United States Patent

Bonzano

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[54] APPARATUS FOR CONTROLLING THE FEEDING OF PAPER IN HIGH-SPEED PRINTERS

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.**.....**318/318,** 197/133, 226/43, 330/30

[51] **Int. Cl.**.....**G05b 5/00,** H02p 5/00, B41j 15/00

[58] **Field of Search**.....318/314, 318, 329, 326, 604, 318/605; 197/133; 226/2, 43, 45

[56] **References Cited**

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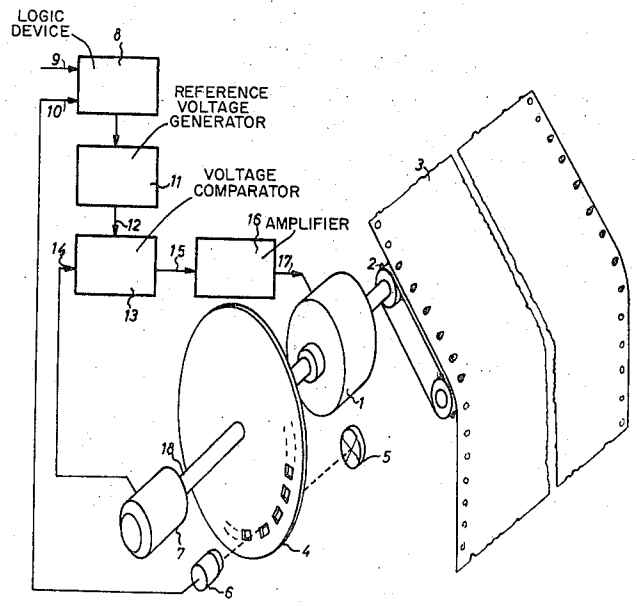
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[57] **ABSTRACT**

Apparatus for controlling the paper feeding in printing apparatus, wherein the feed motor speed is controlled by the combined effect of a speed-space detector whose output is speed-proportional voltage and said pulses are compared with a predetermined pulse number, and wherein the results of said comparison are employed in combination to provide a suitable paper feed power control through a bidirectional amplifier which does not require a stabilized power supply.

4 Claims, 6 Drawing Figures



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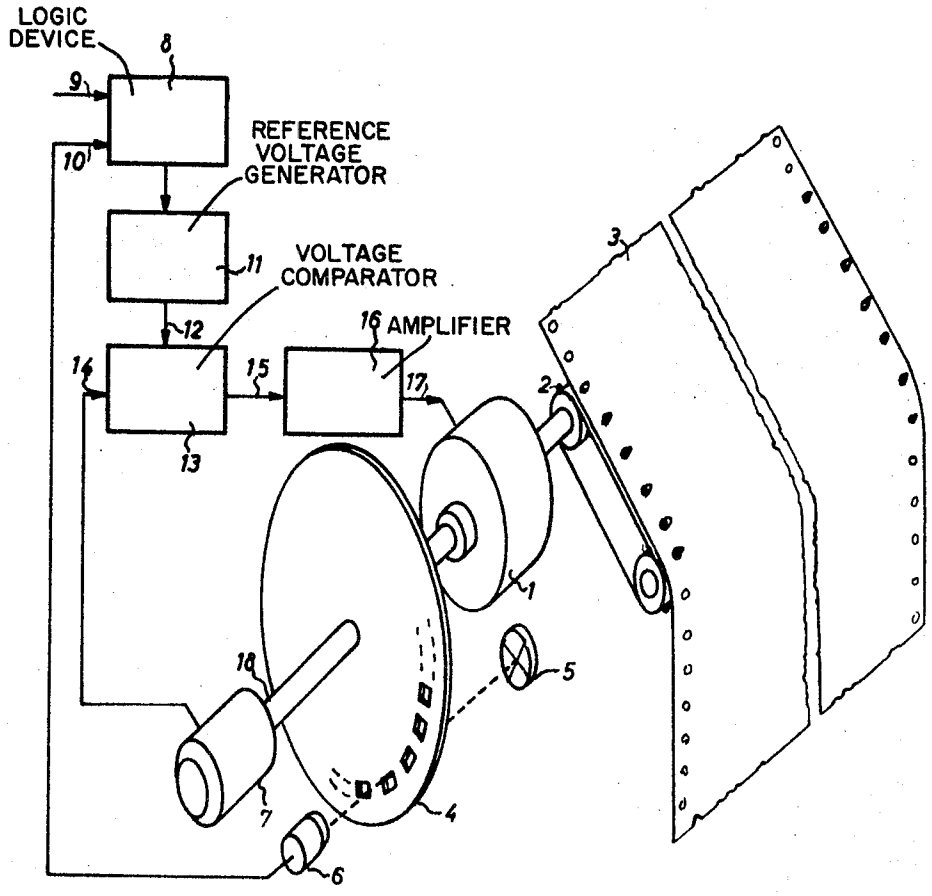


