

[54] **HIGH SPEED DATA PROCESSOR LINE PRINTER**
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[52] U.S. Cl. **101/93.21, 197/127**
[51] Int. Cl. **B41j 1/08**
[58] Field of Search..... **101/93 C, 110; 197/127**

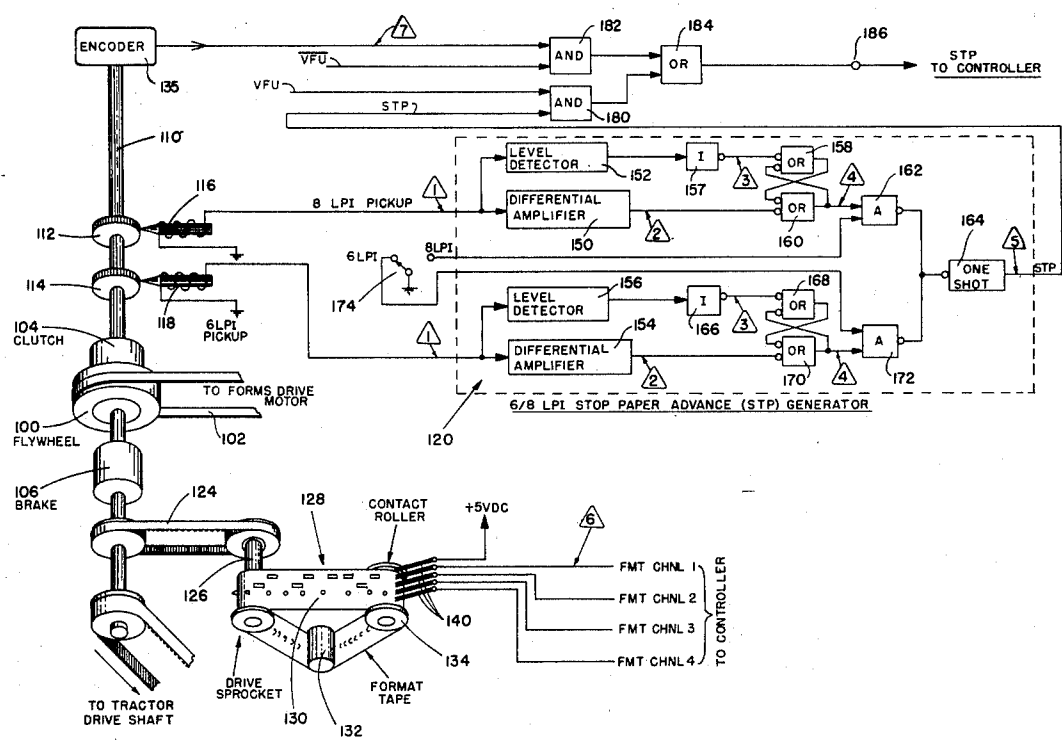
3,739,720 6/1973 Jones et al. 101/93 C
Primary Examiner—Edgar S. Burr
Assistant Examiner—Edward M. Coven
Attorney, Agent, or Firm—Jessup & Beecher

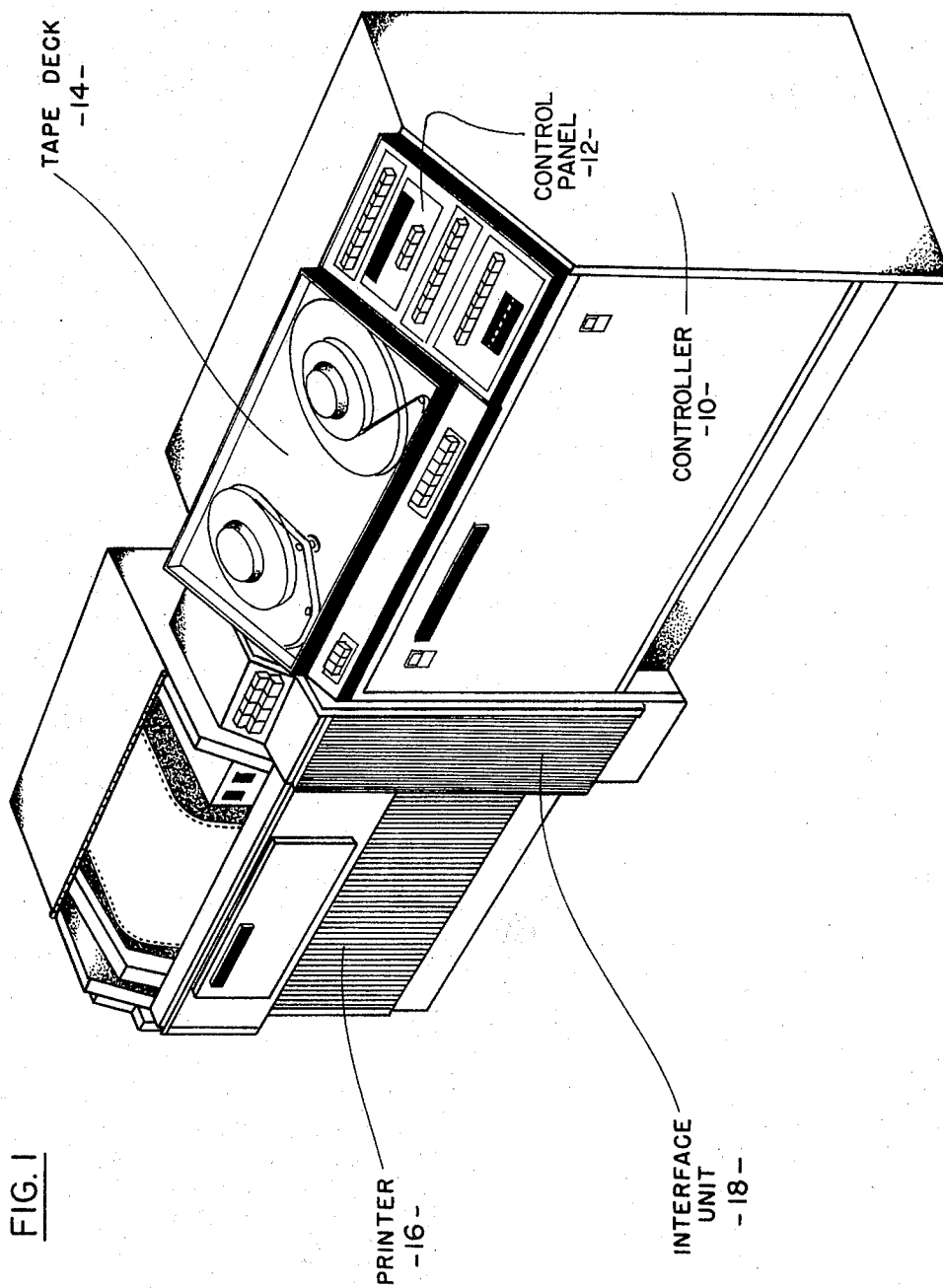
[57] **ABSTRACT**
A high speed line printer is provided which may be incorporated as a component of an off-line system for printing encoded identification data on labels, or the like. The particular system to be described accepts the output of a data processor, as recorded on a magnetic tape, and it automatically transforms the recorded information into human-readable characters and code bar machine-readable symbols, which are imprinted on labels or other forms. The printer to be described is a drum type, impact, line printer, which is capable of high speed operation, and which is controllable to print out alphanumeric and special characters, as well as a set of code bar symbols for a variety of tag and label sizes, with a high degree of speed, precision and accuracy.

