CONVENTION APPLICATION FOR A PATENT

We hereby apply for the grant of a Patent for an invention entitled

"PRINthead COMPENSATION ARRANGEMENT FOR PRINTER"

which is described in the accompanying complete specification. This application is a convention application and is based on the application or applications for a patent or patents or similar protection made in the following country or countries on the following date or dates:

in (d) U.S.A. on (e) 1.11.77 No. (f) 847,569

My/Our address for service is care of ARTHUR S. CAVE & CO., Patent and Trade Mark Attorneys, 1 Alfred Street, Sydney, New South Wales, Australia 2000.

Dated this (g) 11th day of October, 1978

By Its Patent Attorneys...

ARTHUR S. CAVE & CO.

G. F. CHODZIESNER
COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952-1969

DECLARATION IN SUPPORT OF A CONVENTION APPLICATION
FOR A PATENT

In support of the Convention Application made by GENERAL ELECTRIC COMPANY, a corporation of the State of New York, United States of America, for a Patent for an invention entitled: "PRINTHEAD COMPENSATION ARRANGEMENT FOR PRINTER"

I, ARTHUR M. KING, of 570 Lexington Avenue, New York, 10022, United States of America, do solemnly and sincerely declare as follows:

1. I am authorised by GENERAL ELECTRIC COMPANY the Applicant for the Patent, to make this Declaration on its behalf.

2. The basic application(s) as defined by Section 141 of the Act was (were) made in the United States of America on the first day of November 1977 by WILLIAM ARLEN HANGER.

3. WILLIAM ARLEN HANGER of P.O. Box 607, Churchville, Virginia, U.S.A.

is (are) the actual inventor(s) of the invention(s) and the facts upon which GENERAL ELECTRIC COMPANY is entitled to make the Application are as follows:

GENERAL ELECTRIC COMPANY is the Assignee of the invention from WILLIAM ARLEN HANGER by virtue of an assignment(s) dated the eighteenth day of January 1978.

4. The basic application(s) referred to in paragraph 2 of this Declaration was (were) the first application(s) made in a Convention country in respect of the invention, the subject of the Application.

DECLARED at New York, New York, United States of America, this 31st day of October 1978

To: Counsel, International Patent Operation

THE COMMISSIONER OF PATENTS
1. Printer control apparatus adapted for operation with a printer of the serial dot matrix character printing type in which a printing head having selectively actuable matrix printing elements moves along the line to be printed, a sensor provides output pulses indicative of such head movement, and a print control counter responsive to sensor output controls the print line locations where the actuation of printing elements is effected characterized in that the average number of sensor output pulses per character is greater than the number of matrix element positions assigned to make up the average character, and compensating means controlled by the mechanical actuation characteristics of the motion of said printing head along said print line for applying additional pulses to said control counter.
AUSTRALIA

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COMPLETE SPECIFICATION

(ORIGINAL)

FOR OFFICE USE

Application Number: 
Lodged: 

Class 

Int. Class 

Complete specification Lodge, Accepted Published

Priority:

Related Art:

TO BE COMPLETED BY APPLICANT

Name of Applicant: GENERAL ELECTRIC COMPANY

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Complete Specification for the invention entitled

"PRINTHEAD COMPENSATION ARRANGEMENT FOR PRINTER"

The following statement is a full description of this invention, including the best method of performing it known to me:

ASC-49
This invention relates to printing devices. The invention relates more particularly to a means for compensating for flight time of the printing elements in a printhead and other printer variations which result in columnar misregistration in printers.

In one form of relatively highspeed printing device, a character printhead is transported parallel to a stationary platen and its printing elements are selectively actuated toward the platen. The printhead elements impact a printing ribbon and a medium which are positioned between the platen and the moving head and forms characters on the medium.

One form of relatively highspeed printer comprises a dot matrix printer. In dot matrix printing, a character is formed by a plurality of printed dots which are selected from a rectangular array or matrix of dot locations arranged in columns and rows. The printing head in a dot matrix printer includes a plurality of individually actuable print wires which are aligned vertically to form one or more of the dots of a matrix column. These print wires are accelerated toward the platen by associated solenoids. Scanning of the head along the platen results in the successive columnar printing of additional dots necessary to form the character.
An important consideration in the reproduction of printed characters, particularly when a large quantity of data is being printed, is vertical alignment or registration between characters which extend in a column over a number of horizontally printed lines. Columnar misregistration is undesirable since it detracts from the overall appearance of the printed material. Furthermore, when printing on vertically ruled forms such as may be used for accounting and business purposes, columnar misregistration can result in overlapping of the printed character on a ruled line and obliterate the character or confuse the reader. In dot matrix printing in particular, the overlapping of a character and a vertically ruled line can in some instances result in the alteration of the character.