Fig. 1

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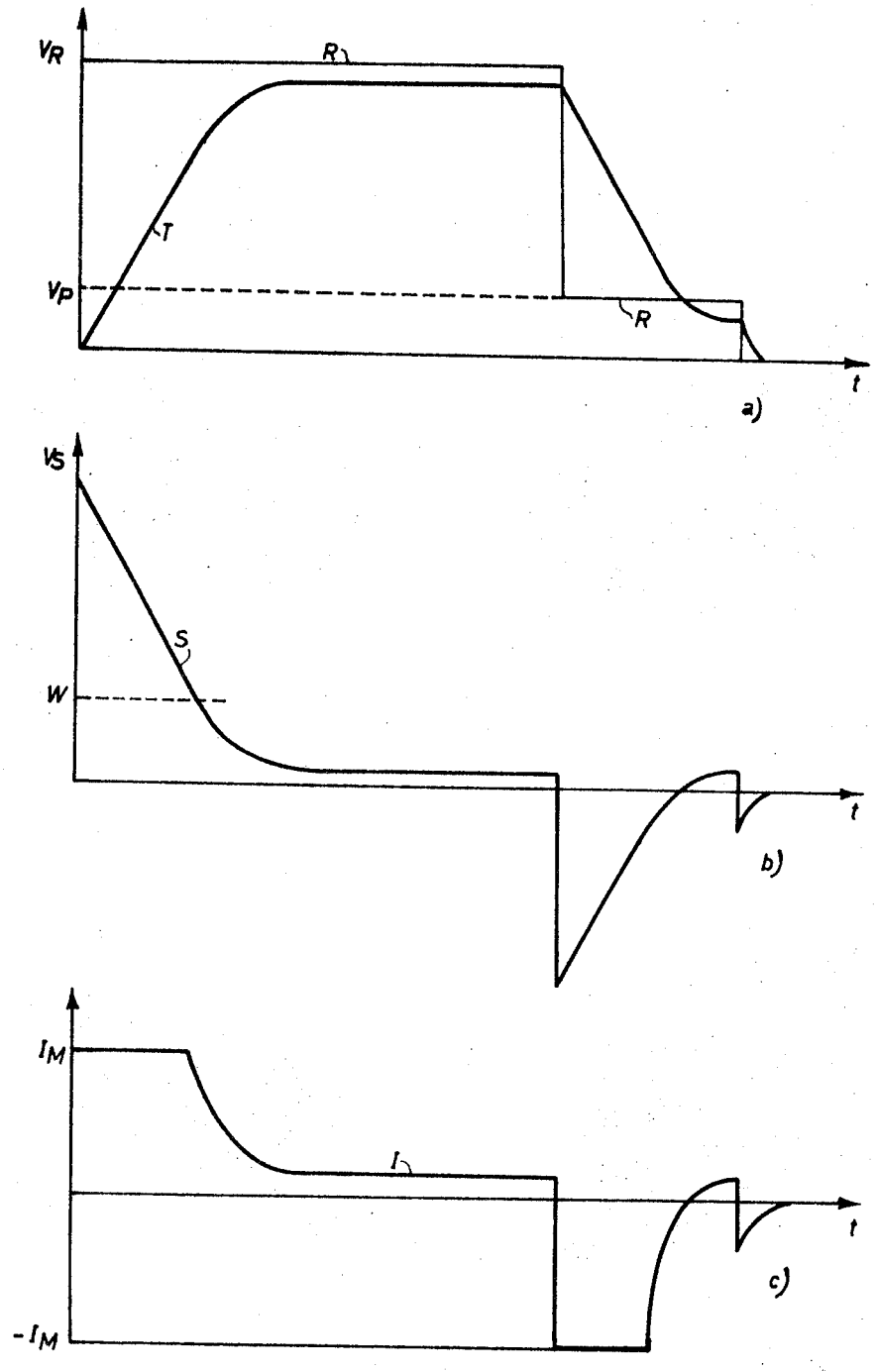


FIG. 2

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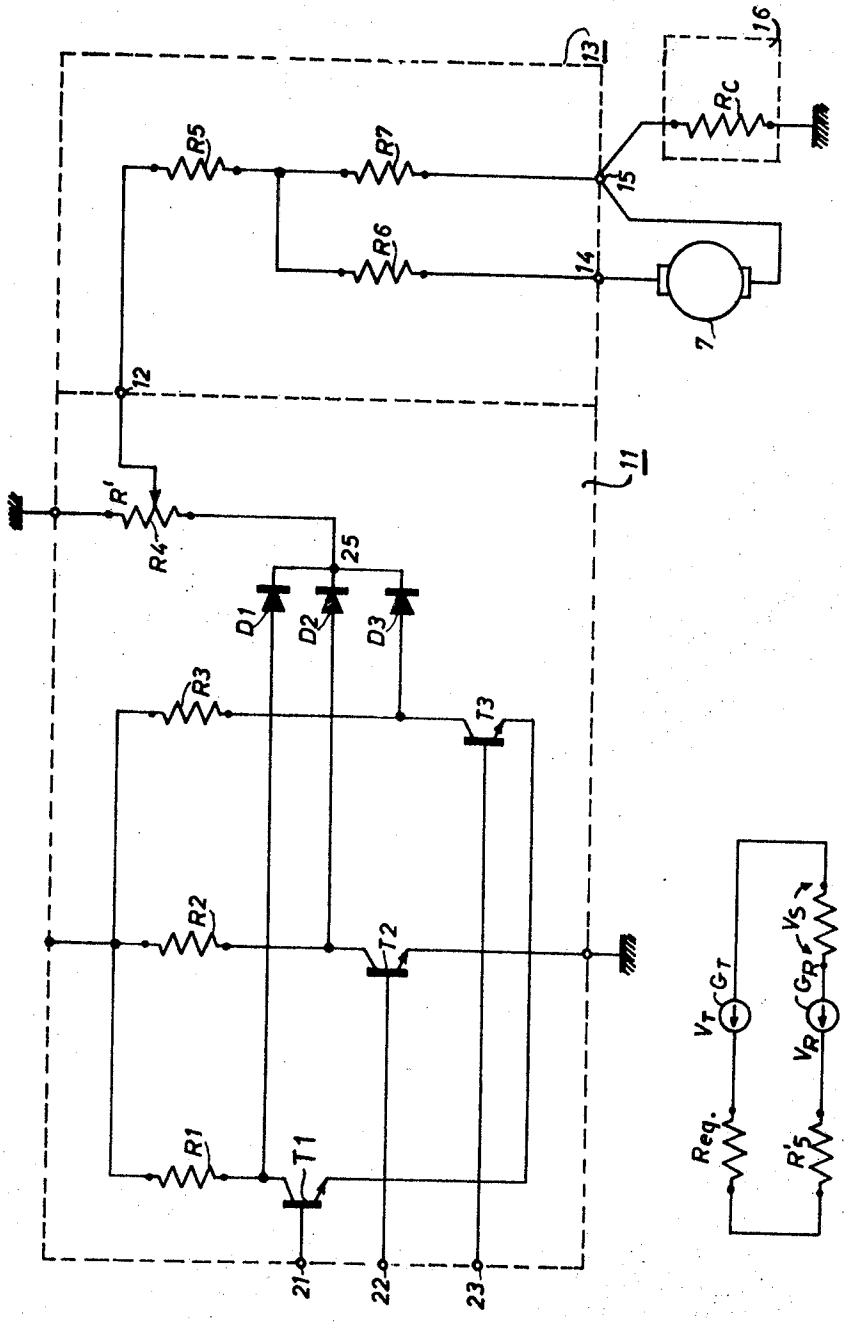


