United States Patent [19]

Naas et al.

[11] **3,838,250**

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[54] **CONTROL FOR A MATRIX PRINTING ASSEMBLY**

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[73] Assignee: **The Singer Company**, New York, N.Y.

[22] Filed: **Jan. 5, 1973**

[21] Appl. No.: **321,177**

[52] **U.S. Cl.** .... **235/61.9 R**, 197/187, 235/61.6 H

[51] **Int. Cl.** **B41j 21/18**

[58] **Field of Search** .... 197/19, 20, 187; 235/61.6 H, 61.9 R

[56] **References Cited**

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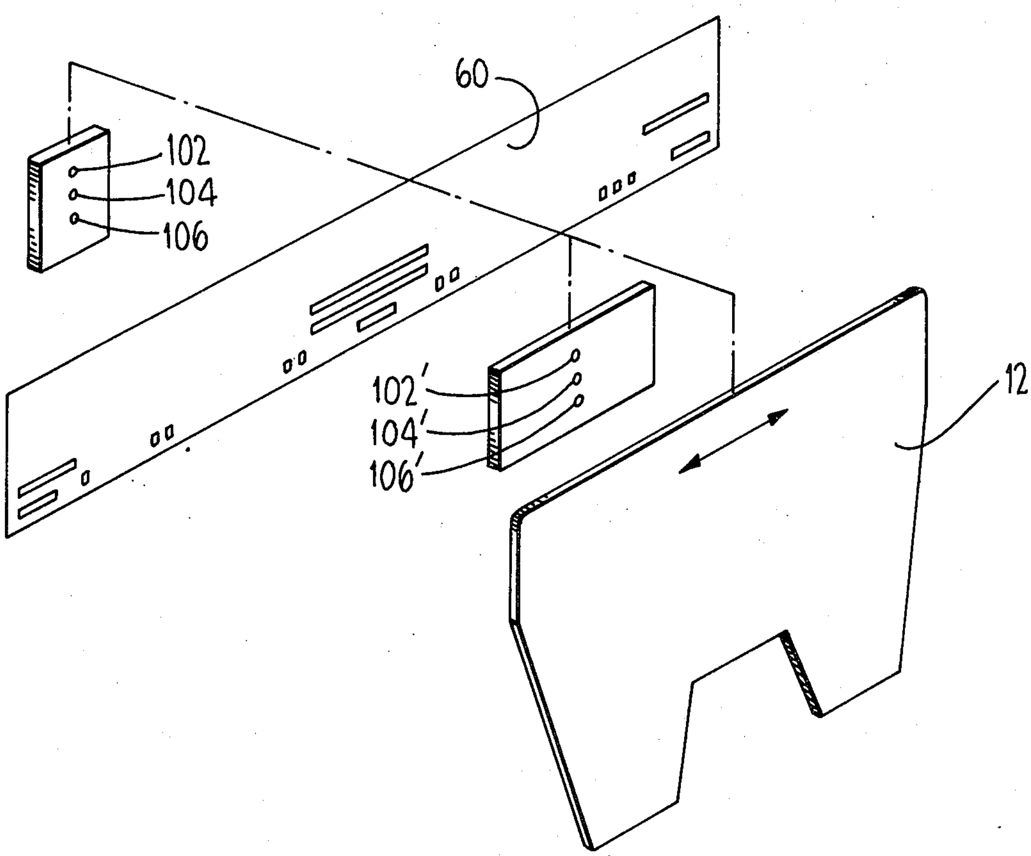
Primary Examiner—Stuart N. Hecker

Attorney, Agent, or Firm—E. L. Bell; J. R. Dwyer; A. W. Kozak

[57] **ABSTRACT**

A control for a matrix printing assembly to determine the character and spacing thereof in a data terminal comprising the combination of a mechanical linear strobe and an electronic timing circuit accurately controlling and positioning the stroke of each rod or stylus of the matrix printer.