[56] **References Cited**

UNITED STATES PATENTS			
3,185,283	5/1965	Spitsbergen et al.	101/93 C X
3,207,067	9/1965	Schaller	101/93 C
3,220,343	11/1965	Wasserman	101/93 C
3,406,381	10/1968	Peyton	101/93 C X
3,736,868	6/1973	Briggs	101/93 C
3,738,263	6/1973	Combs	101/93 C
3,739,719	6/1973	Potter	101/93 C

3 Claims, 16 Drawing Figures





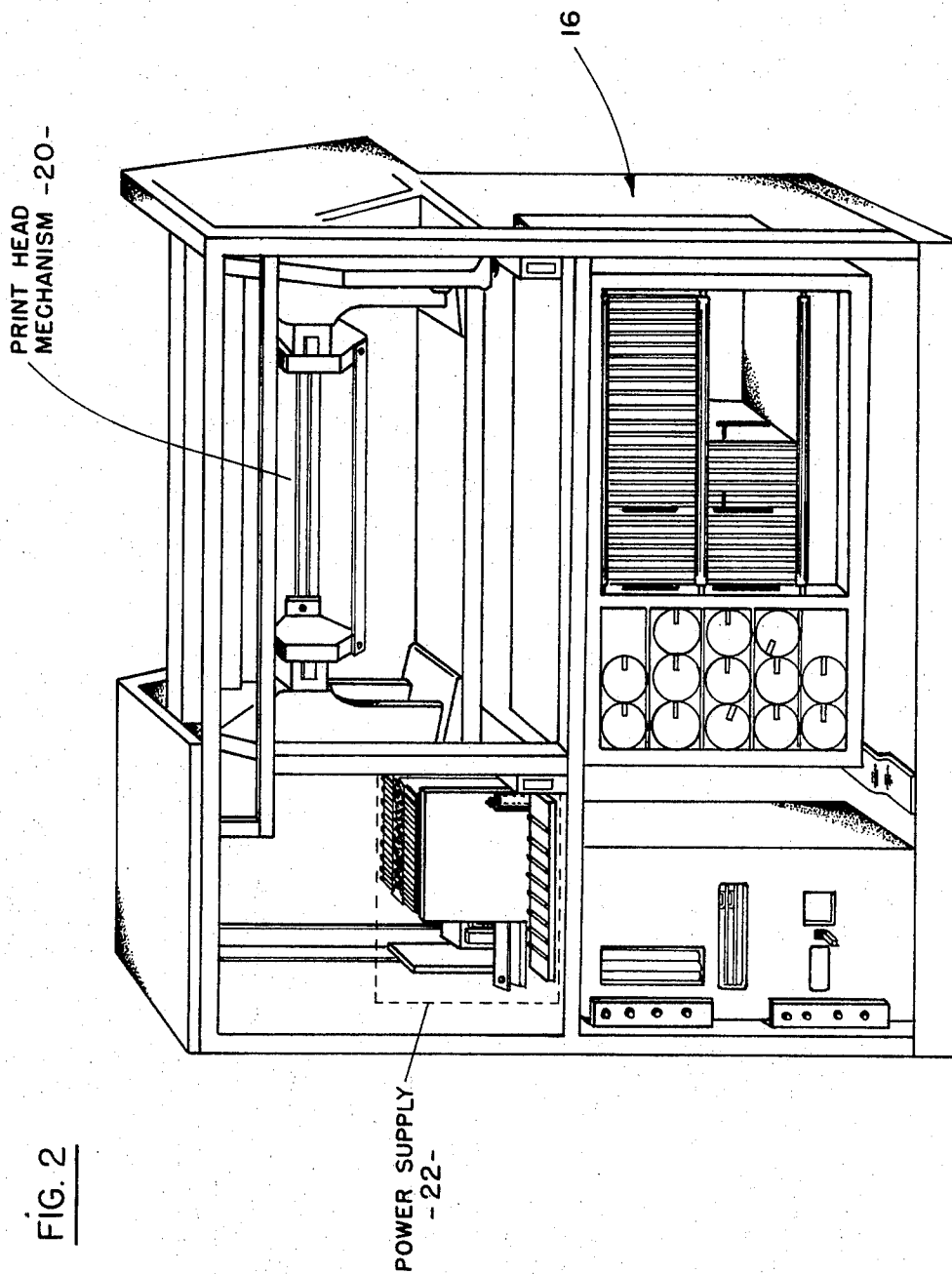


FIG.3

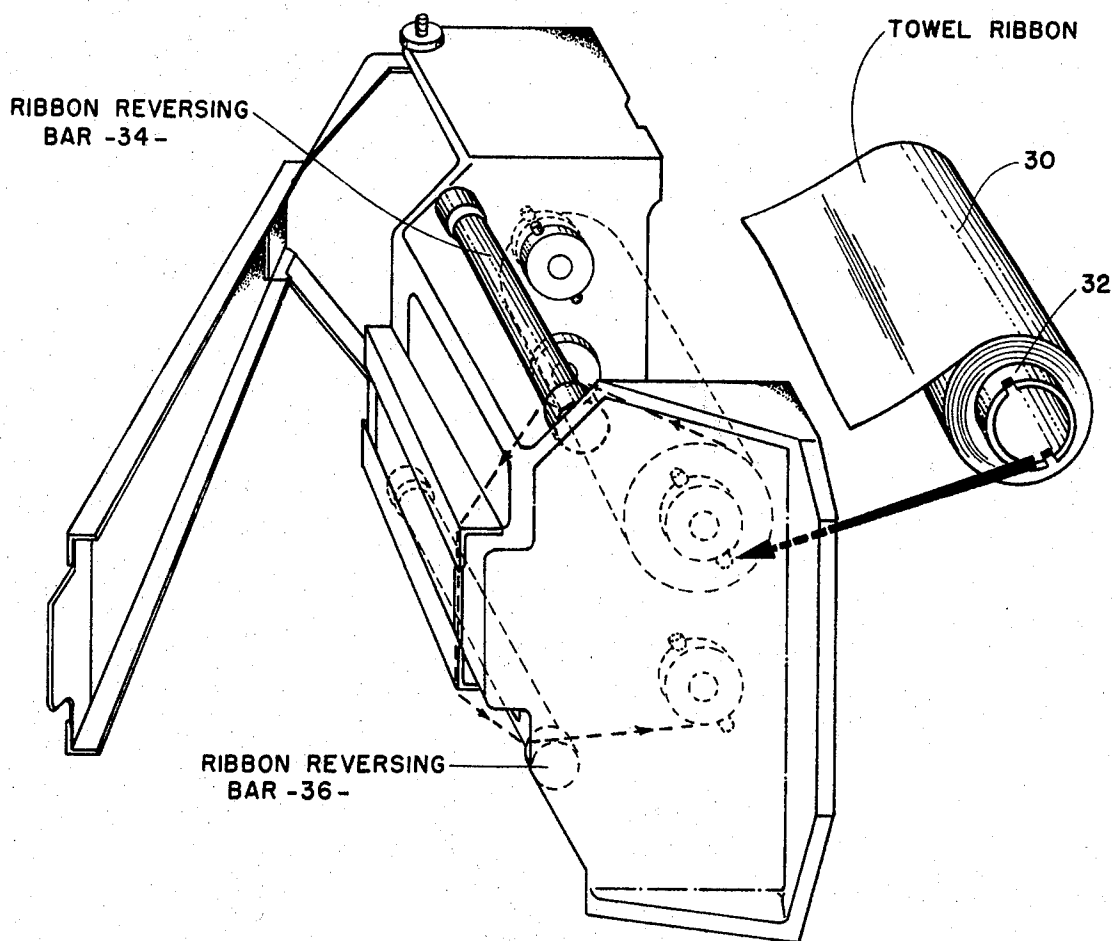
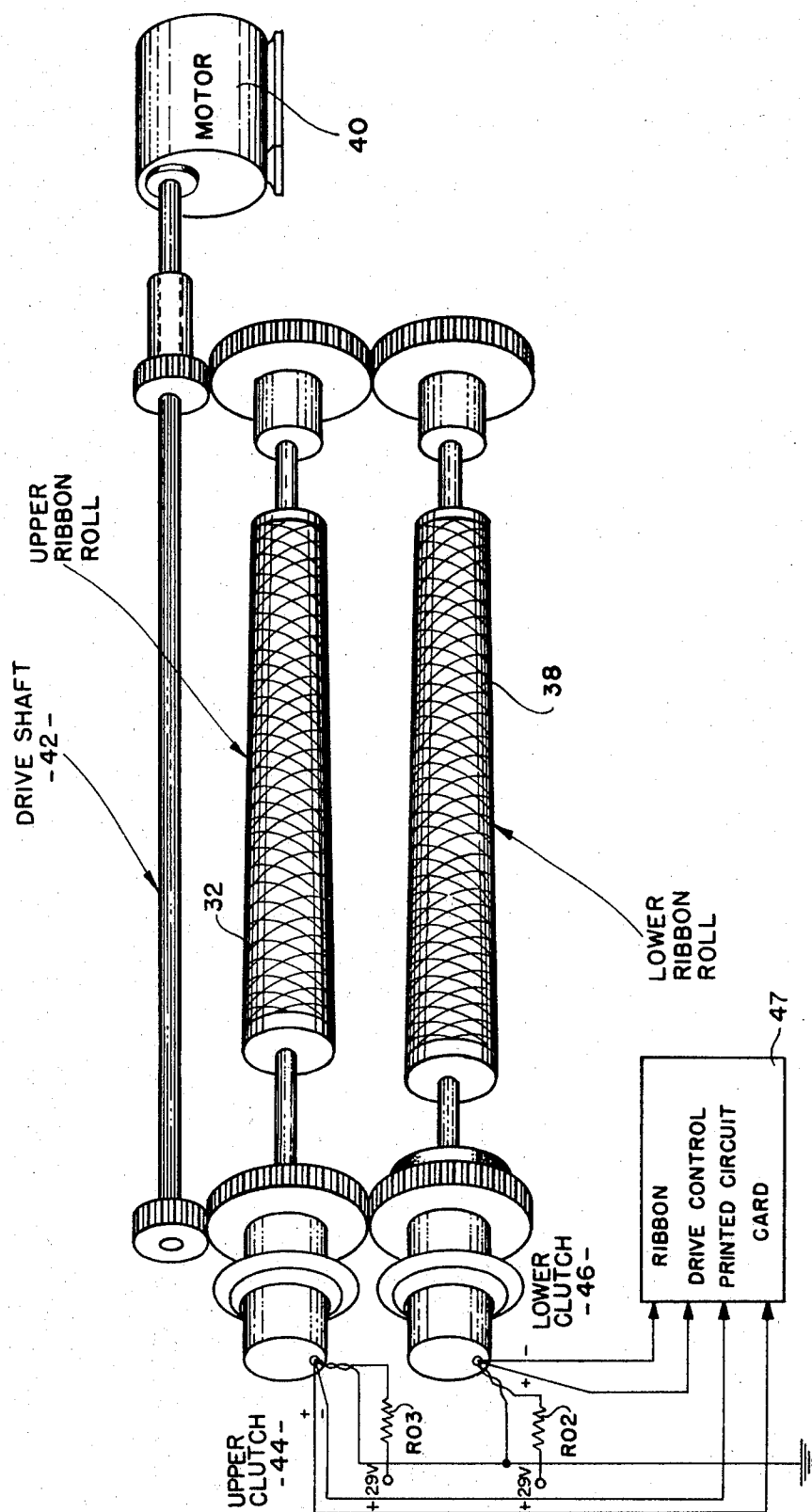