FIG. 3

FIG. 3a

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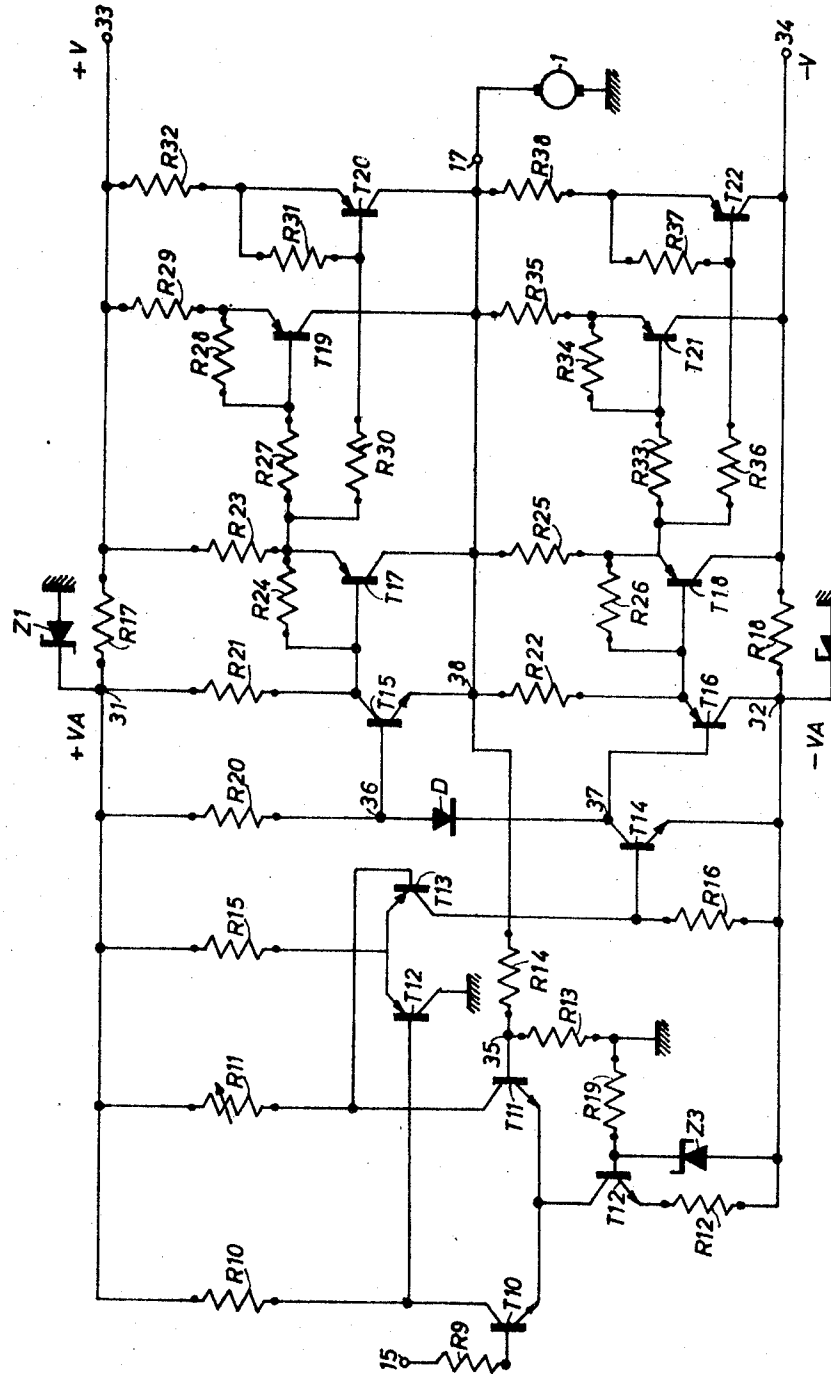


FIG. 4

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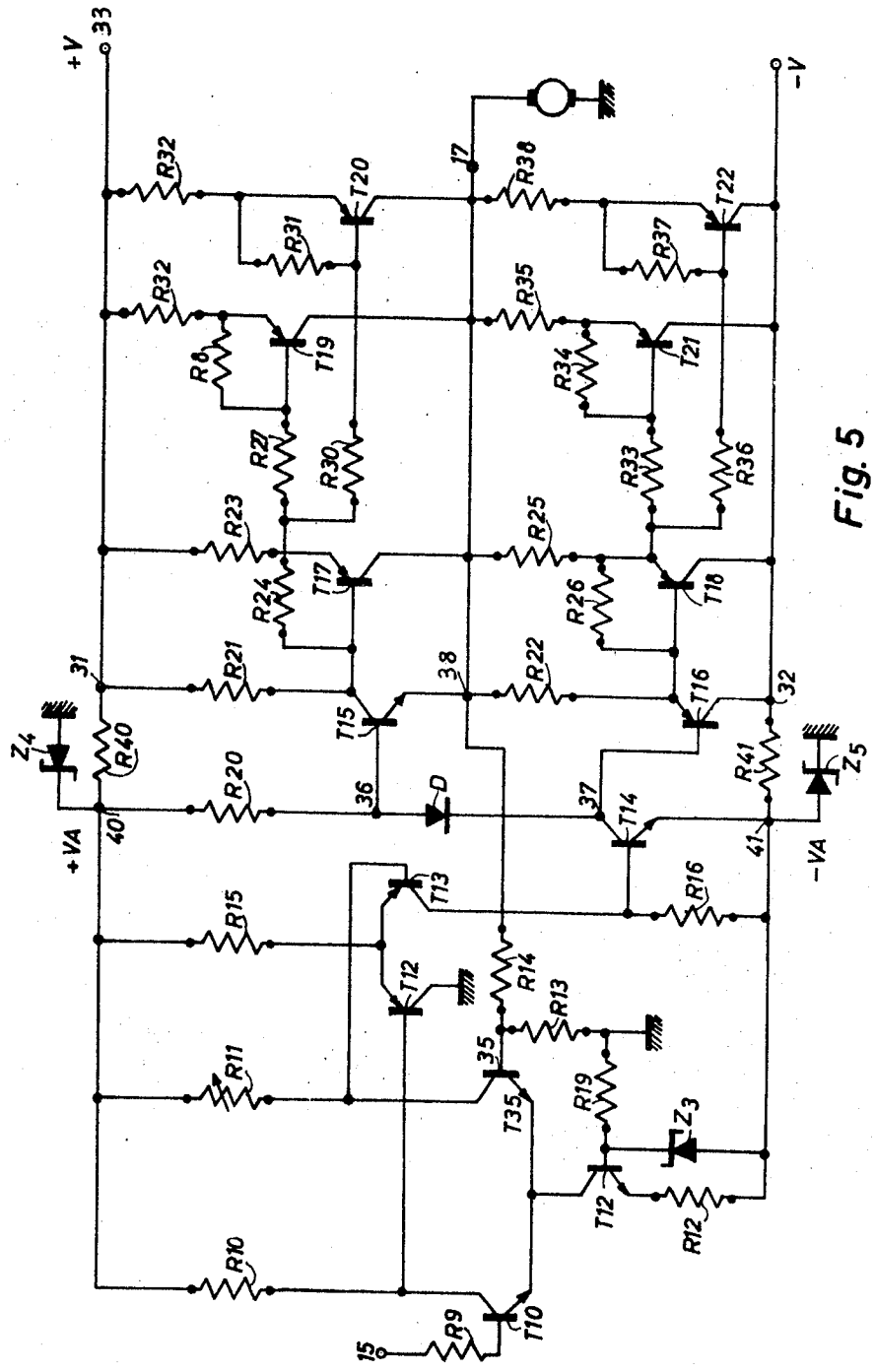