15 Claims, 10 Drawing Figures



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SHEET 1 OF 7

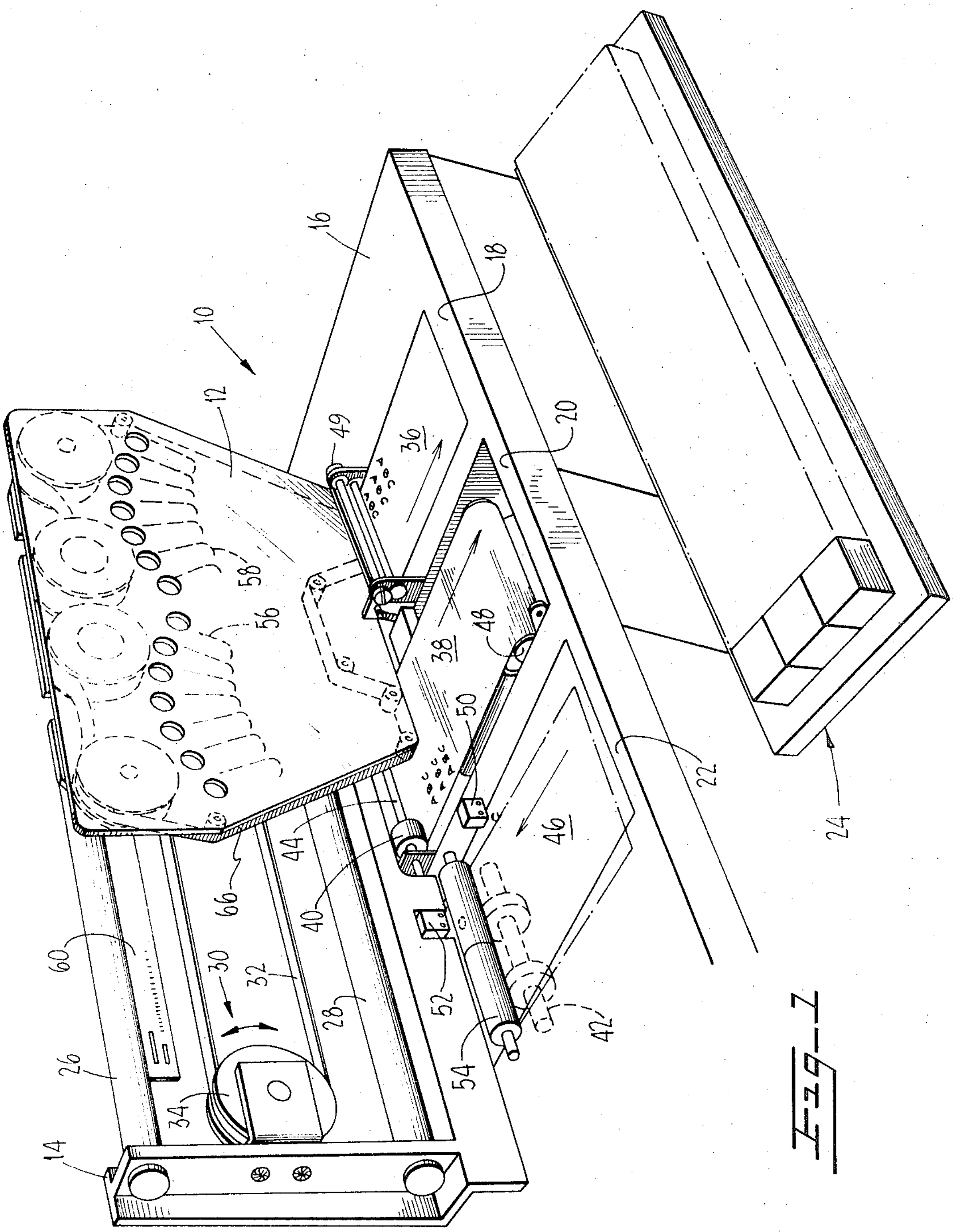


Fig_1

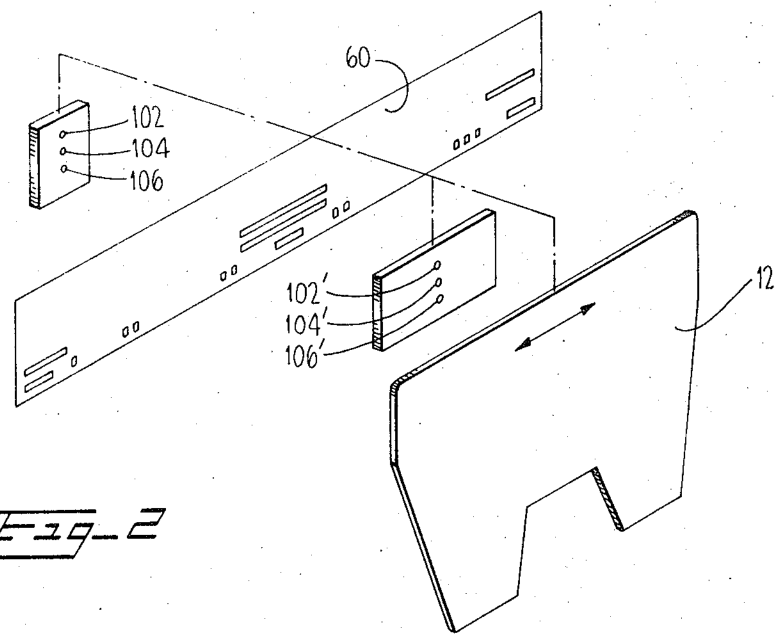


Fig. 2

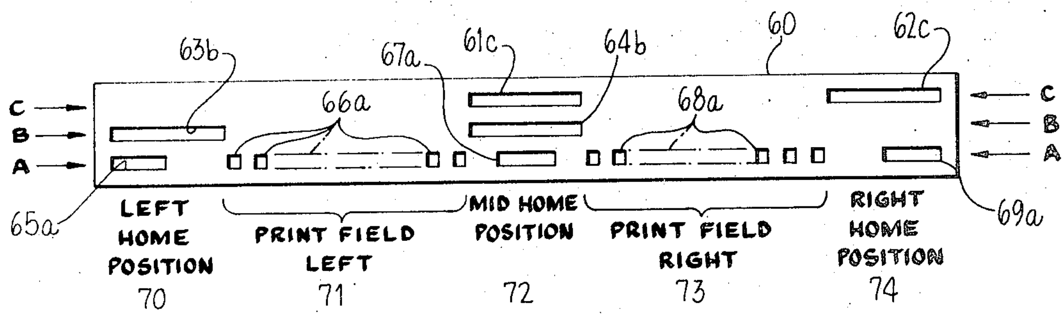


Fig. 3A

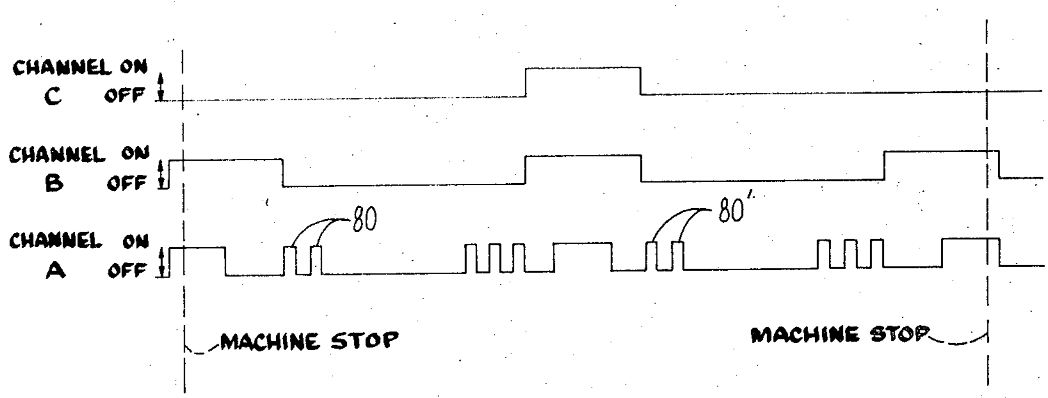


Fig. 3B

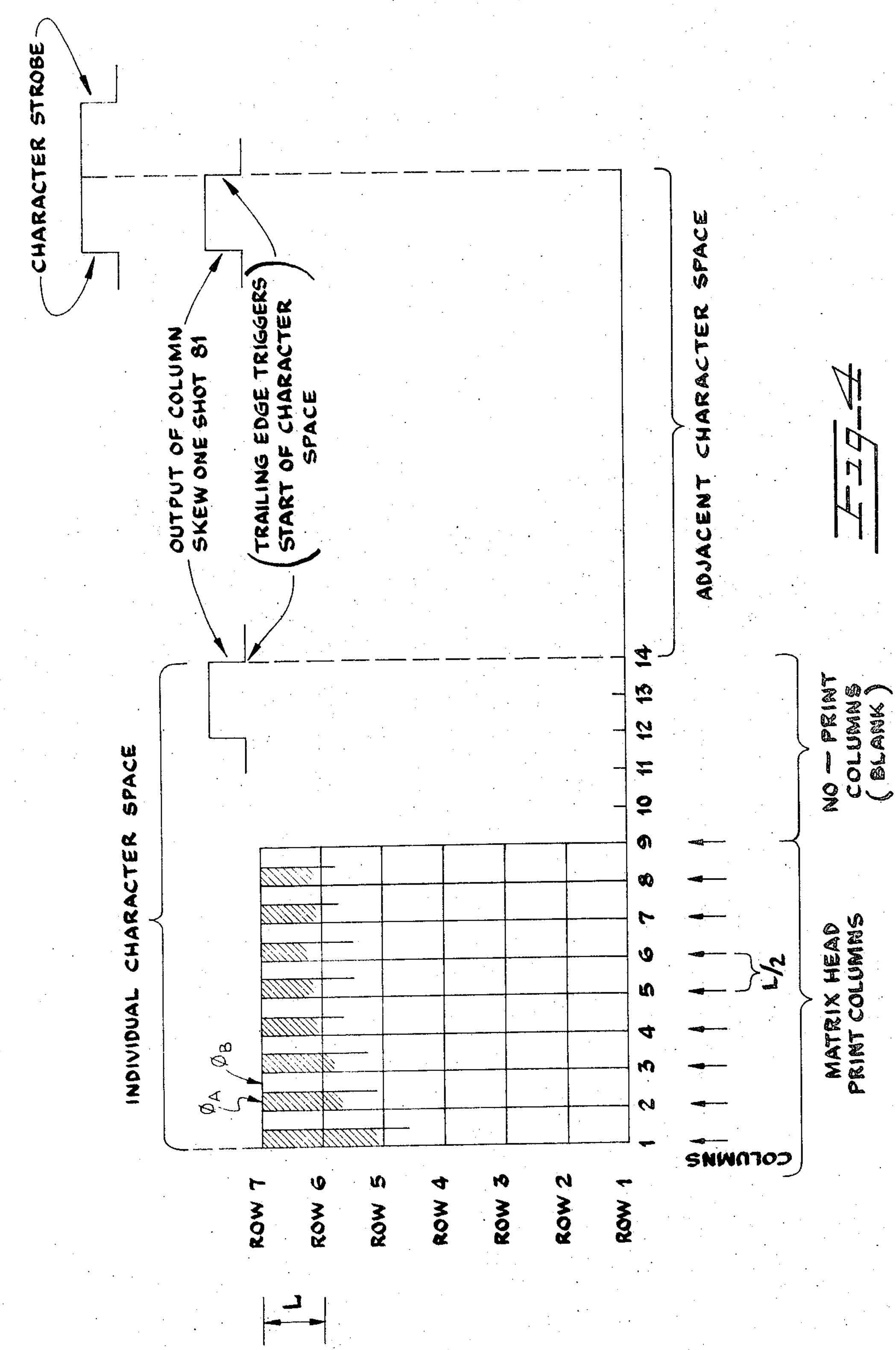
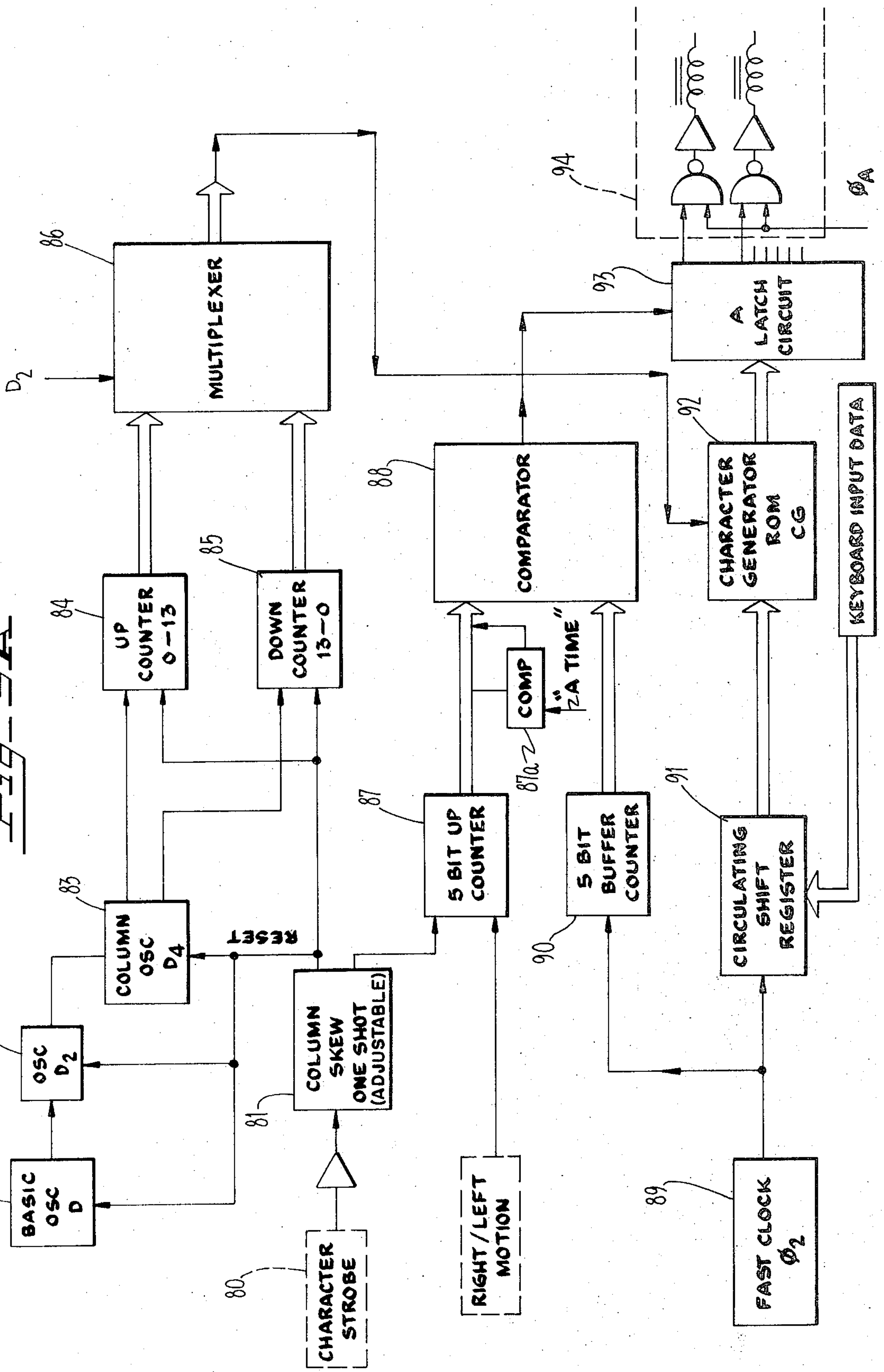

