A further object of the invention is to provide an improved energy absorbing or braking mechanism for high speed, relatively low torque systems, such as the spacing mechanism of a phototypesetting machine.

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

In the drawings:

FIG. 1 is a schematic and block diagram showing the overall arrangement of a typical phototypesetting machine to which the present invention is directed;

FIG. 2 is a circuit diagram showing details of the character decoder which is incorporated in FIG. 1;

FIG. 3 is a circuit diagram of the brake control shown in FIG. 1, for controlling the operation of an energy absorbing system according to the present invention;

FIG. 4 is a perspective side view of a spacing motor drive and energy absorbing mechanism according to the present invention;

FIG. 5 is an end view of the device shown in FIG. 4; and

FIG. 6 is a detailed view of the energy absorbing mechanism per se.

Referring to the drawings, which illustrate a preferred embodiment of the invention, FIG. 1 shows the general arrangement of a phototypesetting apparatus embodying the features of the present invention. The apparatus is controlled by a perforated code tape **10**, or an equivalent memory or record, and this tape passes through a pair of readers **12** and **15**. The direction of travel of the tape is such that it first passes through the reader **12** and then through the reader **15**. Both of these readers are preferably of a known type as shown in United States Patent No. 3,027,072, called a "star wheel" reader, or a conventional reader of equivalent function.

The reader **12** is arranged to ignore all code words (e.g., a complete group of code perforations across the tape) on the tape except any of the three "end-of-line" codes, which indicate an accepted line, or a rejected line, or a non-justified line. The output contacts of reader **12** are connected through a cable **17** to an end-of-line decoder circuit **20**. This circuit includes appropriate controls for the drive of the reader **12**, and thus will permit the reader to continue to pass tape therethrough until one of the three aforementioned codes appears on the reader. At such time, reader **12** will stop on the appropriate code word while the function operations dictated by the code are completed. This may mean that reader **12** will "hold" on a code while an entire line is being composed.

The reader **15**, termed hereafter the "character reader," has its outputs connected through a cable **25** to a separate character decoder circuit **30**. The essential details of this circuit are shown in FIG. 2. The circuit includes controls for the drive of reader **15**, and these likewise are arranged to stop reader **15**, among other reasons, whenever one of the three end-of-line codes appears in the reader. Therefore, reader **15** will stop for example on the end-of-line code for a previously composed line, the reader **12** will stop on the end-of-line code for the line which is to be composed, and the portion or loop of tape between the readers, as shown in FIG. 1, will contain the information necessary to compose a full line of composition.

Details of the end-of-line decoder circuit **20** are unimportant for purposes of explaining the present inven-

tion. Suffice to say that the output circuits from this decoder will pass through a cable 32, for example as control voltages applied to one or mores wires in the cable, and the wires from the cable are connected to a length memory circuit 35 (for example conventional memory circuits) which in turn is arranged to preset a length counter 37 upon command. This counter is part of a justification computer which also includes a controlled flip-flop FF1, connected to the length counter, and arranged to connect the output of a 100 kc. pulse generator 38 to the length counter 37.

Likewise, other leads of cable 32 are connected to preset a word space memory circuit 40, into which is set the number of interword spaces in the line being composed, for purposes of justifying computation. The word space memory may likewise include a conventional memory circuit, and is arranged to preset a word space counter 42 which cooperates with the length counter 37 in making the justifying computation. Control over the justifying computing operation is exercised by a control flip-flop FF2 which in turn switches on or off the 1 kc. pulse generator 45.

For purposes of simplification, the parts 35–45 are shown as subdivisions of an entire block 48, which will hereafter be identified as the justification computer. Its output is in the form of a number of electronic pulses passed through line 50 to the spacing control motor 57 which is driven from the space control circuit 55. This motor and circuit may be of the type disclosed in said application Patent No. 3,183,806.

Whenever the character decoder circuit 30 receives the code for a justified interword space, an appropriate signal is transmitted through the output line 58 of that circuit to the justification computer, and this initiates the operation of the computer whereby the amount of space not occupied by characters in the line of composition, having been stored in the length memory 35, is set into the counter 37, and is divided by the number of interword spaces which are similarly stored in the word space memory 40 and set into counter 42. The resulting quotient is expressed in terms of the number of spacing pulses from the justifying computer output through line 50 to the space control circuit 55.