Fig. 5

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APPARATUS FOR CONTROLLING THE FEEDING OF PAPER IN HIGH-SPEED PRINTERS

BACKGROUND OF INVENTION

This invention relates to apparatus for controlling the paper feeding in high-speed printers, particularly in printers employed in information processing systems. Accordingly, this invention concerns apparatus for controlling the acceleration, the braking, and the reversal of a low inertia motor according to a predetermined sequence.

The feeding of paper in high-speed printers is usually provided by means of a motor which drives a system of sprocket, or toothed, wheels or chains, whose teeth engage in a set of sprocket holes provided in the paper. The distance of the paper advancement must be an integral multiple of a definite quantity, usually the minimum spacing between consecutive printed lines. This quantity is called the "line pitch."

According to requirements, the paper may be controlled to advance, in response to an appropriate line feed signal, one, two, or even three line pitches at a time during normal printing operations, to obtain printed texts of different densities. The paper may also be controlled to advance through a large number of line pitches by the "slew" operation, in which a substantially large portion of blank space is interposed between portions of printed text.

Apparatus is known for precisely controlling the position of the paper at the end of each line feed or slew operation. This usually comprises mechanical means, such pin-and-ratchet devices, gears, and the like. However, devices are costly and are subject to considerable wear and tear as a consequence of the mechanical stresses to which they are subjected. Moreover, they are usually noisy and frequently go out of adjustment.

Other feed control apparatus uses low inertia motors for directly controlling the paper feed operation. Such motors may be, for example, direct current motors with printed-circuit rotors, controlled by bidirectional amplifiers suitable for imparting to the motor high accelerating or decelerating torques. The paper feed operation requires, in this instance, three states: a first state of fast acceleration, a second state of constant speed and a third state of fast deceleration (braking). In the first state the controlling amplifier delivers a large current of predetermined polarity, in the second state the current delivered is only that required to compensate for the energy lost by friction in order to maintain the motor at constant speed, and in the third state the amplifier delivers a large current of reversed polarity. To obtain the same distance of line pitch in each state, the motor speed and, therefore, the amplifier current delivered in each state, must be precisely controlled, so that, under like control conditions, the paper advances the same number of line pitches during equal intervals.

It is therefore necessary for the motor control amplifier to have an output almost perfectly stable and independent of external conditions. In particular, in the prior art, great importance is given to stabilizing the direct current source delivering the current controlled by the motor control amplifier. However, precise stabilization of a large d-c current source is very burdensome and costly.

Therefore, it is the object of the instant invention to provide a paper feed control system of low cost, great accuracy and high reliability.

SUMMARY OF THE INVENTION

According to the invention this object is attained by supplying the motor from a bidirectional amplifier which is controlled by a signal provided from comparing a reference voltage and a voltage generated by a tachometric generator driven by the motor. Stabilization of the current delivered by the amplifier is obtained in a simple and efficient manner by stabilizing an intermediate stage of the amplifier utilizing low power Zener diodes.

Although the invention is primarily directed toward paper feeding in a high-speed printer, it may be used in a number of

other instances wherein it is necessary to control acceleration, constant speed, and deceleration and reversal a rotating mechanical device driven by a low-inertia motor. For example, the invention is useful with the tape transport capstan of a tape handler of the "single capstan" type.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be described with reference to the accompanying drawings, wherein:

FIG. **1** is a block diagram, including a perspective view of a portion of a high-speed printer of the invention;

FIG. **2** illustrates waveforms of various voltages and currents in the embodiment of FIG. **1**;

FIG. **3** is a schematic diagram of the reference voltage generator and voltage comparator of the invention;

FIG. **3***a* is a diagram of the equivalent circuit of the voltage comparator of FIG. **3**;

FIG. **4** is a schematic diagram of the bidirectional amplifier of FIG. **1**; and

FIG. **5** is a schematic diagram of a variation of the amplifier of FIG. **4**;

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. **1**, a paper feed motor **1** drives a toothed chain member **2**. Member **2** engages sprocket holes in and thereby moves a paper web **3**. Either shaft of motor **1**, or on another shaft directly driven by the motor, are mounted a photodisc **4**, and a tachometric d-c generator **7**. Disc **4** is provided at its periphery with a set of uniformly spaced holes associated with a photoelectric pick-up device which comprises a lamp **5** and a photocell, or photodiode, **6**. Generator **7** delivers at its terminals a voltage proportional to the rotational speed of motor **1**.

The distance between adjacent holes on the periphery of photodisc **4** corresponds to the angle through which motor **1** must rotate to advance paper web **3** by a single line pitch. Therefore, photocell **6** receives a light pulse, and delivers an electric pulse, each time that the paper web advances a line pitch.

The paper feeding occurs either "step-by-step," each step spanning one, two or three line pitches, or by "slewing," wherein the paper web advances through a substantially larger number of line pitches. Although slewing may occur at different speeds, depending on amount of spacing required, the slew speed is always greater than the step-by-step speed. For example, three speeds may be employed: a low speed for the step-by-step advancement, an intermediate speed for "slow" slewing, and a high speed one for "fast" slewing. Possible values for these three speeds may be 600 mm/sec., 1,000 mm/sec., and 1,800 mm/sec.

In FIG. **1**, a logical device **8** receives, instruction signals on an input lead **9**. The instruction signals correspond to the required type of feeding; i.e., step-by-step feeding by one, two or three line pitches, slow slew or fast slew, and number of pitches per slew operation. The pulses delivered by photocell **6** are supplied to logical device **8** on an input lead **10**.

Logical device **8** responds to the instruction signals to control a reference voltage generator **11**, which generates a reference voltage V_R for determining the rotational speed of motor **1**. The reference voltage generated by generator **11** is applied to an input lead **12** of a comparator **13**. Comparator **13** compares two voltages, reference voltage V_R and a voltage V_T, termed the tachometric voltage. The tachometric voltage V_T, which is proportional to the voltage generated by tachometric generator **7**, is applied to input lead **14**. The ratio between the tachometric voltage V_T and the voltage delivered by generator **7** is so chosen, that for each different reference voltage, the tachometric voltage provided at the corresponding motor speed is slightly lower than voltage V_R.