High speed printers have, at times, exhibited this undesirable columnar misregistration. During the formation of a character by high speed impact printing, the print head and printing elements which advance along the platen and which has appreciable mass are subject to delay or flight time between the time at which the print elements are initially actuated and the time at which they impact the print medium to form a character. Since the head is moving parallel to the platen, the character will be printed at a location displaced from the point of initial actuation. In dot matrix printers, for example, the print wires each have significant mass which causes a delay between the time of solenoid energization and the time a dot is actually formed. The printer includes means for locating the head and for establishing printing locations along the platen. Print element flight time results in a divergence or flight time displacement between the print location called for by the printer control and the actual position of the printed character.

Highspeed printers may provide for incremental or stepwise printing or for continuous printing. In incremental printing the printing head which is controlled from a keyboard or from a communication line is stepped to a plurality of successively spaced printing positions at which the character or dot matrix column is to be printed. During continuous printing the head is maintained in continuous motion and printing occurs while the head is moving
laterally along the platen. The lack of columnar alignment over successive lines often becomes apparent when the printer is operated in an incremental mode and particularly when the input characters are selected from a keyboard. During incremental printing, flight time displacement is encountered in the course of each acceleration to, or deceleration from maximum printing velocity. The flight time displacement during acceleration or deceleration can occur over a distance of one to three characters. While in continuous printing mode, the flight time displacement is not as severe, none the less the highspeed printing technique of printing successive lines in alternately different directions results in a doubling of the lack of columnation which can become objectionably apparent.

In addition to the flight time displacements, above referred to, other mechanical characteristics of the device contribute to an undesired lack of columnar alignment in the printout. These characteristics include a mechanical cocking of the printhead and the existence of an elastic play in the head drive system. The printhead is generally supported and transported on a track such as, for example, an elongated machined rod which extends in a direction parallel to the platen. In a dot matrix printer, the printhead includes a printhead body which is also accurately machined for movement along the rod. A mechanical clearance is provided between the track and the moving head to enable binding free start-stop movements. This clearance permits a cocking of the printhead on the track when inertial forces occur as the head is being accelerated or decelerated along the track. The cocking causes a drag between the head and the track and albeit relatively small, it occurs in a direction opposite to the accelerating force and causes irregular head movement which contributes to displacement of the printhead character.

In some highspeed printer arrangements, the printhead is accelerated along the track by a drive means which exhibits a spring factor arising from elastic deformation of the drive train. The spring factor characteristic results in a delay and displacement of the printed character. A spring characteristic occurs, for
example, with a drive mechanism utilizing an elastomeric belt.

The flight time, cocking and spring factor displacements while individually and cumulatively contribute to an increased columnar misregistration.

The present invention aims to provide an improved printer having means for reducing columnar misregistration.

Another aim of the invention is to provide an impact printer having means for compensating for structural and operating characteristics which result in a displacement of printed characters.

The invention is also concerned with compensation for flight time displacement of printer elements.

A further object of the invention is to provide an improved impact printer having means for compensating for mechanical cocking of the printhead to reduce print displacement.

Another object of the invention is to provide an improved impact printer having means for compensating for printed elastic characteristic of a printer head drive which tend to produce character displacement.

In accordance with features of this invention, a printer is provided having a character printing head means and an elongated printing platen. A transport means advances the printing head means in a direction substantially parallel to a longitudinal axis of the platen. Printing wire actuating means are provided for accelerating selected printing wires toward the platen at predetermined print positions. Circuit means are provided for varying the time of initiation of the printing wire activation in order to compensate for displacement of the printhead means from the predetermined print positions which can occur as a result of flight time of the printhead elements (wires) and other mechanical characteristics of the printing elements and head.