In a similar manner, the cable 32 contains leads arranged to preset a leading memory circuit 60 which in turn is arranged to set up a leading counter 62 controlled by flip-flop circuit FF3. The output of this circuit is through lead 63 from the pulse generator 64 comprising part of the leading computer indicated generally at 65. The output line 63 provides an input to a leading control circuit 66, comparable to the space control circuit 55, as also described in the aforementioned Patent No. 3,183,806. This circuit controls the leading drive motor 67.

The tape 10 is shown in FIG. 1 as a conventional perforated paper tape having eight channels for information, whereby a so-called "eight-bit" code word can be used for recording purposes. These channels are indicated by the letters *a–h*, and further reference thereto will be made with regard to the particular channel, for example, 10*e*. The tape is advanced by a sprocket wheel (not shown) incorporated in the reader, it being understood that this reader construction is generally the same for both readers 12 and 15. The drive sprocket has a suitable stepping drive which causes a step-by-step advance of sprocket wheel, whereby successive code words on the tape can be presented to the star wheel reading apparatus. It will be understood that a code word comprises a corresponding area in each of the channels 10*a–h*, preferably aligned across the tape, and each code word will comprise a bit of information from a channel according to presence or absence of a hole in the tape.

For each channel there is a reading star wheel mounted on a corresponding lever arm in the reader. Each lever arm has a corresponding contact arm 84*a–84h* (FIG. 2), and these arms form electrical circuit contacts each of which moves between related stationary contacts, identified as contacts 85*a*1 and 85*a*$\bar{1}$ through 85*h*8 and 85*h*$\bar{8}$. These are shown in FIG. 2 on the input side of the character decoding circuit. The reader, therefore, will present outputs on these contacts according to the position of the corresponding star wheel, and for every code word there will be a possible completed circuit through each lever arm 84*a–84h*, differentiating between presence and absence of a hole. Not all of the available output circuits are required, however. Note in FIG. 2 that no circuit is used for $\bar{3}$, $\bar{4}$, $\bar{5}$, $\bar{6}$, or $\bar{7}$.

Each time the reader 15 reads a code word, it will decide this code word and distinguish between a character identification (or character selection) code and a function controlling code. Basically, the difference between these two types of codes is determined by the presence or absence of a hole in the channel 10*h*, i.e., an "8" or "$\bar{8}$" signal.

Referring to FIG. 2, it will be noted that such a condition is represented by a completed circuit between the contact arm 84*h* and the "$\bar{8}$" contact, identified as 85*h*$\bar{8}$. Presence of an $\bar{8}$ signal (no hole in channel 10*h*) will determine that the code word pertains to selection of a character. Conversely, presence of an "8" signal determines that the code word is for some function control. Various ones of the functions are noted as legends over the corresponding circuit output lines shown in FIG. 2. For example, the E.O.L. (end-of-line) circuit, which is the end-of-line signal, is represented by completed circuits from $\bar{1}$, 2 and 8. These are the significant digits of the end-of-line code word.

Assuming for purposes of explanation that a character code is presented to the reader 15, then appropriate signals will be presented on one or more of the character code output circuits which are identified in FIG. 2 as 100*a*, 100*b*, 100*c*, 100*d*, 100*e*, 100*f* and 100*g*. Each of the decoding circuit lines is connected through a transistor amplifier, one of which is shown schematically at 102. The seven selection output lines pass through cable 105 to the character selector circuit 108. This circuit is controlled by the code reading photocells 110, as more fully explained in said Patent No. 3,059,219, and the character selector circuit in turn controls the function of a spark control unit 112 and a flash control unit 113,

These units are separate triggering circuits, the spark control unit being connected to the electrodes 115 to cause a spark to jump the gap therebetween and produce an instantaneous flash of light when the desired character passes the projection station, indicated by the dot-dash line 116 which shows the optical axis of the system.