Assume, first, that this ratio is equal to unity, wherein voltage V_T is the same as the actual voltage delivered by generator **7**. In comparator **13**, the tachometric voltage is subtracted

from the reference voltage. The difference voltage delivered by comparator **13** is a control voltage V_S which is applied to an input lead **15** of a bidirectional amplifier **16**. This difference voltage may be positive, if the reference voltage is higher than the tachometric voltage, in which case the output lead **17** of amplifier **16** delivers a positive control current which causes motor **1** to rotate in a direction appropriate for feeding the paper. If the difference voltage is negative, amplifier **16** supplied to the motor a negative control current, which has a braking effect. If the difference is zero, the motor is not supplied with control current.

The waveforms of FIG. **2** illustrate the reciprocal relationship between the tachometric voltage V_T and the control voltage V_S and illustrate the current delivered to the motor, for the example of a fast slewing. In this example, responding to the received instruction signals, logical device **8** selects a reference voltage representing the fast slew. Line R (waveform a) represents this reference voltage V_R and line T represents the corresponding tachometric voltage V_T. Initially, when motor **1** is at rest, the tachometric voltage is zero, so that the control voltage V_S, which is the difference between voltages V_R and V_T and is represented by line S (waveform *b*), is equal to reference voltage V_R. Accordingly, amplifier **16** delivers a positive control current I_M as shown by line I (waveform *c*).

As the motor starts turning and increases its speed, the tachometric generator delivers an increasing voltage as represented by line T. The control voltage V_S correspondingly decreases, as shown by line S, which is the difference between the ordinates of lines R and T. When voltage V_S becomes less than a predetermined threshold value W, corresponding to the saturation conditions of amplifier **16**, the control current output I_M decreases from its initial maximum value I_M, and, therefore, the acceleration and the slope of curve T decrease. When the control current is only sufficient to compensate for frictional losses, the acceleration becomes zero and the motor runs at constant speed.

During the rotation of motor **1**, the pick-up device associated with photodisc **4** transmits a number of pulses, equal to the number of line pitches advanced, to logical device **8**. Logical device **8** counts these pulses by means of a counter. When the number of pulses received by device **8** reaches a quantity $n-k$, wherein n is the programmed number of line pitches of the current slew, and k is an integer suitably chosen, for example **5**, reference voltage V_R is reduced to the value V_p, corresponding to step-by-step feeding. Accordingly, V_R becomes lower than V_T, and a negative control voltage V_S is delivered to amplifier **16**, which thereupon delivers a negative control current I_M. This negative control current abruptly slows motor **1** and reduces its speed to the step-by-step value.

This braking action requires the duration of k photodisc pulses. When the n^{th} pulse is received by logical device **8** the reference voltage is reduced to zero, the control voltage V_S again goes negative, and the braking current brings the motor to a halt.

It is apparent that the precision of the final position reached by the paper web at the end of a feeding operation is conditioned by the precision of action controlled by the braking current. If such action is too strong, the paper web halts too early, whereas if it is too weak, the paper overshoots the intended final position.

Reference voltage generator **11**, FIG. **3**, comprises three transistors T_1, T_2 and T_3, for example of the NPN type. The collectors of these transistors are supplied from a common positive voltage source, +V, (for example, +20 v) through respective resistors R_1, R_2, R_3. The emitters of transistors T_1, T_2, and T_3 are grounded. The collectors of transistors T_1, T_2, and T_3 are also connected to the anodes of the respective diodes D_1, D_2, and D_3. The cathodes of these three diodes are all connected to one end **25** of a potentiometer R_4, whose other end is grounded. The bases of transistors T_1, T_2, and T_3 are connected to the respective input terminals **21**, **22**, **23**.

Terminals **21**, **22**, and **23** receive control signals from logical device **8**, which correspond to the required reference voltage to be delivered. The control signals on terminals **21**, **22**, and **23** represent binary values, the binary **1** being represented by a positive voltage (for example instance +5 V), and the binary 0 being represented by 0 v.

When a binary 1 signal; i.e., a positive voltage, is applied to all of the three input terminals **21**, **22**, **23**, the three transistors T_1, T_2, and T_3 conduct, their collector voltages drop practically to 0 v and, consequently, point **25** drops to 0 v. Accordingly, reference voltage V_R on lead **12** is at 0 v. In this instance, motor **1** is supplied with no current and no paper feeding occurs.

If a binary 0 signal is applied to input terminal **21**, while input terminals **22** and **23** receive binary 1 signals, transistor T_1 becomes non-conductive. Current flows through resistor R_1, diode D_1 and potentiometer R_4. Accordingly, lead **12** is brought to a reference voltage V_p which depends on the values of resistor R_1 and potentiometer R_4, and the position of the movable tap of potentiometer R_4. Since the resistance of resistor R_1 is considerably greater than that of potentiometer R_4, the reference voltage V_p is substantially less than the source voltage, $+V_1$. By adjusting the movable tap of potentiometer R_4, the value of voltage V_p is brought to that required for step-by-step feeding.

If a binary 0 signal is applied to both input terminals **21** and **22**, transistors T_1 and T_2 become non-conductive. Resistors R_1 and R_2 effectively become parallel connected through respective diodes D_1 and D_2. The resulting resistance value is lower than in the immediately preceding case, so that the reference voltage at lead **12** is higher, being a reference voltage V_L required for the slow slew.

If a binary 0 is applied to both input terminals **21** and **23**, resistors R_1 and R_3 become effectively parallel connected. Since the value of resistor R_3 is relatively small with respect to that of resistor R_1, the resulting resistance value is further reduced. Therefore the voltage at lead **12** is relatively high, being the reference voltage V_F required for the fast slew.

The following table gives the binary values applied to the input terminals for each of the four control conditions, and the related reference voltages provided:

Condition	Input Terminals			Ref. Voltage
	21	22	23	
No feeding	1	1	1	0
Step-by-step	0	1	1	V_p
Slow slew	0	0	1	V_L
Fast slew	0	1	0	V_F

Only four of the eight possible combinations of binary values at the three input terminals are used herein. Therefore, four remaining combinations are available if additional reference voltages are needed. The choice of the four combinations is only representative; different combinations may be selected depending on the resistance values and disposition employed. Moreover, since only four reference voltages are employed in the preferred embodiment, only two input terminals are required to provide the four different combinations of applied binary values. However, such an arrangement might set too rigid a constraint on the voltage values obtainable from particular resistance values. Instead, with the disclosed arrangement the values of the three resistances may be freely chosen to obtain the most suitable ratio between the three required feeding speeds.