The illustrated arrangement includes a source of electrical signal and a counter are provided for establishing a plurality of counts representative of successively positioned, predetermined matrix column printing positions along the platen. Circuit means are provided for sensing movement of the printhead and for varying the predetermined count in accordance with the movement of the head printing means. The latter circuit means provide for varying the
predetermined count to compensate for displacement occurring as a result of flight time of the printing elements and other mechanical characteristics of the printer.

These and other objects and features of the invention will become apparent with reference to the following specification and to the drawings wherein:

FIGURE 1 is a fragmentary perspective view of an impact printer constructed in accordance with features of this invention;

FIGURE 2 is a diagram illustrating an encoder disc used with the printer of FIGURE 1;

FIGURE 3 is a diagram illustrating a rectangular, dot-matrix array;

FIGURE 4 is a block diagram of a circuit arrangement embodying features of the invention; and

FIGURE 5 is a schematic diagram of a circuit arrangement, partly in block form, for compensating for delays for displacement of the printer mechanism.

Referring now to FIGURE 1, an impact printer of the dot matrix type is shown to comprise a printhead 10 which is supported for transport adjacent a platen 12 on a track comprising a machined rod 14. The rod or rail 14 is spaced away from the platen 12 and extends in a direction parallel to a longitudinal axis 16 of the platen. Positioned between the head 10 and the platen 12 are a record medium comprising an edge perforated elongated, sheet 18 and an inked print ribbon 20. Conventional sprocket wheels, not shown, engage the edge perforations 19 and provide for stepped advancement of the sheet 18 in the direction of the arrow 21. The printhead 10 may be transported back and forth along the rail 14 in directions represented by arrows 22 and 23 parallel to the platen 12. It is driven by a gear belt 24 which is formed of an elastomeric material. The gear belt 24 is coupled to the head 10 and extends about a drive capstan 25 and an idler gear 26. Rotating motion is imparted to the capstan 25 by a drive shaft 28 of a servo motor 30. An encoder disk 32, described more fully hereinafter, is mounted on the drive shaft 28 for rotation therewith. As the gear belt 24 which is mechanically
coupled to the printhead 10 and to the capstan 25 is driven in one
direction or the other, the head 10 will be driven along the rail 14
in directions indicated by the arrows 22 and 23, depending upon
the direction of rotation of the drive shaft 28. The head 10 is
provided with a number of independently and selectively actuable
projecting pins or print elements 34 which are selectively driven
toward the platen 12 by short driving pulses as the printhead 10 moves
along the platen 12 in the direction of the arrow 23. This actuation
of the print pins (which are the ends of wires) causes printing of
character dots. Head 10 will also be moved along the platen 12 when
the head is driven in the direction of the arrow 22 so that printing
occurs when the head is moved in either direction.

As already generally indicated, the printhead 10 includes a
vertically aligned array of print wires which is referred to gener-
ally in FIGURE 1 by the reference numeral 34. Each of the print
wires of the array is selectively, electromagnetically energized by
short driving pulses applied to an associated solenoid winding, not
illustrated. A print wire is driven toward the axis 16 of the platen
12 and the end of the print wire impacts the ribbon 20, the sheet 18
and the platen 12. Impact causes printing of an inked area corre-
sponding to a face of the wire. One or more of the print wires are
selectively energized to print the elemental character dots located
within a single matrix column. The head 10 may be incrementally or
continuously driven and during the head movement, the members of the
array of print wires are selectively energized to form one or more
dots at successive dot matrix columns thereby which build up as a
matrix of dots to form the desired character.

FIGURE 3 illustrates a segment of a print line which is scanned
by the array 34 of wires of the printhead 10 during head movement
along the platen 12. The array of wires 34 comprises seven vertically
aligned wires each one of which prints along one of the rows 50-62
during head movement. Printhead movement may be incremental or
continuous. During incremental operation, the head is moved to
successive predetermined column locations 64-104. During continuous
operation, the head is continuously moved past each of these predeter-
mained column locations. In either case, when the vertical array
print wires 34 is aligned with a predetermined column location, it is desired that the head selectively print dots in one or more of the rows 50-62 in accordance with a predetermined code for that matrix column of the character being produced. The printhead 10 will continue to scan or move across successive columns and to print dots in the matrix columns to make up characters in dot matrix form as it moves parallel to the platen.