CHARACTER STROBE
OUTPUT OF COLUMN SKEW ONE SHOT 81
(TRAILING EDGE TRIGGERS START OF CHARACTER SPACE)
ADJACENT CHARACTER SPACE
INDIVIDUAL CHARACTER SPACE
ØA
ØB
ROW 7
ROW 6
ROW 5
ROW 4
ROW 3
ROW 2
ROW 1
1 2 3 4 5 6 7 8 9 10 11 12 13 14
COLUMNS
L/2
L
MATRIX HEAD PRINT COLUMNS
NO — PRINT COLUMNS (BLANK)

Fig-4

Fig-5A


MULTIPLEXER
86
D2
UP COUNTER 0-13
84
DOWN COUNTER 13-0
85
COLUMN OSC D4
83
RESET
OSC D2
82'
BASIC OSC D
82
COLUMN SKEW ONE SHOT (ADJUSTABLE)
81
CHARACTER STROBE
80
COMPARATOR
88
COMP
87a
"A TIME"
5 BIT UP COUNTER
87
RIGHT/LEFT MOTION
5 BIT BUFFER COUNTER
90
FAST CLOCK Ø2
89
CIRCULATING SHIFT REGISTER
91
KEYBOARD INPUT DATA
CHARACTER GENERATOR ROM CG
92
A LATCH CIRCUIT
93
94
ØA

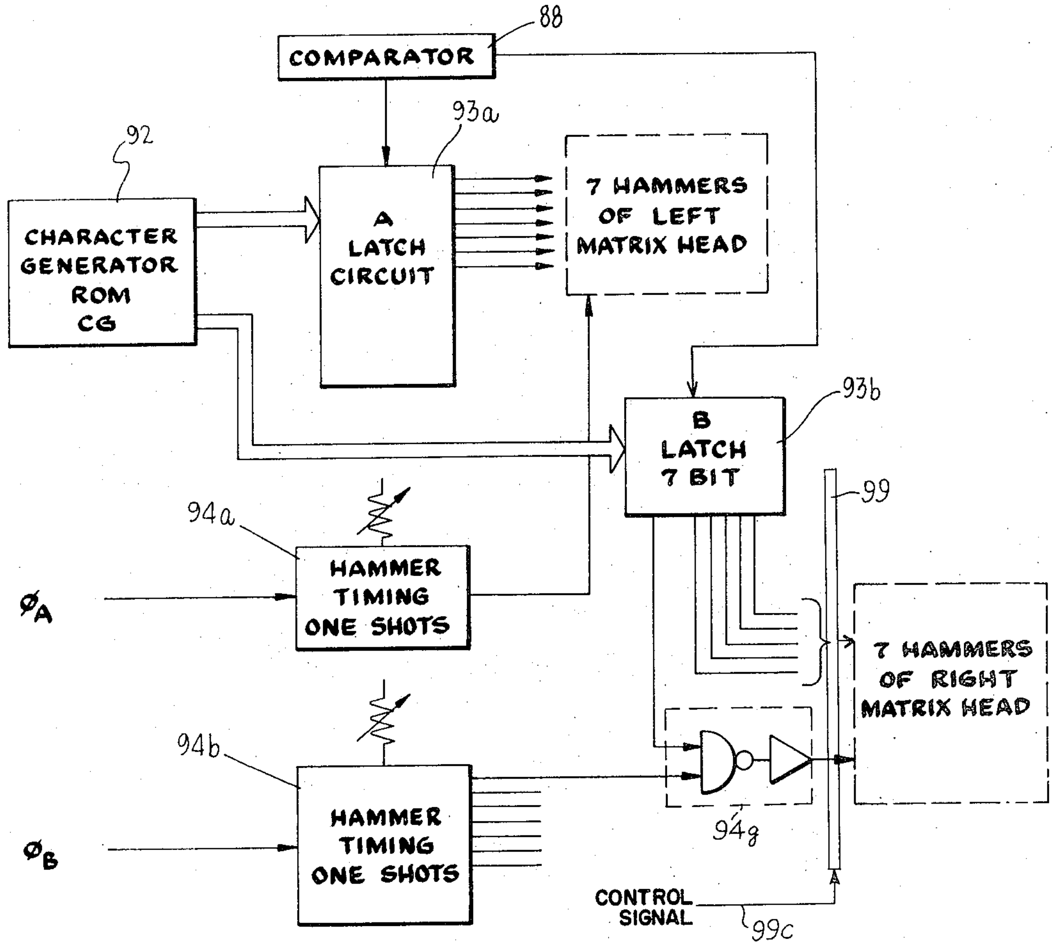

88
COMPARATOR
93a
92
CHARACTER GENERATOR ROM CG
A LATCH CIRCUIT
7 HAMMERS OF LEFT MATRIX HEAD
93b
B LATCH 7 BIT
99
94a
HAMMER TIMING ONE SHOTS
ØA
7 HAMMERS OF RIGHT MATRIX HEAD
94b
HAMMER TIMING ONE SHOTS
ØB
94g
CONTROL SIGNAL
99c

Fig. 5B

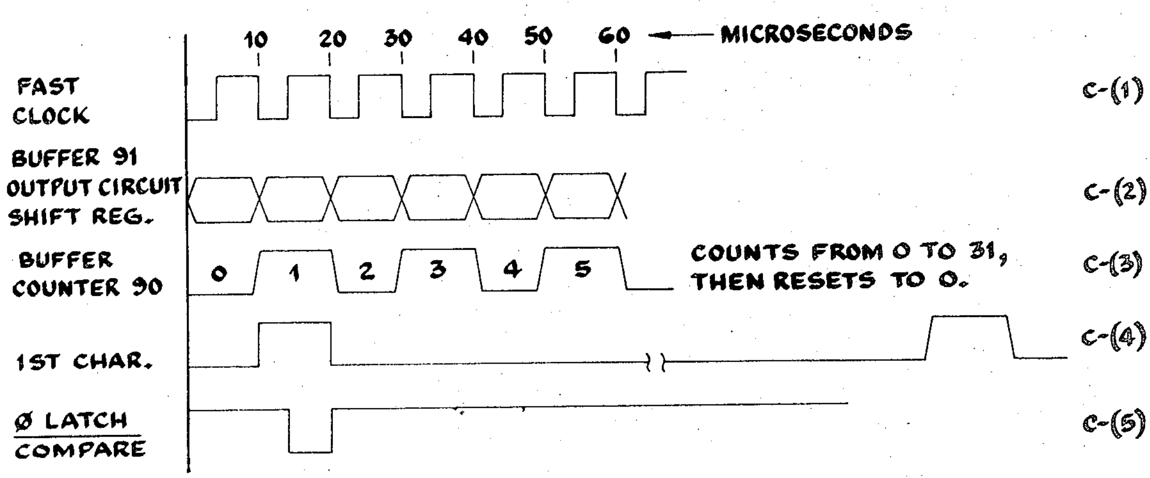

10 20 30 40 50 60 MICROSECONDS
FAST CLOCK
C-(1)
BUFFER 91 OUTPUT CIRCUIT SHIFT REG.
C-(2)
BUFFER COUNTER 90
0 1 2 3 4 5
COUNTS FROM 0 TO 31, THEN RESETS TO 0.
C-(3)
1ST CHAR.
C-(4)
Ø LATCH COMPARE
C-(5)