Rotating continuously at fairly high speed, e.g., 2400 r.p.m. across the optical or projection path, is the character disc 120 which is preferably an opaque plate-like member having the individual characters formed as transparencies such that a shaped light beam is formed by the light passing through the selected character. The timing of the flash is of course precise and of such short duration that the character image bearing light beam is effectively stationary. This beam passes through the font selector prism system 122, as described in United States Patent No. 3,099,945, and thence through the size controlling lenses 125. From these lenses the character image bearing beam passes through an optical flat 127, or the like, which may be pivoted between two positions by the space controller solenoid 128, as described in said Patent No. 3,183,806, and thence the image is focused on the photosensitive material 130, which may be film or paper draped over and controlled by the spacing carriage 132. This carriage is moved transversely to the optical system by the spacing control motor 57 through the rack and pinion drive 133. Leading movements of the photosensitive material, i.e., vertically, are provided through the elongated gear 134 driven from the leading control motor 67.

As soon as a character image is recorded on the photosensitive material, spacing movement of this material is provided by the controlling motor **57**. Information for this purpose is derived from the character unit width code or data on the disc **120**. This code is read by flashing the elongated light tube **140** under control of the flash unit **113**, at the same time that the character is photographed. A unit width code is thus projected to the bank of code reading photocells **142**, and their outputs are fed through cable **144** to the space computer **145**. This computer is provided with a control flip-flop FF4 and a pulse generator **146**, and which includes a separate input through cable **150** from a drum type selector switch **152** which is coupled to the lens positioning controller **154**, these parts in turn being under control of the size control circuit **95**.

As is explained in greater detail in United States Patent No. 3,141,395 the result is a burst of electronic spacing pulses which are transmitted along the spacing circuit line **148** to the space control circuit **55**. The number of these pulses is related to the actual width to be alloted to the character image just photographed, in terms of picas and fractions of a pica, or piclets.

It should be noted also in connection with FIG. 1 that there is a second character disc **120***a*, and it may be moved alternatively into the optical system under control of a disc shifting apparatus **155** which is driven by disc shifting pneumatic cylinders, one of which is shown at **156**. Operation of these cylinders is controlled by a disc change control circuit **160** operating from signals passing through cable **162** which leads the decoder circuit **30**.

In explaining the tabulating and leader insert controls, it is desirable to mention certain features of the operation of the photographic machine. Thus, with reference to FIG. 1, and as previously mentioned, when a control tape **10** is fed into the readers **12** and **15**, the reader **12** passes over code words except the end-of-line codes, and when one of these codes appears to the reader **12**, it stops and maintains this code in a reading position. The tape in the meantime builds up as a loop between the two readers, and when the reader **12** reaches the end-of-line code for an acceptable line, it sends a "go ahead signal" to the reader **15** which in turn proceeds to read all of the code words, one at a time.

Each time the reader **15** reads a code word it transmits the appropriate code to the character decoder circuit **30**, and as an incident to this operation a tape step signal is sent to the reader and the reader steps to the next code and waits. In the meantime, the decoder circuit operates to determine whether a character selection code or a function control code is presented, and routes the information accordingly either to the character selector or to the appropriate one of the function control circuits. Among these circuits is the tabulate circuit **175**. As soon as the character selection operation, or the function operation is complete, then a signal is transmitted to the character decoder which in turn generates a "tape read" pulse or signal to the reader **15**.

The read pulse amplifier **170**, shown schematically in FIG. 2, has an input **171** through which the feedback or "go ahead" pulse is received, and has two separate output lines **172** and **173** which both transmit the tape read pulse. Line **172** leads to the common connection of the first seven stations of the reader and line **173** leads to a stepping switch in the size control circuit **95**. Since all operations of the machine require an output pulse through either the **8** or $\overline{8}$ line of the character decoder (note FIG. 2), normal operation of the machine is suspended for the automatic size change function by interrupting the read pulse circuit to the common input of the eighth station (**84***h*) of the reader. The details of this operation are not important to details of this invention. Thus, for purposes of explanation it can be assumed that an output read pulse over line **172** is accompanied by a simultaneous read pulse through line **173**.