Prior art arrangements have provided a means for predetermining the location of these matrix columns and for monitoring the position of the printhead 10 in order to correlate the printing of dots to form dot matrix characters at predetermined locations. However, as indicated hereinbefore, various physical factors can operate to cause the printed dot to be laterally displaced from the predetermined column location. For example, in printing column 76 the column dots, because of these characteristics, are actually printed, at times, between the columns 76 and 78.

FIGURE 4 is a block diagram of a circuit arrangement for monitoring the position of the moving printhead as it travels along the print line (FIGURE 3) and for compensating for the physical factors enumerated hereinbefore which can result in a printed dot being displaced from the desired dot matrix column location. Actuating means for driving the selected printing elements toward the platen 12 at predetermined matrix column locations are provided and includes print wire driver circuits 120 individually coupled to the separate print wire solenoids 122. As indicated hereinbefore, each of the print wires is electromagnetically driven toward the platen by an associated solenoid. In the vertical array of print wires 34, each of the seven print wires has an associated solenoid. The solenoids in any one matrix column location are selectively energized by information derived from character identifying input information interpreted through Read Only Memory (ROM) 124. One such ROM of this type is ROM-S8564 available from American Micro Systems, Inc. The ROM 124 stores the dot matrix format for each of the plurality of characters which can be formed by the printer. Each stored character has a 9 column dot format. This ROM is addressed by a character code such as the standard ASCII code which is derived from a source of
character information 126 such as a data communication line or a keyboard associated with the printer. The ROM 124 is also addressed by matrix column address information derived from a programmable logic array 128. The ASCII code selects the particular character which is to be printed while the column address information from the programmable logic array indicates the particular matrix column to be printed. The output of the character ROM 124 therefore provides information to the print wire drivers 120 with respect to those wires which are to be energized at a predetermined matrix column location.

Character printing density is provided at a routinely used density, such as 10 characters per inch (25.4mm), or the character can be compressed to provide greater densities such as 13, 15 and 16.5 characters per inch (25.4mm). When operating at compressed densities, the predetermined dot matrix column locations for the compressed characters are shifted relative to the locations at lower densities. The programmable logic array 128 is provided for selecting the predetermined matrix column locations at each of the character densities. This programmable logic array can be a transistor matrix. Inputs are provided to the array 128 from a reference counter 130 and from a character density signal source 132 which can be an operator controlled selector panel or a data line. In one arrangement the counter 130 counts to a modulus of 66 for each of the characters of the smallest character density and to a corresponding lesser modulus for characters of greater density. The matrix of logic array 128 enables output lines 133 representing dot matrix column locations for the selected character density. The enabled output lines 133 apply this dot matrix column location information to the ROM 124 for addressing particular column locations for a selected character. This technique for character compression is described more fully and is claimed in a copending U.S. patent application of C.M. Jones and W. A. Surber Serial No. (847,585) filed concurrently herewith, the disclosure of which is incorporated herein by reference and which application is assigned to the assignee of this invention.

Reference counter 130 indicates the position of the printing head 10. As described in greater detail hereinafter, input signals
to the reference counter for stepping the counter by incrementing or decrementing the counter are derived from a head position transducer 134 which includes the encoder disc 32. The disc 32 (Fig. 2) includes indicia comprising a plurality of radially extending indicia 136 for generating position reference signals. As the printhead 10 moves along the platen, the counter 130 is continuously incremented by these signals and the increments represent possible dot matrix column locations as well as positional locations intermediate the dot matrix column locations. The indicia 136 are formed to a relatively high resolution so that a plurality of intermediate location signals are generated. The position of the printhead is thereby monitored as a result of the signals generated from the disc and these signals are utilized to provide indications of matrix column locations for the printing of the matrix column characters through the counter 130.

The printing head displacement during the flight time and other printing head displacements resulting from characteristics of the printer are compensated for by a circuit means 138 which supplies compensating incrementing or decrementing signals to the counter 130. The compensation circuit means 138 applies a compensating incrementing or decrementing signal to the counter 130 in accordance with information supplied thereto from circuit means which sense movement of the head printing means 10. A compensating count is applied to the counter 130 in order to advance or retard actuation of the print head wires at an earlier or delayed position so as to cause the print head wires so that the character dots will be printed in the desired position in the predetermined dot matrix column. For example, referring to FIGURE 3, if character dots are to be printed in matrix dot column 76 and the physical factors enumerated hereinbefore operate to cause a displacement so that in an uncompensated situation the dots would be actually printed between columns 76 and 78 of FIGURE 3, then the compensating circuit means 138 applies an incrementing count to the counter 130 for initiating printing at an instant before the head 10 reaches location 76 by a distance sufficient to assure that the actual printing occurs at the column 76.