Fig. 6C

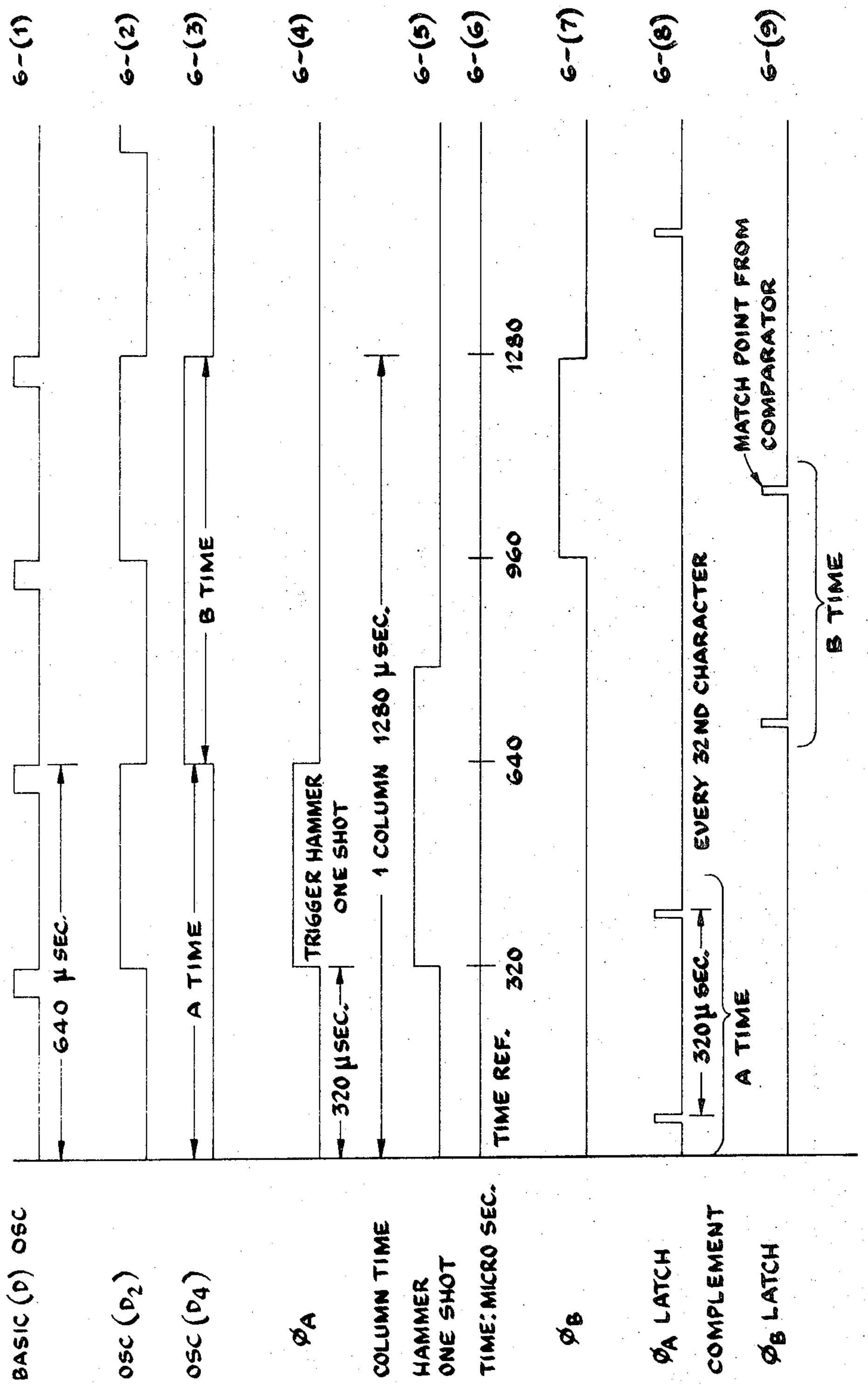

BASIC (D) OSC
OSC (D2)
OSC (D4)
ØA
COLUMN TIME
HAMMER ONE SHOT
TIME: MICRO SEC.
ØB
ØA LATCH
COMPLEMENT
ØB LATCH
6-(1)
6-(2)
6-(3)
6-(4)
6-(5)
6-(6)
6-(7)
6-(8)
6-(9)
640 µ SEC.
A TIME
B TIME
320 µ SEC.
TRIGGER HAMMER ONE SHOT
1 COLUMN 1280 µ SEC.
TIME REF.
320
640
960
1280
320 µ SEC.
A TIME
EVERY 32 ND CHARACTER
B TIME
MATCH POINT FROM COMPARATOR

Fig. 6A

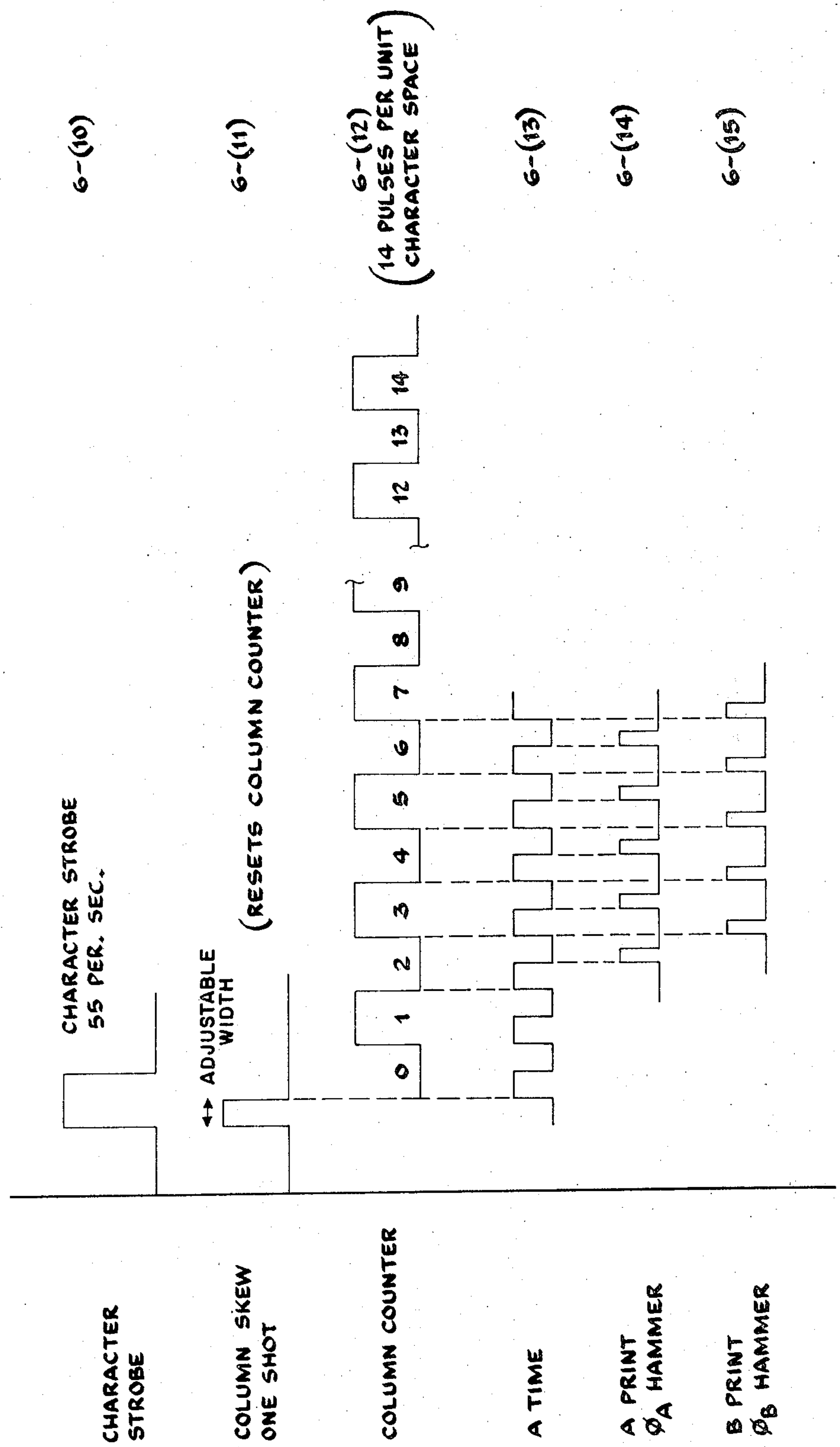

CHARACTER STROBE
COLUMN SKEW ONE SHOT
COLUMN COUNTER
A TIME
A PRINT ØA HAMMER
B PRINT ØB HAMMER
CHARACTER STROBE 55 PER. SEC.
ADJUSTABLE WIDTH
(RESETS COLUMN COUNTER)
0
1
2
3
4
5
6
7
8
9
12
13
14
6-(10)
6-(11)
6-(12)
(14 PULSES PER UNIT CHARACTER SPACE)
6-(13)
6-(14)
6-(15)

Fig. 6B

CONTROL FOR A MATRIX PRINTING ASSEMBLY

CROSS-REFERENCES TO RELATED APPLICATIONS

U.S. application entitled "A data Terminal With Dual Three-Station Printing" of Howard R. Cederberg and Charles W. Wiedeman, filed Jan. 5, 1973 as Ser. No. 321,176; and U.S. application entitled "An Assembly for Spooling an Audit Trail in a Data Terminal" of James G. Savage and Arnold L. Hawkins, filed Jan. 5, 1973, as Ser. No. 321,196.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to the means for positioning and controlling a matrix type printer and is particularly directed to the means of positioning and controlling a matrix printer in data terminals commonly known as electronic cash registers.

2. Description of the Prior Art

Conventional matrix printers have a plurality of wires, each individually moved by a magnetic actuator, usually against a return spring, to impact a record medium to print a character, one wire imprinting one spot or dot of the character at a time. Such matrix printers use either seven or 35 such wires positioned in aligned configuration at the point of impact and are individually and sequentially strobed so as to print the character.

Heretofore, the strobing of each wire, the positioning of the entire character on the media, and the spacing between characters to form lines and columns of printed matter have been effected by electronic circuitry, usually timing devices or counters of some type. Unfortunately, however, experience has shown that reliance upon electronic circuitry, alone, has not been satisfactory and skewing of the printed characters, especially columns of printed matter, has resulted.

SUMMARY OF THE INVENTION

This invention combines the mechanical and electronic aspects of a linear strobe bar and electronic circuitry cooperating in combination to precisely position and print characters on a record media for a point-of-sale data terminal. The linear strobe bar, accurately positioned on the data terminal, contains a plurality of slots of a selected size and location which cooperate with sensing devices movable with the matrix printer of the data terminal so that as the printer moves transverse the recording media, the sensing devices, according to the selected slot and required character, enable the electronic circuitry to strobe the wires of the matrix printers to print the character as required by the input to the data terminal. The circuitry and slots on the mechanical strobe bar are designed to provide a correct spacing of the characters for the appropriate rows and columns to be printed on the record media as the latter's drive incrementally moves the media in the data terminal.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a portion of a data terminal skeletonized and with the cover removed to illustrate the carriage for the matrix printers with the linear strobe bar positioned to position and control the spacing of the characters in rows and columns on the record media;

FIG. **2** is a schematized exploded view of the sensing devices mounted to move with the carriage relative to the linear strobe bar;

FIG. **3A** is a plan view of the strobe bar enlarged as compared to FIG. **2** to show the details thereof;

FIG. **3B** is a timing diagram for each of the light sensors in relation to the linear strobe bar channels;

FIG. **4** is a schematic spacing and timing sketch illustrating the 9 × 7 printing matrix and nonprint space.