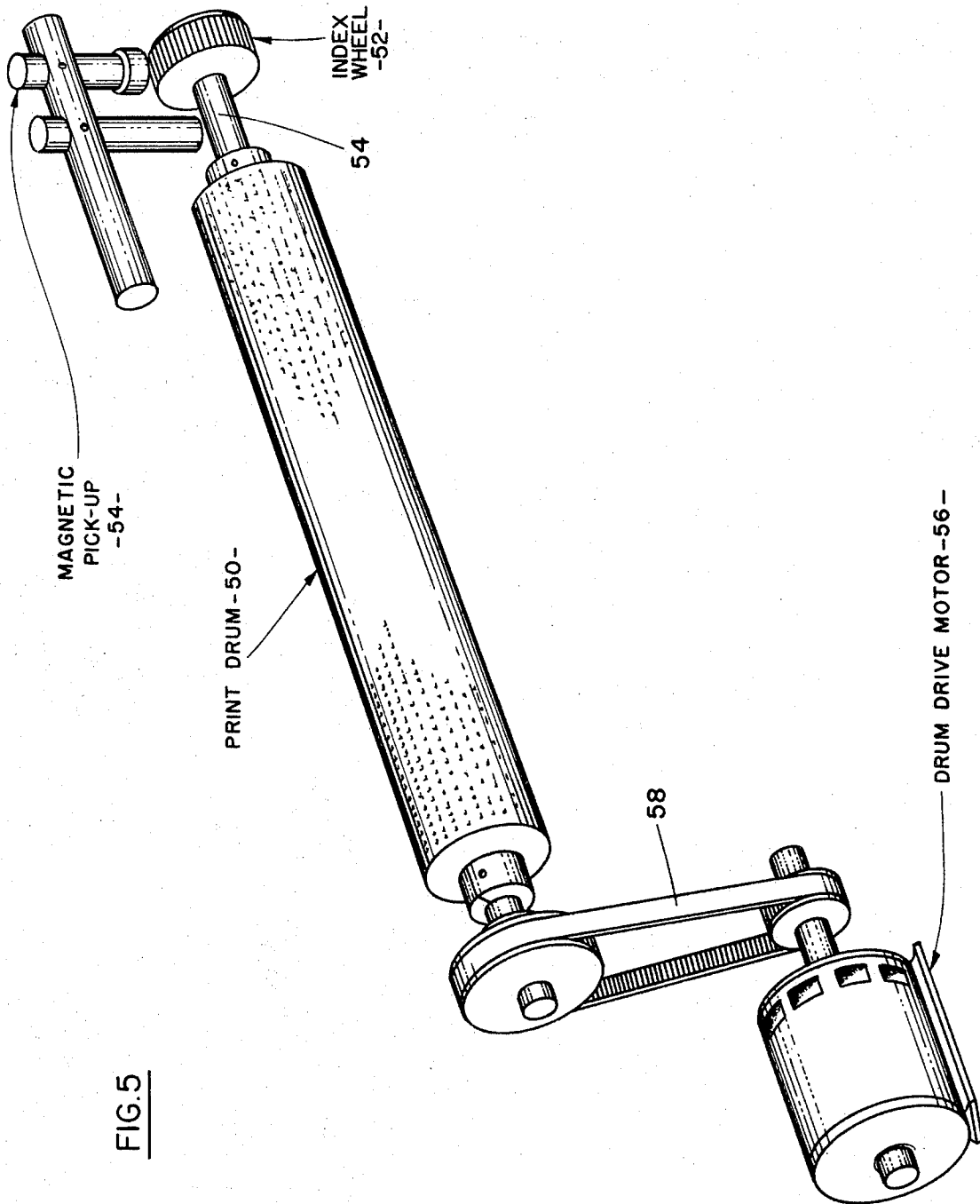


FIG. 4





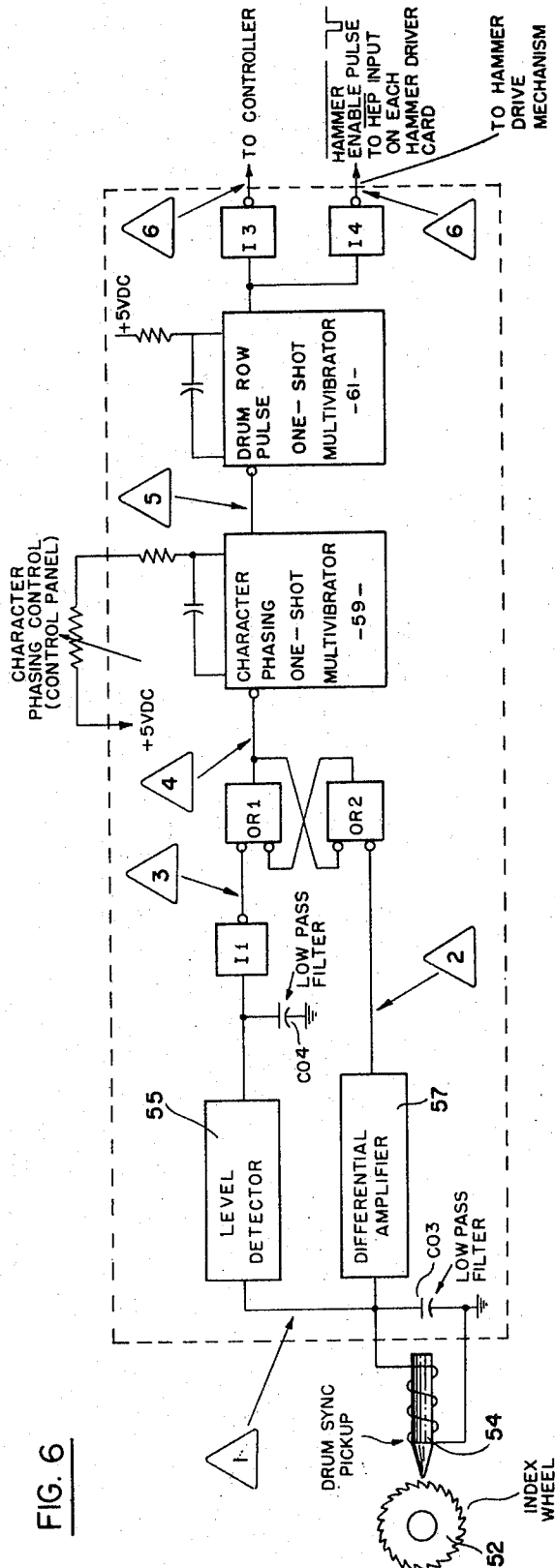