The movable tap of potentiometer R_4 permits adjusting the step-by-step feeding speed to the required value. If R′ represents the portion of potentiometer R_4 between the movable tap and ground, the reference voltage V_R is proportional to R′. However, the ratios between the various reference voltages are independent of R′, depending only on R_1, R_2, R_3 and R_4. Thus, adjusting the potentiometer tap does not change the ratios between the speeds.

A set of suitable values for these resistances is, for example, the following:

$R_1 = R_2 = 2.2$ Kohm

$R_3 = 400$ ohm

$R_4 = 500$ ohm

which provide the following set of reference voltages:

$V_p = VR'/2{,}700$

$V_L = V\,R'/1{,}600$

$V_S = V\,R'/838$

where V is the value of the voltage source.

Thus, the ratios between reference voltages and corresponding speeds are:

$V_L/V_p = 1.69$

$V_S/V_p = 3.24$

If the step-by-step feeding speed is, for example, 22 inches per second (560 mm/s) the slow slew speed is appr. 37 ½inches per second (950 mm/s) and the fast slew speed is 71 inches per second (1,800 mm/s).

Comparator **13**, FIG. **3** comprises resistors R_5, R_6 and R_7, connected as shown. The comparator receives the reference voltage V_R on lead **12** and delivers the control voltage V_S on lead **15**, which is the input to amplifier **16**, represented in FIG. **3** by its input resistance R_C.

The tachometric generator **7** is connected across leads **14** and **15** and delivers a voltage V'_T proportional to the rotational speed of motor **1**, and, accordingly, to the feed rate of the paper web. Resistors R_6 and R_7 form a voltage divider so that between lead **15** and point **18** there is a tachometric voltage V_T equal to: $V'_T\,R_7\,(R_6 + R_7)$. The resistance values R_6 and R_7 are chosen such that the tachometric voltage V_T is comparable to the reference voltage V_R; i.e., for each different reference voltage V_R there is a rotational speed of the tachometric generator for which V_T is equal to V_R.

Applying Thevenin's theorem of electric circuits to the circuit comprising the tachometric generator and resistors R_6 and R_7, there is derived an equivalent circuit comprising an ideal voltage generator G_T delivering voltage V_T, in series with a resistor R_{eq} whose resistance is that of resistors R_6 and R_7 in parallel:

$$R_{eq} = R_6\,R_7/(R_6 + R_7)$$

Accordingly, the equivalent circuit of comparator **13** is shown in FIG. **3***a*, where in G_R is an ideal voltage generator providing the reference voltage V_R and R'_5 is a resistance equal to the sum of the resistances of resistor R_5 and the portion R' of potentiometer R_4 included in the circuit P. The control voltage V_S is the voltage developed across resistance R_C.

The current I in the equivalent circuit of FIG. **3***a* is given by:

$$V_R - V_T = (R_{eq} + R'_5 + R_C)\,I$$

Since $V_S = R_C I$, the equation may be written as:

$V_R - V_T = [(R_{eq} + R'_5 + R_C)/R_C]V_S = KV_S = V'_S$, where K is a constant and V'_S is a fictitious signal voltage, proportional to control voltage V_s.

Thus, waveforms of FIG. **2** are valid even if, in place of the voltage V'_T of generator **7**, the effective voltage V_T is considered, and if, in place of the control voltage V_S, the fictitious signal voltage V'_S is taken into account, because the voltage V'_T is proportional to voltage V_T and voltage V'_S is proportional to voltage V_S. This requires only changing the scale of waveforms *a* and *b*. Moreover, for $V_R = V_T$, $V'_S = 0$, and

$$V_S = 0.$$

The bidirectional amplifier **16** of FIG. **4** provides the control current to motor **1**. Amplifier **16** comprises a voltage preamplifier including two differential amplifiers and a final stage, which include transistors T_{10}, T_{11}, T_{12}, T_{13} and T_{14}, and a current amplifier including a first stage which uses complementary transistors T_{15} and T_{16}, a second stage which uses non-complementary transistors T_{17} and T_{18}, and a final stage which uses two parallel-connected power transistors T_{19} and T_{20} for the positive output and two parallel-connected power transistors T_{21} and T_{22} for the negative output.

The first differential amplifier comprises the NPN transistors T_{10} and T_{11}. The collectors of transistors T_{10} and T_{11} are supplied from the stabilized voltage source + VA, through the respective resistor R_{10} and variable resistor R_{11}. The emitters of transistors T_{10} and T_{11} are connected to the collector of a transistor T_{12}, whose emitter is connected, in turn, through a resistor R_{12} to the stabilized negative voltage source −VA. The stabilized voltage sources +VA and −VA are obtained respectively from two non-stabilized supply voltages + V and − V, applied to the respective supply terminals **33** and **34**. These two supply voltages are substantially equal in amplitude and are symmetrically connected with respect to a reference voltage, which usually is the ground voltage.

Stabilization of the voltages + VA and −VA is provided by stabilizing circuits comprising the respective Zener diodes Z_1 and Z_2 and resistors R_{17} and R_{18}, arranged according to well-known techniques.

A Zener diode Z_3 is connected between the emitter of transistor T_{12} and one end of resistor R_{12}, thereby maintaining, in cooperation with resistor R_{19}, the base of transistor T_{12} at a constant voltage with respect to the stabilized negative voltage − VA. Thus, the current flowing through resistor R_{12} is maintained at a constant value and, consequently, the sum of the currents flowing rhough transistors T_{10} and T_{11} is held constant.

The base of transistor T_{10} is connected through a resistor R_9, to input lead **15**, on which the control voltage V_S is supplied. The base of transistor T_{11} is connected to a point **35**. Point **35** is the central point of a voltage divider comprising resistors R_{13} and R_{14}, one end of such voltage divider being grounded and the other end being connected to a terminal **17**, which supplies motor **1**. As it will be explained hereafter, a feed-back effect is thereby obtained.

When motor **1** is at rest, and no current flows therethrough, both terminal **17** and point **35** are at ground voltage (0 v). If input lead **15** is also at 0 v., the same amount of current must flow through transistors T_{10} and T_{11}. Therefore, if R_{11} is equal to R'_{10}, the collectors of transistors T_{10} and T_{11} are at the same voltage. This balanced condition can be achieved by a fine adjustment of variable resistor R_{11}, if it is necessary to compensate for differences in the intrinsic resistance of the transistor. However, such differences usually will be very small, inasmuch as transistors T_{10} and T_{11} are matched to have equal characteristics, to the extent possible.