FIGS. **5A** and **5B** are simplified block diagrams of the electronic circuitry which coordinates with the linear strobe bar and enables the printout on paper media regardless of direction of carriage motion.

FIGS. **6A**, **6B**, and **6C** illustrate various logic and timing functions of the system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. **1**, the data terminal **10** (with cover removed for purposes of clarity) is shown as comprising, overall, a carriage **12** movable laterally with respect to a frame **14**, a work level surface **16** having three print stations **18**, **20** and **22**, and an appropriate keyboard **24**. The three print stations **18**, **20** and **22** are, respectively, a receipt station where the customer's receipt is printed (if a receipt is required), an audit station where the storekeeper's record (audit trail) of all transactions are printed, and a form station where the customer's order form or bill of sale is printed, if required.

By this arrangement, the carriage **12**, will move, not only from the printing position shown, viz., at the audit station and receipt station, but to the form station and audit station as well as traversing each pair of stations so that appropriate rows and columns of data entered into the data terminal at the keyboard **24** is appropriately printed out. The carriage **12** is mounted on a pair of bars **26** and **28** to hold the carriage in parallel relationship with the platen **16** and the rest of the data terminal and transverse movement on the parallel bars is accomplished by a suitable drive mechanism **30** including a belt **32**, attached to carriage **12**, and pulley means **34** motivated by a reversible motor (not shown).

In the embodiment shown, a receipt **36**, if required, is printed in the receipt station **18** and an audit trail **38** is printed in the audit station **20** when the carriage **12** is in the position shown as the two record media (paper) are moved forward, i.e., in thhe direction of the keyboard **24**, and forms a suitable supply, such as a roll of paper, by a suitable roller feed mechanism **40** driven by a motor and clutch means **42** coupled to shaft **44**. When the carriage **12** is positioned to the left from that shown, a form **46**, such as a customer order form or bill of sale, is printed in station **22** at the same time the audit trail **38** is being printed.

The audit trail **38** is rolled onto a spool **48** partially shown in FIG. **1**, while the receipt **36** is severed, when a complete transaction is recorded, by a suitable cutting mechanism, indicated in its entirety as **49**. Also, the forms station is provided with a pair of electronic sensing means **50** and **52** which determine when a form **46** is properly located in the forms station, otherwise the terminal is inhibited from operating; suitable electronics being provided for this purpose. Rollers **54** feed the form in a direction opposite from the direction of travel of the audit trail by suitable gearing to couple the rollers to shaft **42** which moves the form and audit trail or audit trail and receipt, or an audit trail alone, as the case may be, incrementally, in response to and in combination with printing mechanisms to form rows and columns of data as determined by the input to the keyboard **24**.

The carriage **12** is also provided with a pair of matrix printers **56** and **58** capable of printing on two of the three stations at the same time, viz., the receipt station and the audit station, or (when the carriage is positioned to the left from that shown) on the form station and audit station.

Suitable ink supply means for the dual matrix printer are located in the carriage and are shown in FIG. **1** only schematically, since the ribbon, its novel inking supply arrangement and other details to improve the operation of the matrix printers and data terminals generally are described and claimed in a copending application. It should be remembered that the matrix printers **56** and **58** are capable of printing an audit trail and a receipt, an audit trail alone or on a form, an audit trail depending upon the mode determined in the keyboard **24.** The proper positioning and printing of the characters in rows and columns is dependent upon the combination of a mechanical strobe means **60** and electronic circuitry which cooperates therewith and it is this combination that will be described in detail hereinafter.

It should be noted at this time, however, that one of the many advantages of matrix printers in the data terminal is the ability to print legibly through several copies of forms in the form station and, also, by suitable electronics described and claimed in the this application, supra, the printing on the receipt is upside down relative to the printing on the audit trail and form. This upside down printing on the receipt enables the complete transaction, such as a sale, to be recorded and totaled in the manner in which any transaction is normally read, i.e., top to bottom, for the benefit of the customer. This is also true of the form printed at the form station since the form moves in a direction opposite to the direction of travel of the receipt. This is not true, however, for the printing on the audit trail, which is stored in the machine to be used by the vendor.

As will be seen in FIG. **1,** the mechanical positioning means in the embodiment shown is the linear strobe mask or bar **60** which is affixed to the frame **14** of the data terminal **10** and is further illustrated in FIG. **3**A in a much enlarged form over that shown in FIG. **1** for purposes of clarity. The linear strobe **60** comprises a relatively thin, long, flat plate containing a plurality of apertures for slots through which sensing device such as phototransistors, LED's (light emitting diodes) or the like are provided to detect the absence or presence of a slot or aperture as the carriage **12** moves back and forth across the carriage bars carrying the sensing device along with it.

Referring to FIG. **3**A, it will be seen that the linear strobe bar **60** is made of three horizontal areas or channels of slots or apertures. The topmost channel, channel C, has a long slot $\mathbf{61}_c$ at the center and a long slot $\mathbf{62}_c$ at the right. The middle channel, channel B, has long slots $\mathbf{63}_b$ at the left and $\mathbf{64}_b$ at the center. The lowermost channel, channel A, has a slot $\mathbf{65}_a$ at the left, a slot $\mathbf{67}_a$ in the center, and a slot $\mathbf{69}_a$ at the right. Between $\mathbf{65}_a$ and $\mathbf{67}_a$ there is a series of small slots $\mathbf{66}_a$ which comprise **32** equally spaced slots. A similar series of **32** slots which are designated $\mathbf{68}_a$ also appear between the larger slots $\mathbf{67}_a$ and $\mathbf{69}_a$ of channel A.

Referring to FIG. **2,** it will be seen that the carriage **12** carries with it a group of sensing devices **102, 104, 106,** and **102′, 104′,** and **106′** which comprise a group of light emitters and light sensors which are aligned with the channels A, B, and C of the linear strobe bar **60.** As the carriage moves to the left and right along the linear strobe bar **60,** the attached light sensing devices **102, 104, 106** and **102′, 104′,** and **106′** will convey a group of signals depending upon the location of the carriage along the linear strobe bar **60.** Thus, a means has been provided by which the carriage position in relationship to the linear strobe bar may be determined at any given time.

Certain indexing or HOME positions have been provided and these have been designated as the left-HOME position **70,** the mid-HOME position **72,** and the right-HOME position **74** which are used to provide certain indexing and other information when the dual matrix head carriage is located in one of these three positions.

Between the left and mid HOME positions **70** and **72,** there is a left print field **71** which allows space for the printing of **30** characters or spaces. Likewise, between the mid-HOME position **72** and the right-HOME position **74,** there is provided a print field-right **73** which provides for spaces permitting the printing of **30** characters or spaces.

Referring to FIG. **3**B, which illustrates the resultant effect of the motion of the sensing devices of the carriage as they move across the linear strobe bar **60,** it will be seen that as the light sensors **102** and **102′** traverse the linear strobe **60** from left to right, then channel C will show that there is no positive or photosensitive output on channel C except for the area of the mid position and the area of the right HOME position **72** and **74.**

Likewise, referring to the situation in regard to channel B where the sensing emitters and sensors **104** and **104′** traverse this channel, it will be seen from FIG. **3**B that channel B is in the "On" or photosensitive position at the left-HOME position **70,** after which it turns off until it reaches the mid-HOME position **72** and again turns off and remains in a normal "Off" position.

In regard to channel A of the linear strobe bar **60** which is scanned by sensing emitters and receivers **106** and **106′**, it will be seen that the light sensing devices are "On" for a portion of the left-HOME position after which they are turned off until they are again turned "On" at a portion of the mid-HOME position **72** and then remain off until they are again turned "On" at the portion of the strobe bar at the right-HOME position **74.**

As a result of the combination of these events of carriage motion in relationship to the linear probe bar **60,** it will be seen that certain definitions can be made from the condition of the light sensing devices, namely, that of the "left HOME" being defined as channel A on, channel B on, and channel, C "off;" the mid-HOME can be defined as all channels A and B and C, being "on;" and the right-HOME can be defined as channel A on, channel C on, and channel B off; further, the print field can be designated as the situation where both channel B is off and channel C is off, while the strobe slots $\mathbf{66}_a$ or $\mathbf{68}_a$ provide strobe "on" pulses as the carriage and sensors move transversely.

As will be seen in FIG. 3B in regard to channel A, the 32 small slots 66_a (print field 71) or the 32 slots of 68_a (print field 73) will cause a series of sharp on/off pulses to occur along specified portions of channel A. These pulses are called "character strobe" pulses and provide as follows:
when channel B is off and channel C is off, but channel A comes "On," then there occurs the initiation of a space and time period which will permit the printing of an individual character, as will later be seen in connection with FIG. 4.

Thus, there has been provided a dual matrix head assembly mounted on a carriage positioned to move left and right across the face of a linear strobe bar. Light sensing means attached to the carriage and working in conjunction with the slots and apertures provided in the linear strobe bar provide sensing signals which tell the electronic circuitry the position of the carriage the areas in which the carriage may stop, and the time and space positions in which it is permissible to print data on the printout paper media.

In order to better understand the requirements of the electronic circuitry in relationship to the printing mechanism, it should be understood that each of the dual matrix heads are composed of seven wire rods or styli which can be actuated electromagnetically by means of output signals from a latch circuit 93 (FIG. 5).

The arrangement of the printable character head is such as that may be described as a nine by seven (9 × 7) matrix. As will be seen in FIG. 4, there is shown a matrix arrangement whereby there is pictured seven rows, each of which are spaced or separated by a distance L. Further, the matrix then further consists of nine columns which are separated by spaces equal to L/2; thus, there is provided a matrix of seven rows each separated by a space L and a series of nine columns, each separated by a space L/2 so as to provide the capability of the matrix dot printer which is programmed to print numerals and/or letters and having the capability of simulating curved areas.