FIGURE 5 illustrates the compensating apparatus in more detail. It includes the head position transducing means 134, the compensation
circuit means 138 and compensating signal sources. The head position transducer 134, shown within the dashed rectangle 134 in FIGURE 5 includes a U-shaped transducer body 140 which houses a light source and photo detector means. The light source is positioned in the housing adjacent one face of the disc 32 and first and second photo-detector cells are positioned opposite the light source, adjacent an opposite surface of the disc 32. The photo detectors are spaced apart in a circumferential direction by a finite number of indicia 136 plus 1/4 slit space. The projection of light from the source through the indicia 136 during rotation of the disc 32 results in the generation of quadrature related first and second signals by the first and second detectors, respectively. The disk 32 rotates in a clockwise or counterclockwise direction, depending upon the direction of scanning motion of the printhead. The generation of quadrature related signals provides signal information from which the direction of rotation of the disk 32 can be determined. These quadrature related signals are coupled via line 142 to a pulse shaping and phase discriminating circuit arrangement 144. This pulse shaping and phase discriminating circuit arrangement provides output pulses on a line 146 representative of clockwise rotation, for example, of the disk 32 and output pulses on a line 148 representative of counterclockwise rotation of the disk 32. These pulses are applied to and step the reference counter 130.

Reference or control counter means 130 comprises a bi-directional binary counter adapted to be incremented or decremented by pulses from the head position transducer and to be incremented or decremented by pulses from the compensation circuit 138. As indicated hereinbefore, the dot matrix characters can be printed at different character densities, resulting in different character widths for the same character. In an illustrative arrangement which is not deemed limiting in any respect, the indicia 136 of disk 32 are formed with a resolution which will provide 660 pulses for each linear inch (25.4mm) of head travel. When printing at a character density of ten characters per inch (25.4mm), 66 reference signals are provided for each 25.4mm of movement representing 66 possible locations for locating nine matrix dot columns. At the density
of ten characters per inch (25.4mm), adjacent matrix dot print columns are separated by 5 intermediate positions and the remaining positions are utilized to establish spacing between the desired printing positions. At ten character per inch (2.5mm per character) then, the reference counter 130 is made to re-set with a modulus of 66. When the disk 32 is rotating in a clockwise direction, the counter input signals on line 146 cause the counter to increment during 66 pulses after which period of time, the counter is reset to re-count to this modulus. When the disk 32 is rotating in a counter clockwise direction, the pulses on line 148 cause the counter to decrement or step down a similar number of counts. Were the system not possessed of flight time and other disturbing non-ideal mechanical characteristic displacements referred to hereinbefore, the desired matrix column printing would occur for example on count 1, 6, and each successive 5 counts up to 65. However, the flight time and the other mechanical delays will in actuality cause the matrix column to be printed at a displaced location intermediate to a dot matrix column at the desired five unit increments.