The collector voltages of transistors T_{10} and T_{11} are applied to the respective bases of PNP transistors T_{12} and T_{13}, which form the second differential amplifier. The emitters of transistors T_{12} and T_{13} are connected together and to one terminal of a resistor R_{15}, which is supplied at its other terminal from the positive stabilized voltage source +VA. The collector of transistor T_{12} is grounded. The collector of transistor T_{13} is connected, through a resistor R_{16}, to the negative stabilized voltage source −VA. This second differential amplifier is symmetrically driven by the output signals of the first differential amplifier. The employment of transistors of opposite conductivity type for the first and second differential amplifiers substantially reduces, through this compensation, the effect of temperature drift.

The collector of transistor T_{13} is also connected to the base of transistor T_{14}. The emitter of transistor T_{14} is connected to the stabilized negative voltage source −VA. The collector of transistor T_{14} is supplied from the stabilized positive voltage source +VA through a resistor R_{20} and a diode D.

The amplifier comprising transistor T_{14} is the final stage of the voltage preamplifier and is provided with output points **36** and **37**, which differ in voltage by the drop through Diode D. In the quiescent condition; i.e., in the absence of an input control voltage V_S, the voltages at points **36** and **37** are balanced with respect to the ground. In this balanced condition the voltage at point **36** is slightly positive and the voltage at point **37** is slightly negative.

When a positive control voltage is applied to input lead **15**, the conduction of transistor T_{10} increases and correspondently the current flowing through transistor T_{11} decreases. The voltage of the collector of transistor T_{10} and of the base of transistor T_{12} decreases, and the voltage of the collector of transistor T_{11} and of the base of transistor T_{13} increases. The resistance of transistor T_{13} and, therefore, the voltage drop between its emitter and collector increases, whereby the

voltage of the base of transistor T_{14} decreases. Therefore, current flowing through transistor T_{14} decreases, whereupon the voltages of points **36** and **37** increases. Conversely, when a negative control voltage is applied to input lead **15**, the voltages of points **36** and **37** decrease. However, the difference between the voltages of points **36** and **37**, being equal to the drop across diode D, does not change appreciably.

The above-described voltage preamplifier is followed by a current amplifier. The first stage of this current amplifier comprises a pair of complementary transistors T_{15} and T_{16}, transistor T_{15} being, for example, of the NPN type, and transistor T_{16} being of the PNP type. The collector of transistor T_{15} is connected to the positive stabilized voltage source +VA through a resistor R_{21}, and its emitter is connected to a point **38**. The collector of transistor T_{16} is connected directly to the negative stabilized voltage source −VA, and its emitter is connected to point **38** through a resistor R_{22}.

The voltages of points **36** and **37** are applied to the bases of respective transistors T_{15} and T_{16}. In the absence of an input control voltage V_S both of transistors T_{15} and T_{16} are in a state of low conduction; i.e., both are close to cutoff. When a positive control voltage is applied to input lead **15** both points **36** and **37** change positively, as described previously herein. Because transistors T_{15} and T_{16} are of opposite conductivity types, transistor T_{15} becomes more conductive and transistor T_{16} becomes less conductive.

The collector of transistor T_{15} is connected to the base of transistor T_{17}. The emitter of transistor T_{16} is connected to the base of transistor T_{18}. Transistors T_{17} and T_{18} are of the PNP type and, with resistors R_{23}, R_{24}, R_{25}, and R_{26}, form an amplifier wherein each transistor is connected as an "emitter follower." Such amplifier provides a substantial amplification of the output current.

Transistors T_{17} and T_{18} drive respectively a pair of transistors T_{19} and T_{20} and a pair of transistors T_{21} and T_{22}. Each of transistors T_{19}, T_{20}, T_{21} and T_{22} with respective sets of resistors R_{27}, R_{28}, R_{29}; R_{30}, R_{31}, R_{32}; R_{33}, R_{34}, R_{35}; and R_{36}, R_{37}, R_{38} forms an emitter follower circuit. The emitter follower comprising transistor T_{19} is in parallel with the emitter follower comprising transistor T_{20}, both such emitter followers being supplied by the positive supply voltage +V. The emitter follower Transistor T_{21} is in parallel with the emitter follower comprising transistor T_{22}, both such emitter followers being supplied by the negative supply voltage −V. In absence of an input control voltage V_S, each of transistors T_{19}, T_{20}, T_{21} and T_{22} is in a state of low conduction, being close to cutoff, so that only a relatively small current flows through these transistors from terminal **33** to terminal **34**, point **38** being at 0v.

When a positive control voltage is applied to input lead **15**, the base of transistor T_{15} becomes more positive and transistor **15** becomes more conductive, whereas although the base of transistor T_{16} also becomes more positive, the conduction of transistor T_{16} decreases. Consequently, point **38** becomes positive and causes a positive increase of the voltage at point **35**, the base of transistor T_{11}. Thus, the difference between the currents through transistor T_{10} T_{11} decreases. Thus, a negative feed-back effect is provided, with its well-known advantages of greater stability and less sensitivity to noise.

The increase in conduction of transistor T_{15} and the decrease in conduction of transistor T_{16} cause a respective decrease of the base voltage of transistor T_{17} and increase of the base voltage of transistor T_{18}. Thus, transistor T_{17} becomes more conductive and transistor T_{18} less conductive. Under these conditions, the decreased voltage of the emitter of transistor T_{17} causes a conduction of transistors T_{19} and T_{20} to increase, whereas the increased voltage of the emitter of transistor T_{18} causes the conduction of transistors T_{21} and T_{22} to decrease. Transistors T_{19} and T_{20} thereby deliver a greater positive current and transistors T_{21} and T_{22} a lesser negative current to terminal **17**.

As a consequence, for a positive control voltage the motor connected to terminal **17** receives a positive current and is accelerated as required. In the opposite case; i.e., wherein a negative control voltage is applied to lead **15**, a negative current is supplied to the motor, with its consequent braking effect.

Since terminal **17** is directly connected to point **38**, there is no need to stabilize the supply voltage in the current amplification stages which follow complementary transistors T_{15} and T_{16}. In fact, the stabilization of the voltage at points **31** and **32**, ensures that the voltage of point **38** is affected only by the control voltage at input lead **15** and not by accidental fluctuation of the supply voltages +V and −V.