Referring to FIG. 4, the space allowable for a single individual character comprises 14 columns of which the first 9 columns are used for printing the wire matrix heads while the remaining 5 columns constitute a no-print area to provide spacing between individual characters.

The strobe pulses derived from the slots 66_a or 68_a (of FIG. 3A) are used to electronically define the start and finish of each individual "character space." The trailing edge of the strobe pulse (FIG. 4) is used to signal the end of one character space and the beginning of the next character space.

As will be discussed later, two alternate timing signals ϕ_A and ϕ_B (FIG. 4) are used to alternately "enable" the activation of the first matrix head printer group and the second matrix head printer group during each individual column count of the first nine (print) columns.

Thus, there is the requirement for information to be delivered to the seven wires of each of the two matrix heads as to whether or not they should activate to imprint a dot pattern or not at any given position of the nine columns involved. Further, since there are nine sequentially printed columns involved in the format of a given character, it is necessary for the system to keep track of and know at any given moment in time exactly which column of a given character matrix is available for printing and which of the seven-wire matrix heads are to be activated for that particular one column of the nine columns that constitute the character matrix.

As was previously discussed in FIG. 3A, the left print field 71 and the right field 73 of sections of the linear strobe bar 60 are provided with thirty-two slots or apertures, each for purposes of locating the spaces and columns under which the printing of each individual character will take place on one or more of the record media. As was heretofore indicated, attempts to print columns of characters utilizing electronic circuitry alone for locating and columnizing the print characters has often resulted in skewed columns, especially on long tape runs. The present solution to the problem of skewed columns is considered to be a major improvement as provided for by this particular invention. Further, the problem of useless or wasted carriage return time has now been eliminated so that carriage motion in either direction is always utilized for printing.

In regard to the combination of the mechanical locating mask (linear strobe bar 60) and the inter-relating electronic circuitry to operate the matrix print heads, the 32 slots of the slot sets 66_a and 68_a precisely locate the columns into which any given character is to be printed, since the print heads will not be free to print unless the conditions of FIG. 3B are fulfilled such that the sensing devices of channel C are off, those of channel B are off, but those of channel A are being strobed by the 32 slots of print field 71 and/or print field 73. Thus, the 32 slots or apertures of the two print fields provide a set of precisely located positions which can be sensed by the electronic circuitry, in regard to when and where it is permissible to print a given character on the printout tape, should such a character be waiting in memory for printout.

A reversible motor moves the carriage and the matrix printer heads back and forth transverse the record or printout media, such as the audit trail and the receipt form as shown in FIG. 1. As the carriage so moves, the sensing devices, of course, move from their HOME slots.

As shown in FIG. 2, the sensing devices and the carriage 12 are aligned on the mid-HOME area. Depending upon the direction of travel, the carriage and sensing devices will move either from the center mid-HOME toward the right or toward the left, and the carriage will move until it comes to either the right HOME area or the left HOME area at which time the carriage will stop. Should there be more characters of data to be printed, of course the reversible motor and carriage will again move to traverse the printing media in order to printout the necessary information until such time as there is no more character information to be processed for printing.

As was previously described in connection with FIGS. 3A and 3B, as the carriage leaves the HOME slot areas, the absence of a signal in the sensing devices of channel C and channel B and channel A indicates the beginning of the print field, such as 71 or 73. As the carriage with its light sensing means continues to move past the linear strobe bar 60, the uncovering of the first slot of 66_a then causes the light sensing signal (known as the character strobe examples of which are shown in FIG. 3B as occurring in channel A) to initiate a series of short pulses, at 80 and 80'.

When the light sensors 106 and 106' (FIG. 2) are sensitized by the first slot (print field) of the set 66_a, this initiates a "character strobe" as shown as element **80** in FIG. 5 (and also FIG. 3B). Referring to FIG. 5A, the character strobe **80** is amplified and used to activate a column skew one-shot multivibrator **81** which multivibrator has a pulse width of a selectable nature that is normally made to be about one-half the width of the character strobe pulse width. The column skew one-shot **81** performs the function of positioning the character to be printed in coordination with the timing of the remainder of the circuitry regardless of which direction the print carriage is moving, that is to say, regardless of which edge of the particular slot is being uncovered; for example, the right edge of the slot 66_a, 68_a or the left edge.

In FIG. 5A, a "basic oscillator" **82** (D) is frequency-divided in half by Oscillator **82'** (D_2) and again frequency divided to one-fourth the frequency by Column Oscillator **83** (D_4). Thus, Column Oscillator **83** may be used to pulse Up Counter **84** and Down Counter **85** at a counting rate of 770 columns per second. The Up Counter **84** counts the character space columns **1–14** of FIG. **4** using the digital numbers 0 to 13. The Down Counter counts in reverse from columns **14** to **1** (again using digital numbers 13–0).

The pulse of the one-shot multivibrator **81** resets the oscillator (D_2) designated element **82'**, and also resets the column oscillator (D_4) **83**, the column oscillator **83** having a pulse width equal (FIG. 6A) to twice the pulse width of the oscillator **82'** (or one-half the frequency).

The output of the column oscillator **83** is connected to an up-counter **84** and down-counter **85.** Elements **84** and **85** are counters having two four-bit column counters. The up-counter **84** and the down-counter **85** provide the function of counting the columns within a given character to be printed, but from different directions in order to permit printing to occur during carriage motion in either direction, that is, right to left, or left to right.

The outputs of the up and down counters are fed to a multiplexer **86** which outputs a signal indicative of the nine columns of print which go to make up any individual character. As seen in FIG. 5A, the multiplexer **86** receives input pulses from oscillator **82'** (D_2). This may be called the "A time" and may be set at 1,540 pulses per second. Thus, multiplexer **86** is made to provide an output of the "up-count" alternated with an output of the "down count."

The column skew one-shot multivibrator **81** also has an output which is conveyed to a print-head position up counter **87** which carries five-bits of information. The five-bit output of this counter **87** corresponds to the position information of the **32** character slots of the left and right print field **71** and **73**: The "up counter," **87** corresponds to the print head and carriage motion moving from left to right. A complementing circuit 87_a alternately provides reverse character position counts which correspond to the motion of the carriage and print head from right to left. The output of the counter **87** which provides information as to print-head position for each of the **32** character spaces is conveyed to a comparator **88.** The comparator **88** is keyed to the "A time" (D_2) **82'** so that it can alternately compare print head position counts in the "up" (left-right) direction and in the "down" (right-left) direction.

Simultaneous with these other units of information being provided to the comparator **88** and the multiplexer **86,** a fast clock oscillator **89** (having approximately 32 times the speed of the oscillator **82'**) provides an output conveyed to a buffer counter **90.** The buffer counter **90** is a five-bit (up) counter, and its output tells the sequence position of the particular character residing at the output end of the circulating shift register **91.**

It will be seen that the comparator **88** receives print-head position count information, and at the same time the comparator **88** receives from the buffer counter **90,** the count position location of characters in memory to be printed. The comparator **88** thus compares the transverse position of the print head with the buffer counter **90** information count which is representative of a particular character and its character space position count.

Concurrently, the oscillatory output of the fast clock oscillator **89** is used to operate a character buffer circulating shift register **91** which consists of a dynamic shift register having an output to a character generator read-only memory **92.** The character generator read-only memory **92** has another input taken from the multiplexer **86** which is indicative of the column position information of a given character to be printed. Thus, when there is a correlation and a "compare" between a character count in the circulating shift register **91** and the correct column count of a character (as indicated by the output of the multiplexer **86**) then the output of the character generator **92** is dumped into the latch circuit **93.**

Referring to FIG. 5B, the remainder of the electronic control circuitry is shown in more detailed form. The latch circuit **93** of FIG. 5A is in reality composed of two latch circuits: an A latch 93_a and B latch 93_b as shown in FIG. 5B.

Referring again to FIG. 5B, it will be seen that the comparator **88** has an output line to the A latch 93_a and to the B latch 93_b. Further, the character generator ROM **92** has an output set of seven lines to the A latch 93_a and to the B latch 93_b.

The output of the A latch 93_a is used to empower the seven hammers of the left matrix head while the output lines of the B latch 93_b comprise a series of lines which go to drive the seven hammers of the right matrix head.

Circuit 94_g (NAND gate and solenoid driver circuit) is shown connected to one output line of B Latch 93_b and also connected to one line of Hammer Timing One-Shot Circuit 94_b. This is exemplary in the drawing to indicate that each of the output lines of A Latch 93_a and B Latch 93_b are similarly provided with such gate circuits as exemplified by 94_g.

Since the right matrix printhead (**58** of FIG. **1**) is required to print on two separate stations (stations **18** and **20** of FIG. **1**) in an 180° inverted printout, the output lines of B Latch 93_b are passed through an inverting circuit **99** (FIG. 5B) which inverts the order of the printhead driving signals from their normal order so that the right printhead **58,** when positioned over station **18** (receipt station) will print its character data in an "upside down" orientation as seen in FIG. **1** on record medium **36.** The inverter **99** is only active when a control signal line 99_c (activated by the right print field apertures 68_a of strobe bar **60** and carriage location signals from strobe bar **60**) indicates that head **58** is printing on record medium **36.**

As seen in FIG. 5A, there was provided enabling circuitry **94** in order to control the operation of the matrix print heads. This system is shown in more detail in FIG. 5B wherein there is provided a group of hammer timing one-shots 94_a which are used to phase the firing of the hammers of the left matrix head; and there is also provided another group of hammer timing one-shots 94_b which are used to phase the timing of the hammer driving for the right matrix head.