The present invention is particularly concerned with operation of the stepping motor **57** in performing the spacing operations according to pulses transmitted to it from the pulse generating means which may be pulse generators in any one of the space computers **145**, the justification computer **48**, or the tabulate control **175**. These pulses are transmitted to the space control **55** on the lines **148**, **50** and **176**, respectively. As shown in FIG. 1, each of these lines also is directed to an OR gate circuit **180**. Whenever spacing pulses are being transmitted to the space control **55**, a D.C. level is established in the OR gate, but when the spacing pulses stop, this level drops and accordingly a signal is transmitted over line **182** to the brake control circuit **185**. Details of this circuit are shown in FIG. 3, and are explained hereafter in greater detail. In general, the operation is such that the brake control circuit applies power momentarily to an energy absorbing mechanism **190** which is incorporated in the output of the stepping motor **57**. For purposes of simplification in terminology, the mechanism **190** is termed a brake, but it should be understood that the function of this mechanism is to absorb energy from the stepping motor output momentarily, but not to lock that output in position. When the stepping motor comes to rest, the brake mechanism **190** is not applied, and the ultimate position of the stepping motor output, and hence of film carriage **132**, remains under the control of the stepping motor, as described in said Patent No. 3,183,806.

The structure of the brake control mechanism is shown in greater detail in FIGS. 4, 5 and 6. The stepping motor **57** is mounted on a supporting framework **200**, and the motor output shaft **202** extends to a toothed clutch **205**. This clutch is normally engaged, as shown, but it can be opened by causing the lever **206** (FIG. 5) to pivot around a pivot pin **207**, carrying the output portion **208** of the clutch, and its shaft, out of engagement with the input side. This movement may be accomplished by energizing a clutch solenoid (not shown). The output member **208** of the toothed clutch thus functions to rotate the pinion **133***a* of the rack and pinion drive **133** which moves the film carriage **132** (FIG. 1).

On the stepping motor output shaft **202** there is fixed a brake disc member **210**. This disc preferably is constructed of a soft iron, and is provided with a rather heavy chrome plating. For example, the plating may be in the form of 0.001 inch. The disc **210** thus forms the rotor portion of the brake mechanism **190**.

The stator of the brake system is formed as an electromagnet including a horseshoe-shaped armature **215** fastened to a carrying bracket **216** which in turn is carried by a relatively thin spring-like plate **217**. This plate is fastened at its upper end to the bracket member **218** which is incorporated in the frame member **200**. Thus, the armature **215** and the remainder of the stator structure is somewhat movable toward and away from the disc **210**, for purposes of compliance. The brake coils **220** are wound on the pole pieces of the armature **215**, as shown in FIGS. 5 and 6, and are provided with power leads **222**. Preferably, the armature is formed as a laminated material since this serves to reduce the electric response time of the brake system by reducing eddy current effects. The same result can be obtained by use of a powdered iron armature structure. The face of the stator pole pieces, as shown in FIG. 5, is thus a flat terminus of the plurality of laminations. These may be arranged either horizontally or vertically, or in some other convenient manner, although a vertical lamination direction is shown.

With reference to FIG. 3, a spacing operation is underway, a D.C. level is established as an output of the OR gate **180**. This is applied to the input line **182** of the brake control, as shown in FIG. 3. This signal is coupled to the base circuit of the transistor Q1, which together with the resistors and capacitors and the diode

CR1, form an edge sensitive amplifier. When the output level in line 182 falls, as a result of cessation of a spacing operation, there is an immediate output from this amplifier circuit through C1 to a one-shot multivibrator circuit provided by the transistors Q2, Q3, and the diodes, capacitors, and resistors connected therethrough, as shown. The output of this multivibrator is coupled to the base of the power transistor Q4.

Thus, an output pulse from the multivibrator will cause the power transistor Q4 to conduct and apply power through the brake coil output lines 225 and thence through the lines 222 to the coils 220 of the brake mechanism. The time constants of the circuit are such that the pulse from the multivibrator circuit is sufficient to energize the brake mechanism for approximately ten to fifteen milliseconds. It has been found that applying a retarding force through the brake mechanism for this amount of time is adequate to obtain a substantial decrease in the time required for the stepping motor output to come to a complete stop.