The compensation circuit means 138, represented by the dashed rectangle in FIGURE 5, senses the occurrence of these characteristics and automatically modifies the accumulated count in the reference counter 130 by increasing or decreasing the count. The count is altered by a number of counts equivalent to the delays encountered, thereby ensuring that a dot assigned to matrix column is actually printed at the predetermined five unit increments. The compensation circuit means includes circuit means for compensating for movement of the head. Flight time engendered displacement is proportional to the speed of the advancing head and this circuit means generates an electrical signal representative of head speed. This circuit means comprises differentiators 150 and 152 and a digital-to-analog converter 154. The pulse signals provided on the lines 146 and 148 are applied to the differentiators 150 and 152. The differentiator outputs comprise pulses of substantially constant width and having a frequency which varies with the rotation rate of the disc 32 and thus with the linear speed of the head 10. These signals are applied
to the converter 154 which provides on an output line 156 a DC analog current signal having an amplitude proportional to the velocity of the head 10 and a polarity representative of the direction of movement of the head. A voltage proportional to this analog current is applied through impedance 157 to a summation point 158 where it is summed with a signal from a digital-to-analog converter 160. The digital input to the converter 160 is provided from a bidirectional binary compensating counter 162. The summation point 158 is coupled to comparators 164 and 168 along with threshold reference voltages $V_{\text{th}}^+$ and $V_{\text{th}}^-$ respectively. As indicated hereinafter, the converter 160 provides a bucking signal via an impedance 163 over a line 165 which causes a null output from the comparators 164 and 168 when its amplitude is equal to that of the output of the converter 154. Outputs from the comparators 164 and 168 are applied to compensating AND gates 170 and 172, respectively. An additional input to the compensating AND gates 170 and 172 is provided in the form of a pulse from the OR gate 174, the inputs to which are derived from the differentiators 150 and 152. The absence of a null at the junction 158 enables the comparator 164 or the comparator 168, depending on polarity. The alternatively enabled AND gates 170 and 172 are pulsed at a rate determined by the frequency of output pulses from the OR gate 174. The frequency of these pulses is proportional to the velocity of the head 10, and they are respectively applied to other increment and decrement terminals of counter 130 where they cause the reference counter 130 to increment or decrement accordingly. In compensating for flight time variations, the reference counter 130 is incremented or decremented by a count which is proportional to the velocity of the head. The incrementing or decrementing will occur during acceleration to maximum velocity or deceleration thereof. However, when the head has attained and is traveling at a constant desired velocity, the incrementing and decrementing is interrupted, since the reference counter 130 now has been stepped sufficiently to compensate for this velocity.

A circuit means is provided for quantizing the velocity and for providing an analog signal for comparison with the analog speed signal of converter 154. The circuit means comprises the binary counter.
162 and the digital-to-analog converter 160. Output pulses of the AND gates 170 and 172 are applied to the counter 162 incrementing or decrementing this counter while the binary output from the counter is applied to the converter 160 which generates a DC analog signal proportional to the quantized value of velocity. This signal is applied by the line 165 to the summing junction 158 for cancelling the output of the converter 154. In operation, the quantizing counter 162 stores a neutral count representing zero velocity of the head 10. This neutral count generates an output from the converter 160 which cancels an equivalent analog output from the converter 154 for the zero velocity condition. As the head 10 accelerates from a stationary position to a maximum velocity, pulses of varying frequency will occur at the output of OR gate 174 and counter stepping pulses will occur either at the output of gate 170 or gate 172. These pulses also increment or decrement both the reference counter 130 and the velocity quantizing counter 162. Stepping of the counter 162 lags slightly behind the output variations of the converter 154 and thus does not inhibit the comparators 164 or 168 until such time as the head 10 attains a constant velocity. When a constant velocity is attained, the output amplitude from the converter 154 stabilizes and the counter 162 establishes a null at the summing junction 158. This null will be maintained until further variations in speed are encountered. When the head decelerates from this constant velocity, the output amplitude from the converter 154 will change, a null will no longer exist at the summing junction 158 and the AND gates 170 or 172 will alternatively cause the counters 130 and 162 to decrement or increment. The counter 162 will follow the variation in output amplitude of the converter 154 until such time as the output of the converter 154 stabilizes. A null will then be re-established at the summing junction 158. At this time, the gates 170 and 172 will be disabled and further incrementing or decrementing of the counter 130 is inhibited. Thus, the count in the reference counter 130 is modified in order to compensate for head movement and, particularly, flight time displacement.

Circuit means are also provided for generating a signal proportional to mechanical error introducing factors occurring in the head
drive systems, such as spring factors. The error is proportional to servo-motor torque. Servo-motor torque is, in turn, proportional to servo-motor exciting current. In FIGURE 5, a source of servo-motor exciting current 173 is provided. A voltage proportional to current is developed across a current sensing impedance 175. This voltage which is proportional to servo-motor current is also proportional to servo-motor torque. The voltage is applied via a summation resistor 176 to the summation point 158. The signal which is characteristic of non-compliance or mechanical errors such as spring wind-up in the system is applied separately to the signal from comparator 160 or it is combined with the velocity signal of the converter 154 and the signal from the converter 160 to offset or cumulate with these signals, depending upon polarity.