Accordingly, the possible fluctuations of the non-stabilized voltage supplying the following stages cannot influence the voltage of point **17**, which supplies motor **1**. Since the current required for the stage with the complementary transistors T_{15} and T_{16} and the preceding stages is substantially lower than that required for the following power stages, a remarkable saving in cost and dimensions of the components of the stabilizing circuit is attained, relative to that which would be required for stabilizing the voltages +V and −V provided at terminals **33** and **34**.

A satisfactory result, with even a lower cost of the stabilizing components, may be provided by the arrangement illustrated in FIG. **5**. The circuit of FIG. **5** differs from that of FIG. **4** in that the supply voltage for the complementary transistors T_{15} and T_{16} is also not stabilized, but only the supply voltage for the preceding stages. By this arrangement, the stabilized voltages +VA and −VA, obtained by use of resistors R_{40}, and R_{41} and Zener diodes Z_4 and Z_5, are present at points **40** and **41**, whereas at points **31** and **32** the non-stabilized voltages +V and −V are present.

The current to be stabilized is further reduced and an additional saving thus results. In this instance the voltages of points **36** and **37**, and therefore the voltages applied to the bases of transistors T_{15} and T_{16} are independent of fluctuations of voltages +V and −V. The effect of such fluctuations on the voltage of point **38**, however, although theoretically not zero, is effectively negligible. In fact, this effect is reduced to the changes in voltage drop across the base-emitter junctions of transistors T_{15} and T_{16}, due to changes in the current flowing through these junctions as a result of such voltage fluctuations.

I claim:

1. A device for controlling paper feed in a printing apparatus, comprising a low-inertia motor, a tachometer device for delivering a tachometric voltage proportional to the paper feed speed, a pulse generator device for delivering a pulse each time the paper is moved a distance equal to a line pitch, a logical control device having inputs to receive command signals and pulses generated by said pulse generator device, a selectively controlled reference voltage generator, for delivering a reference voltage in response to a set of control signals generated by said logical control device according to the command signals and pulses received thereby, said reference voltage generator comprising first, second and third transistors having the collector thereof supplied from a common voltage source through respective first, second and third resistors, the bases of said transistors, being connected to respective first, second and third input terminals, the emitters of said transistors being directly connected to ground, the collectors of said transistors being further connected to one electrode of respective first, second and third diodes, the other electrodes of each of said diodes being connected to one fixed terminal of a potentiometer, the other fixed terminal of said potentiometer being connected to ground, and the movable tap of said potentiometer being connected to the output terminal of said reference voltage generator, a comparing device for comparing a voltage proportional to said tachometric voltage and said reference voltage and for generating a signal voltage having an amplitude depending on the difference between said reference voltage and said voltage proportional to the tachometric voltage, and a bidirectional amplifier for controlling the rotational speed of said low-inertia motor by means of a supply current controlled in amplitude and direction by said signal voltage,

said reference voltage generator operating to deliver to said output terminal a particular reference voltage, selected among a plurality of predetermined reference voltages, in response to the patterns of signals when appropriate patterns of signals are applied by said logical control device to said reference voltage input terminals.

2. The device of claim 1, wherein said comparing device comprises first and a second series connected resistors connected between a first input terminal and an output terminal, a third resistor connected between the point common to said first and second resistors and a second input terminal, said tachometric device applying between said output terminal and said second input terminal a tachometric voltage proportional to the rotational speed of said motor, said first input terminal being directly connected to the output terminal of said reference voltage generator.

3. Apparatus for controlling the slewing of a print-receiving member to a precise final position in a high-speed printer in response to input command signals representing the number of line pitches through which said member is to be slewed, comprising: an electric motor for slewing said print-receiving member through a printing position, means for sensing the slewing of said print-receiving member and for delivering a first type signal representing said slew speed and a pulse each time said print-receiving member moves a distance of one line pitch through said printing position, first control means responsive to the receipt of said input command signals for generating a reference signal having a first value representative of a predetermined slew speed, said first control means comprising first, second and third transistors having the collector thereof supplied from a common voltage source through respective first, second and third resistors, the bases of said transistors, being connected to respective first, second and third input terminals, the emitters of said transistors being directly connected to ground, the collectors of said transistors being further connected to one electrode of respective first, second and third diodes, the other electrodes of each of said diodes being connected to one fixed terminal of a potentiometer, the other fixed terminal of said potentiometer being connected to ground, and the movable tap of said potentiometer being connected to the output terminal of said first control means, second control means responsive to said input command signals and to said pulses to generate a second type signal when said print-receiving member requires slewing only through a predetermined number of remaining line pitches, said first control means being responsive to said second type signal for changing said reference signal to a second value representative of a deceleration of said motor, means for delivering a third type signal representing the algebraic difference between said reference signal and said first type signal, and means responsive to said third type signal to control the speed of said motor.

4. Apparatus for controlling the slewing of a print-receiving member to a precise final position in a high-speed printer in response to input command signals representing the number of line pitches through which said member is to be slewed comprising: an electric motor for slewing said print-receiving member through a printing position, a speed-sensing member for sensing the speed of slew of said print-receiving member and for delivering a first type signal representing said slew speed, a line pitch sensing member for sensing the slewing of said print-receiving member and for delivering a pulse each time said print-receiving member moves a distance of one line pitch through said printing position, first control means responsive to receipt of said input command signals for generating a reference signal having a first value representative of a predetermined slew speed, said first control means comprising first, second and third transistors having the collector thereof supplied from a common voltage source through respective first, second and third resistors, the bases of said transistors, being connected to respective first, second and third input terminals, the emitters of said transistors being directly connected to ground, the collectors of said transistors being further connected to one electrode of each of said diodes being connected to one fixed terminal of a potentiometer, the other fixed terminal of said potentiometer being connected to ground, and the movable tap of said potentiometer being connected to the output terminal of said first control means, second control means responsive to said input command signals and to said pulses to generate a second type signal when said print-receiving member has been slewed through the number of line pitches represented by said input command signals less a predetermined number of line pitches, said first control means being responsive to said second type signal for changing said reference signal to a second value representative of a deceleration of said motor, means for comparing said reference signal and said first type signal for delivering a third type signal representing the algebraic difference between said reference signal and said first type signal, and means responsive to said third type signal to control said motor to accelerate said print-receiving member to said predetermined slew speed after said apparatus receives said input command signal and, after said second type signal has been generated, for decelerating said print-receiving member to stop after having been slewed through the precise member of line pitches represented by said input command signals.

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