As will be subsequently shown in the timing diagrams, the firing of the left print head and the right print head is done on alternate cycles even though they appear to be printing simultaneously due to the high rate of printing.

FIGS. **6A**, **6B**, and **6C** are timing drawings illustrative of various timing cycles used by the electronic control circuitry of the printing system. These timing diagrams may be understood more completely by concurrent reference to the drawings and description of FIGS. 5A and 5B to which they also refer.

Referring to FIG. **6A**, at line **6-1**, there will be seen the basic oscillator (D) pulses which correspond to element **82** of FIG. 5A.

Line **6-2** shows the timing cycles involved in oscillator **82'** (D_2) wherein the pulse frequency is divided in half in that oscillator D_2 provides only one output pulse during the time that the basic oscillator (D) is providing two output pulses.

Line **6-3** shows the timing cycle provided by oscillator **83** (D_4) which further subdivide its on/off pulses into longer time periods. These time periods constitute "A Time" where the logic output is "zero" or false, and a "B Time" where the logic output is "one" or true.

Line **6-4** shows the "On" time in this cycle that it is possible to trigger the hammer-one-shot for the hammers of the left print head. Similarly line **6-7** shows the phase B trigger hammer one-shot "On" time which can be used to trigger the print heads of the right print head.

Line **6-5** shows the time available for firing the hammers of the left print head through the enabling circuitry **94.**

Line **6-6** shows basic reference timing markings in microseconds to give some idea of the relative times involved.

Line **6-8** shows how a "match" can occur during the "A Time" in order to cause a printout of the left print head; and likewise, line **6-9** shows how a "match" from the comparator may occur in order to print out information through the right-hand print head during "B time."

Just below line **6-4** there is shown a time designation indicating that one column of the character printing space has a time equivalent of 1,280 microseconds and this is plotted on the timing diagram in order to show relative occurrence times.

The basic oscillator (D) shown at line **6-1** is shown to have a single cycle time of 320 microseconds while the oscillator D_2 has a cycle time of 640 microseconds. The oscillator (D_4) (at line **6-3**) has a cycle time of 1,280 microseconds and is the equivalent time for one column time. Thus, the time period for "one column" has been split into "A Time" and a "B Time" as shown at line **6-3** which also correlates with the drawing of FIG. **4** where there is shown a phase A time and a phase B time. Since the fast clock **89** runs at least **32** times greater than the basic oscillator D, or **64** times greater than the "A Time" rate, then during the course of any one particular column print time, all 32 character spaces in memory (circulating shift register **91**) are scanned for their position and compared in the comparator **88** so that there will be at least two "matches" occurring every 320 microseconds which is one-half of the A time available for printing on the left matrix print head. Likewise, there are at least 32 character spaces in circulating register **91** which are scanned with the possibility of at least two "matches" occurring during the "B Time" or printout time for the right matrix print head.

Referring to FIG. **6B**, there is shown a series of timing diagrams indicating relative relationships between the character strobe pulses and other timing functions. In FIG. **6B**, line **6-10**, there is seen a character strobe pulse occurring (which is normally set at **55** pulses per second). Line **6-11** shows the column skew one-shot **81** (as referred to in FIG. 5A), and as seen, the column skew one-shot pulse is approximately half the pulse width of the character strobe pulse but is initiated by the leading edge of the character strobe pulse. Referring to FIG. **6B**, it will be seen in line **6-(10)** that the character strobe pulse, which is derived from a slit (66_a, 68_a of FIG. 3A) in the strobe bar, has a leading edge which triggers the column skew one-shot as seen in line **6-(11)**. The trailing edge of the column skew one-shot pulse, line **6-(11)**, starts the column counter line **6-(12)** so that th matrix printhead may initiate its printout for each column of the character space.

While the carriage is moving in the left to right direction, the character strobe is triggered by the left edge of the slit in the strobe bar. However, if the carriage and printhead are moving in the opposite direction, from right to left, then it is the right-hand edge of the slit of the strobe bar which triggers the character strobe and the column skew one-shot pulse. Now since the slit in the strobe bar is of a finite width, and the left-hand edge of the slit is separated from the right-hand edge of the slit, then therefore it can be seen that the triggering "start" pulse on the left to right motion is going to be different position-wise from the triggering or "start" pulse when the carriage is moving from right to left, since the left edge of the slit and the right edge of the slit in the strobe bar are separated by a gap. The effect of this would normally be to cause characters which were printed in left to right motion to be out of columnar alignment with characters which were printed while the carriage was moving in the other direction, from right to left.

Thus, by providing an adjustment for the column skew one-shot of FIG. **6B** and line **6-(11)** thereof (the adjustment is in the width of the column skew one-shot), this adjustment has the effect of compensating for the print solenoid lag time, the flight time of the wire styli, and the width of the strobe bar slit, so that when the character printout is made in the left to right direction and then made in the right to left direction, a visual comparison can be made to see how well the characters in each line fall one under the other. Thus, the adjustment of the width of the column skew one-shot pulse width can be done by visually watching the printout columnar alignment as the printing occurs in both directions.

As was seen in FIG. 5A, the output of the column skew one shot is used to reset the basic oscillator D, the oscillator D_2, the oscillator D_4, and also the up and down counters **84** and **85.** Further, as was indicated in FIG. **4,** the trailing edge of the output pulse of the Column skew one-shot **81** triggers the start of a character space. Also, the trailing edge of the pulse of the column skew one-shot resets and restarts the basic oscillator D which is used to pulse the column counters **84** and **85.** Referring to line **6-12,** the start of the basic oscillator (D) triggers the column counters **84** and **85** into pulses which are shown having numbered spaces between them. These numbered spaces between the **14** pulses are the timing features which define the total character space for the printout and spacing of each individual character, and also define each of the nine "print" and five "no print" columns of the character space shown in FIG. **4.**

Line **6-13** of FIG. **6**B shows the "A Time" timing pulses which have half the pulse-width but double the frequency of the pulses from the column counter shown in line **6-12.** The "on" portions of the "A Time" pulses are one-half the pulse width of the column counter pulse width. The trailing edges of the "A Time" pulses trigger the phase A pulses of line **6-14** for enabling the firing of the left print head; the leading edges of the "A Time" pulses trigger the phase B pulses of line **6-15** to enable the firing of hammers in the right print head.

Lines **6-14** and **6-15** show the print hammer pulses in timing sequence for the A print hammer and the B print hammer (left and right print head hammers) which are shown to operate alternately in slightly different phases. The printer of this embodiment uses a carriage having dual printheads, a left printhead and a right printhead (as one faces the front of the keyboard of the terminal). A unique problem arises here in that, as seen in FIG. **1,** the left printhead will always be arranged to write or print its characters in the printout orientation as shown on the paper record **38** of the audit trail station **20.** This means that a person facing the front keyboard can directly read the characters since they are in the proper orientation for one facing the front of the machine. The last 20 lines of the transaction are visible to the operator on the audit trail.

However, on the receipt station **18,** and the record paper **36,** it will be seen that the orientation of the character printout is reversed and inverted. The result is to produce a receipt oriented in standard accounting form (top to bottom) for the customer's receipt.

The dual type printhead carriage **12** operates to cover and to print out on any two of the three printout stations. When the carriage **12** is in the position shown in FIG. **1,** then the left-hand printhead **56** will be printing with its orientation for a person standing in front of the machine, and the right-hand printhead **58** will be printing in the reverse inverted orientation.

Now, when the dual printhead carriage is moved to the left side of the machine, it will be seen that while the left-hand printhead **56** will still be printing in the "front" orientation for an operator facing the keyboard, however, the right-hand printhead **56** must be in a "reversed" condition from what it had previously been in that it must now also print in the "front" printout orientation for a person facing the keyboard.

Thus, while the left-hand printhead **56** will always print in the same orientation (the "front" orientation), the right-hand printhead **58** must reverse itself when it is printing on the audit station **20.** That is to say, it must reverse and invert its printout from its printout as shown on the receipt station **18** on the paper record **36.**

Thus, the situation involved here is not simply a case where one printhead is simply duplicating the other printhead, but rather is a situation in which the two printheads are separated in space and operate under different conditions and have different output results at certain times.

Station **46,** the forms station, prints in the "front" orientation and the form moves inwardly toward the machine to provide the proper orientation of the printout.

Referring to FIG. **6**C, there is shown another group of timing diagrams relative to the electronic control circuitry of the data terminal printer.

Line C-**1** shows the output pulses of the fast clock **89** which are made to run at least **32** times greater than the basic oscillator frequency D. Line C-**2** shows the output of the circulating shift register or buffer **91** maintaining constant character information reading until the end of each fast clock cycle after which there is an information change, but the character information remains constant during the entirety of the fast clock cycle. This indicates that there is a period of approximately 10 microseconds wherein the character information at the output of circulating shift register **91** is stable and useable.

Line C-**3** of FIG. **6**C shows how the the trailing edge of the fast clock pulses are used to trigger the buffer counter **90** in order to count the character spaces in coordination with the character spaces in the circulating shift register. The buffer counter **90** counts spaces from 0 up to 31, then resets to 0 again.

Line C-**4** shows the entry of the first character into the circulating shift register **91** as being located in the number one position since the position zero is not used but is a (spacing) position.

Line C-**5** of FIG. **6**C indicates that during the time of the first character position, there will be a "match" as a result of the comparator **88** which will set the latch unit **93** for a printout through one of the print heads.

The fast clock **89** pulses the circulating shift register **91** so that, when the printhead is at any given position across the printing line, the circulating shift register pulses more than 32 times during the column dwell time, so that at any given character space-column position, all characters in the circulating shift register are scanned.