For example, without the energy absorbing or braking mechanism, measurements of the time required for the stepping motor output to stabilize at its final position indicated that approximately one hundred milliseconds were required in order to damp the stepping motor output. It should be recalled that this motor is required to step at up to three hundred steps per second, and that the ultimate position which it is to attain at the end of a spacing operation is dependent upon the electromagnetic field resulting from a particular energization (as to polarity) of the motor windings. This system is fully explained in said Patent No. 3,183,806. It is possible that the output may actually overrun slightly, and then return to the ultimate desired position. In this regard, it should be kept in mind that the movements referred to here are very slight, since each step produces only a small actual movement of the film carriage. With the present invention it has been possible to reduce the "settling" time of the system to approximately twenty milliseconds, or in other words this time time has been decreased to about one-fifth the previous time required. The pulse applied through the brake coils 220 is shaped to give a short rise time and a relatively slower decay time. Thus, the brake mechanism engages quickly, but releases somewhat more slowly, thereby assisting in quiescing the movement of the stepping motor output as it seeks its proper position.

The present invention, therefore, provides a means for removing kinetic energy from the spacing system of a phototypesetting machine, thereby obtaining a net gain in time during each spacing operation which, during the course of several hours of operation of the machine, may amount to a substantial span of time. More important, the system assures that the film carriage is stabilized in the desired position before the next character is photographed. This system thus contributes to the accuracy of placement of the character images at the high speeds required of commercial phototypesetting systems.

The invention is its broader aspects also is concerned with the control of stepping motors used for other purposes, such as driving a high speed tape reader, or in any device where digital or stepping drive is required with rapid deceleration.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form 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 apparatus having means for projecting character images of different widths along a common path and a means for mounting photosensitive record material in an image plane over said projecting means for recording the images to produce lines of composition, and including spacer means operative to cause spacing movement between said mounting means and said common path, said spacer means incorporating a stepping motor having an output member adapted for movement in a predetermined number of equal steps for causing spacing movement in digital fashion and for maintaining its position solely through the application of an electrical field within said stepping motor, means for generating digital spacing information representing spacing movements desired, and circuit means operative to direct said digital spacing information as control pulses to said stepping motor to cause operation thereof in a predetermined number of steps; the improvement comprising a deceleration control circuit responsive to said circuit means to generate a signal indicating the cessation of operation of said generating means, a selectively operable energy absorbing mechanism connected to said position control member for retarding movement thereof, and a circuit controlling the operation of said energy absorbing mechanism to render it operative at each cessation of operation of said generating means for absorbing energy imparted to said output member and thereby damping oscillations of said output member to improve the damping time characteristics of the spacer means.

2. Apparatus as defined in claim 1, wherein said circuit controlling the operation of said energy absorbing mechanism includes a multivibrator circuit operatively connected to produce a single energizing pulse to said energy absorbing mechanism in response to an output from said deceleration control circuit, such pulse having a relatively rapid rise time and relatively slower decay time to cause said energy absorbing mechanism to engage quickly against further movement of said motor output member and to release more slowly to enable said motor output member to achieve its final position under the control of the electrical force field than existing within said stepping motor.

3. In a phototypesetting apparatus having means for successively projecting character images of different widths along a common path and a means for mounting photosensitive record material in an image plane for recording the images in succession to produce lines of composition, spacer means operative to cause relative spacing movement between said common path and said mounting means, an electrical stepping motor having an output rotor shaft, an output connection between said rotor and said spacer means, said motor including means for creating an electrical force field movable one step at a time in response to a control pulse and operative on said rotor to maintain precise positioning thereof and to move said rotor in precise stepped spacing increments, means generating digital spacing information for each character image in the form of a number of pulses corresponding to the width of such image during the time interval between photographing successive character images, space control means directing such pulses to said motor to provide step-by-step spacing movement of said spacer means according to the spacing information for each related character image, a brake control circuit means operative to provide an output signal indicating cessation of operation of said pulse generating means, and an energy absorbing damping mechanism connected to said rotor shaft and controlled by said brake control circuit means to exert a momentary braking force on said rotor shaft at the terminal portion of each spacing operation to minimize oscillations of said rotor shaft and thereby to improve the damping time characteristics of the spacer means.

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JOHN M. HORAN, *Primary Examiner.*