As indicated hereinbefore, mechanical cocking of the head can result in a drag and thus a displacement in the printed dot matrix column. Cocking is a characteristic which occurs during acceleration and deceleration and will have a positive or negative sense depending upon the direction of acceleration. A circuit means is provided for generating a signal indicative of the cocking. The voltage at the current sensing impedance 175 is also applied to a comparator 178 which is polarity sensitive and which provides an output with polarity dependent on the direction of acceleration of the printhead 10 and magnitude dependent on the magnitude of that acceleration. This indication is also applied by a summation resistor 180 to the summation point 158, either separately from the signal from the converter 160, or in combination with the speed and compliance signals.

There has thus been described an improved control system for an impact printer wherein means are provided for compensating for dot column displacement in a dot matrix printer caused by errors growing out of mechanical limitations of print element and head movement. Compensation is made for flight time and for other mechanical characteristics including noncompliance (elastic wind-up) in the drive system and mechanical cocking thereby reducing dot misregistration errors in printed material composed of dot matrix characters,
whose appearance is highly sensitive to such errors. This invention is particularly advantageous for use in serial printers which are used for the printing of text material with variable character width or compression.

While there has been described a particular embodiment of the invention, it will be apparent to those skilled in the art that variations can be made thereto without departing from the spirit of the invention and the scope of the appended claims.
The claims defining the invention are as follows:

1. Printer control apparatus adapted for operation with a printer of the serial dot matrix character printing type in which a printing head having selectively actuable matrix printing elements moves along the line to be printed, a sensor provides output pulses indicative of such head movement, and a print control counter responsive to sensor output controls the print line locations where the actuation of printing elements is effected characterized in that the average number of sensor output pulses per character is greater than the number of matrix element positions assigned to make up the average character, and compensating means controlled by the mechanical actuation characteristics of the motion of said printing head along said print line for applying additional pulses to said control counter.

2. Printer control apparatus according to Claim 1 characterized in that said compensating means supplies pulses controlled by the print head velocity along said print line.

3. Printer control apparatus according to Claim 1 characterized in that said compensating means supplies pulses controlled by the print head acceleration along said print line.

4. Printer control apparatus according to Claim 1 characterized in that said print head movement is produced by a motor operating through a drive train and said compensating means supplies pulses corresponding to motor torque.

5. Printer control apparatus according to Claim 1 characterized in that said print head movement is produced by a motor operating through a drive train and said compensating means supplies pulses corresponding to drive train wind-up.

6. Printer control apparatus according to Claim 2 characterized in that said pulses supplied by said compensating means increment the count of said control counter.
7. Printer control apparatus according to Claim 2 characterized in that printing is carried out during movement said printing head during both directions of movement of said printing head along said print line and said pulses supplied by said compensating means increment the content of said control counter during one direction of movement and decrement the content of said control counter during the other direction of movement.

8. Printer control apparatus according to Claim 1 characterized in that said compensating means includes a compensating counter, means for developing an analog signal corresponding to direction and velocity of head movement, means for applying said analog signal to a summing point, first and second compensating gates each having an input connected with a pulse source, means connecting an input of each of said compensating gates with said summing point, a compensating counter, means connecting the outputs of said gates with said control counter and with said compensating counter, means for converting count indications of said compensating counter to analog signals, and means for applying said analog signals to said summing point.

9. Printer control apparatus according to Claim 8 characterized in that head movement is produced by a motor operating through a drive train, and that analog signals corresponding to motor torque are applied to said summing point.

10. Printer control apparatus according to Claim 9 characterized in that analog signals corresponding to drive train wind-up are applied to said summing point.

11. Printer control means according to Claim 10 characterized in that the means for providing analog signals corresponding to drive train wind-up has an operating threshold controlling the delivery of such signals.
12. Printer control apparatus according to any one or more of Claims 8-11 characterized in that the means connecting an input of said compensating gates to said summing point comprises respective operational amplifiers respectively connecting an input of each of said compensating gates with said summing point, each of said operational amplifiers being characterized by a threshold of operation.

13. Printer control apparatus substantially as described with reference to the drawings.

DATED this 11th day of October, 1978

GENERAL ELECTRIC COMPANY,

By Its Patent Attorneys,

ARTHUR S. CAVE & CO.