Thus, when the comparator **88** detects that a "match" has occurred as between the buffer counter **90,** the 5-bit "up" counter **87** (which counter **87** provides information as to the printhead position for each of the 32 character spaces), then the comparator **88** will trigger the A latch **93** so that the character generator signals from character generator ROM **92** can operate to cause the printhead to print the appropriate dot pattern for the character column.

However, the character generator ROM **92** must be gated by the output of the multiplexer **86** which provides the appropriate character-column-code to the character generator ROM **92** as to which particular orientation of the character to be printed.

Since we have an up-counter **84** and a down-counter **85,** it does not make any difference whether the printhead is moving from left to right or right to left. Since printing can take place in either direction, the "up" counter **84** is used for printhead motion from left to right and the "down" counter **85** is used for printhead motion from right to left.

The multiplexer **86** alternately switches between the up-count and down-count column code in feeding character generator ROM **92** when printing is occurring on both the receipt station and audit station simultaneously. The use of either the up-count or the down-count is determined by the direction of printing motion. The control signal D'_2 to multiplexer **86** selects the appropriate up or down counter code.

The complementing circuit 87_a takes the information of the 5-bit up counter **87** and complements it so as to provide reverse character position counts which correspond to the motion of the carriage and printhead from right to left.

The "up-counter **87**" corresponds to the printhead position where the carriage is moving from left to right while the complementing circuit 87_a provides reverse character position counts of the printhead position corresponding to the motion of the carriage and print head from the right to the left side.

In essence, the subject printer eliminates the need for "carriage return" such that the printer is always printing while moving in the right to left direction or in the left to right direction. There is no loss or wasted time for the action of returning the carriage printhead to an initial or beginning position, as is characteristic of the prior art.

Thus, the conditions for a printout are:

a. that the output character of the circulating shift register have a count--address (provided by buffer counter **90**) which when supplied to the Comparator **88,** matches up with the count of the 5-bit up counter **87.** The "count" of Counter **87** gives the position information of the **32** character spaces of the left and right print fields **71** and **73**;

b. that the given output character of circulating shift register **91** is fed into character generator ROM **92** and generator ROM **92** is supplied (by multiplexer **86**) the appropriate column code of the **14** columns of the character space which is determined by the up-counter **84** or the down-counter **85.**

Thus, herein has been described a data terminal printing unit with electronic control circuitry capable of accurate and positive printing on any one of three separate print stations or alternately on any two of said print stations simultaneously.

The present set of printout stations have been described as a receipt station, an audit-trail station, and a forms station. Any two of these stations may be activated for simultaneous printing during any particular cycle of transaction activity; or if not necessary, the only printout that is needed to take place will take place on the audit trail printout station. Another feature of the present embodiment involves the feature in which the printout on the receipt station is printed out in upside down orientation to the printout at the audit trail and forms station. This is easily accomplished by the use of inversion or complementing circuitry. Concurrently, with this feature of one print station printing upside down to another print station, it should also be noted that the problem of column skewing has been resolved thereby and also no longer occurs.

What is claimed is:

1. In a data terminal printer system providing for printout of characters on a recording medium programmed for a series of character-spaces each of said character-spaces being programmed to consist of m vertical columns of which n columns are used for character printout and (m-n) columns are provided for non-print spacing, the combination comprising:

a. a plurality of printout stations having separate recording media each of which are separately movable;

b. carriage means movable transversely back and forth across said printout stations;

c. first and second dot matrix printheads mounted on said carriage means; said printheads including a plurality of wires for impacting on said recording media;

d. sensing means for determining the location of each of said printheads relative to each of said plurality of printout stations and relative to each column of each unit character-space;

e. means for generating character strobe pulses indicative of character-spaces available for printing on each of said plurality of printout stations;

f. a circulating shift register for storage of character data to be printed, said circulation rate being at least 32 times the rate of said character strobe pulses;

g. means for input of data characters into said circulating shift register;

h. means for providing a real-time count of each character-space located opposite the real-time location of said printhead during printhead motion in either of two directions;

i. first counting means for providing information as to what particular column of a character-space is available for printing by each of said first and second matrix printheads;

j. multiplexing means to alternately provide a count of each character-space column during carriage motion for the left-right direction of motion and for the right-left direction of carriage motion;

k. second counting means for providing character position information from said circulating shift register to said first and second matrix printheads, said position information including data for left-right carriage motion and for right-left carriage motion;

1. comparison means for comparison of the printhead position count of each of said first and second matrix printheads with the count of each character position in said circulating shift register, said comparison being responsive to the appropriate direction of carriage motion;

m. memory translation means for programming a selected character symbol into signals representative of dots in a series of columns; and

n. circuit means, activated by said memory translation means, for empowering selected wires of said printhead as said printhead is positioned at each column of a character-space, said circuit means empowering said first and second printheads in alternate phases.

2. In a data terminal printer system providing for programmed printout of data characters in a group of unit character spaces, each unit character space having 14 vertical columns per character space of which nine columns are used for character printout and five columns are used for non-print spacing, the combination comprising:

a. a plurality of printout stations having movable recording media;
b. carriage means movable transversely back and forth across said printout stations;
c. first and second wire matrix printheads mounted on said carriage means;
d. indicia means for programming the location of character-spaces available for printing on each recording media for each printout station;
e. sensing means for determining the carriage and printhead position relative to each of said character spaces available for printing;
f. means for input of data characters in a memory device;
g. means for addressing each of the data characters in said memory device; and
h. means for matching the programmed character space positions with the appropriate data character address positions in said memory device during transverse motion of the printheads in either direction in order to trigger the first and second printheads into a printout of the proper character in the proper character space on the preselected printout stations desired.

3. The printer system of claim **2** including means for the alternate triggering of the first and second printheads for printout during the period of any given column count which was started by the character position strobe derived from said indicia means.

4. The printer system of claim **2** including means for vertical columnar alignment of characters printed on one line of recording media with characters printed out on other lines of recording media.

5. The printer system of claim **2** including means for adjusting the time between the initiation of a character strobe pulse, which locates an available character space on the recording media, and the initiation of a series of column count pulses, which pulses permit character imprintation dots to be printed by said printheads.

6. In a printing device in which the printed characters are formed of differential combinations of the dots of a matrix of dots arranged in sequential columns, the combination comprising:
a. a plurality of printout stations each having separately movable recording media;
b. carriage means movable transversely back and forth across each of said print-out stations;
c. first and second wire matrix printheads mounted on said carriage means and juxtaposed movably across said plurality of printout stations, said printheads being capable of printout while moving from left to right or right to left;
d. means for programming character spaces on said printout stations;
e. sensing means for establishing the printhead positions relative to each programmed character space;
f. means for intake and storage of character input data;
g. means for matching printhead position information with stored character data location information in order to trigger the printout of a stored character at a programmed location on one or more of the recording media of the plurality of printout stations;
h. initiating means for activating said first and second printheads into printout of a sequential series of columns of dots whether said printheads are moving from right to left or left to right.

7. The printing device of claim **6** including timing means for alternately triggering the printout times of the said first and second printheads during each period of column strobing of each character to be printed.

8. The printing device of claim **6** including adjustment means for said initiating means, said adjustment means providing for the vertical columnar alignment of printout characters on one line of the recording media with the printed out characters on succeeding lines of the recording media.

9. The printing device of claim **6** including means for simultaneous printing on two of said plurality of printout stations whereby the printout from said second printhead is selectively controlled to print characters in a front orientation or a reverse orientation.

10. The printing device of claim **6** wherein said sensing means comprises an indicia bar having indicia to indicate end-stop positions for said printhead and to indicate programmed character space positions as being available for printout separately for each of two different positions of said carriage means and including readout means to read said indicia from said indicia bar for conversion to electronic timing signals.

11. In a printing device in which the printed characters are formed of differential combinations of the dots of a matrix of dots arranged in sequential columns the combination comprising:
a. a printout station having movable recording media;
b. carriage means movable transversely back and forth across said printout station;
c. printhead means mounted on said carriage means, and capable of printout during carriage motion back and forth across said print-out station;
d. sensing means for establishing the printhead position relative to each character space programmed as available for printing on said recording media;
e. means for intake and storage of character input data;
f. means for matching printhead position information with stored character data location information for printout of a stored character at a designated location on the recording media, said means for matching being operative for causing character printout during forward or reverse motion of said carriage means.

12. The printing device of claim **11** including means for vertical columnar alignment of the printout of characters on one line of the recording media with the printout of characters on other lines of the same recording media.

13. The printing device of claim **11** wherein said sensing means comprises an indicia bar having selected indicia to indicate end stop positions for said printhead and to indicate character print positions programmed as available for printout on said recording media and including means for initiating the printout of a combination of dots in a column during the time that the printhead means is moving from left to right or is moving from right to left; and including means for adjustment of said initiating means so that the printout of characters on one line of print of said recording media is properly aligned columnarly with the printout of characters on succeeding lines of print of said recording media.

14. The printing device of claim **13** wherein said initiating means includes:

an indicia bar having slitted apertures for programming positions of available character-space positions available for printout along said recording media;

movable light and photodetector sensing means referenced to said printhead position for scanning said slitted apertures and for providing a character strobe pulse;

a column skew one-shot circuit triggered by the leading edge of said character strobe pulse and for providing a column-skew pulse;

column-counting circuitry for strobing the various columns of a character-space, said column-counting circuitry being triggered by the trailing edge of said column-skew pulse.

15. The printing device of claim **14** wherein the column skew one-shot circuit is adjustable in order to regulate the width of the column skew pulse.

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