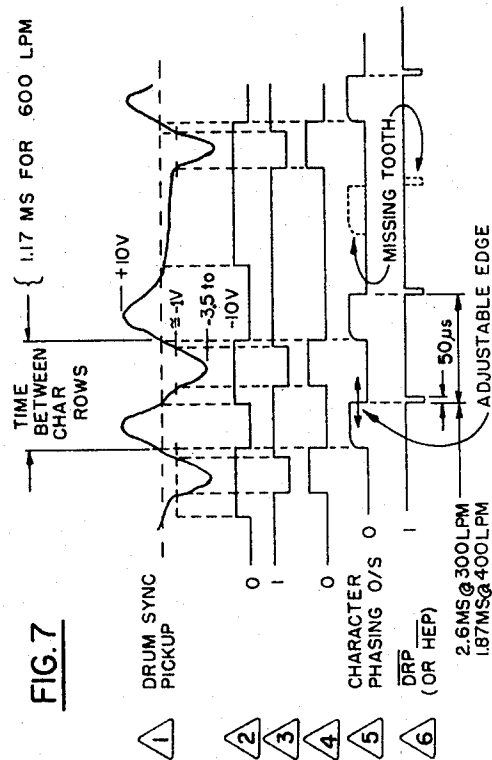


FIG. 8

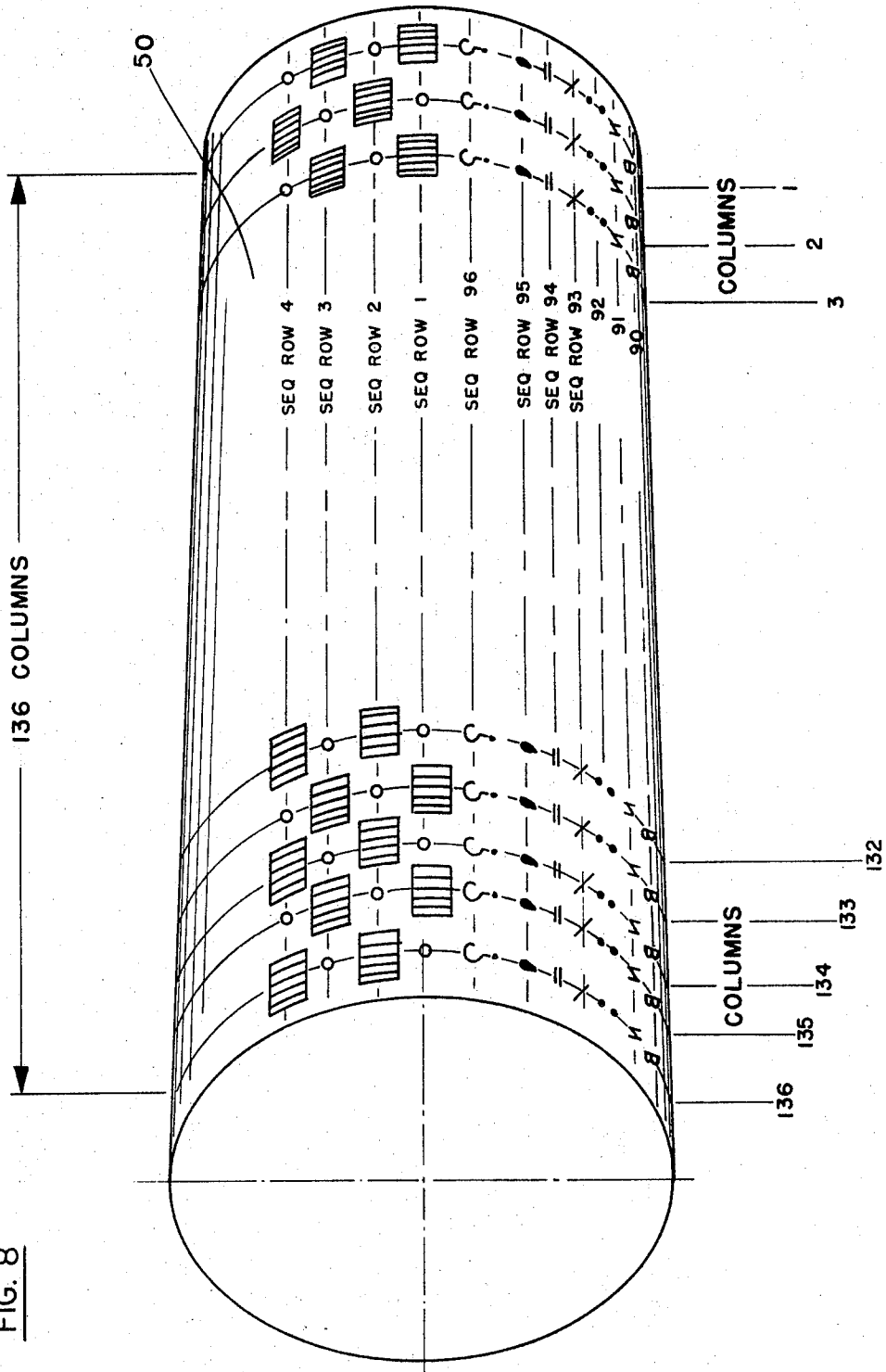
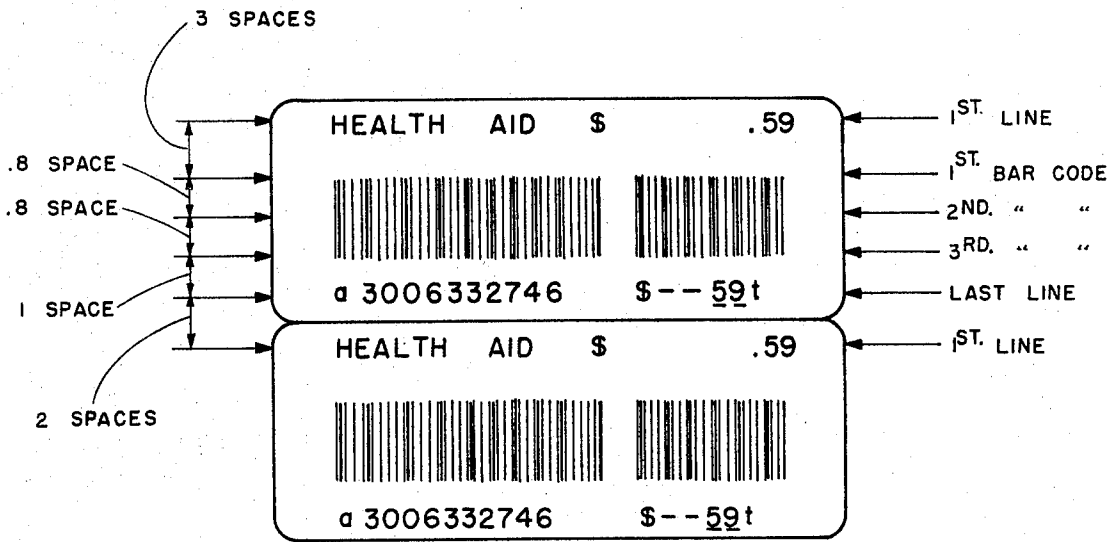
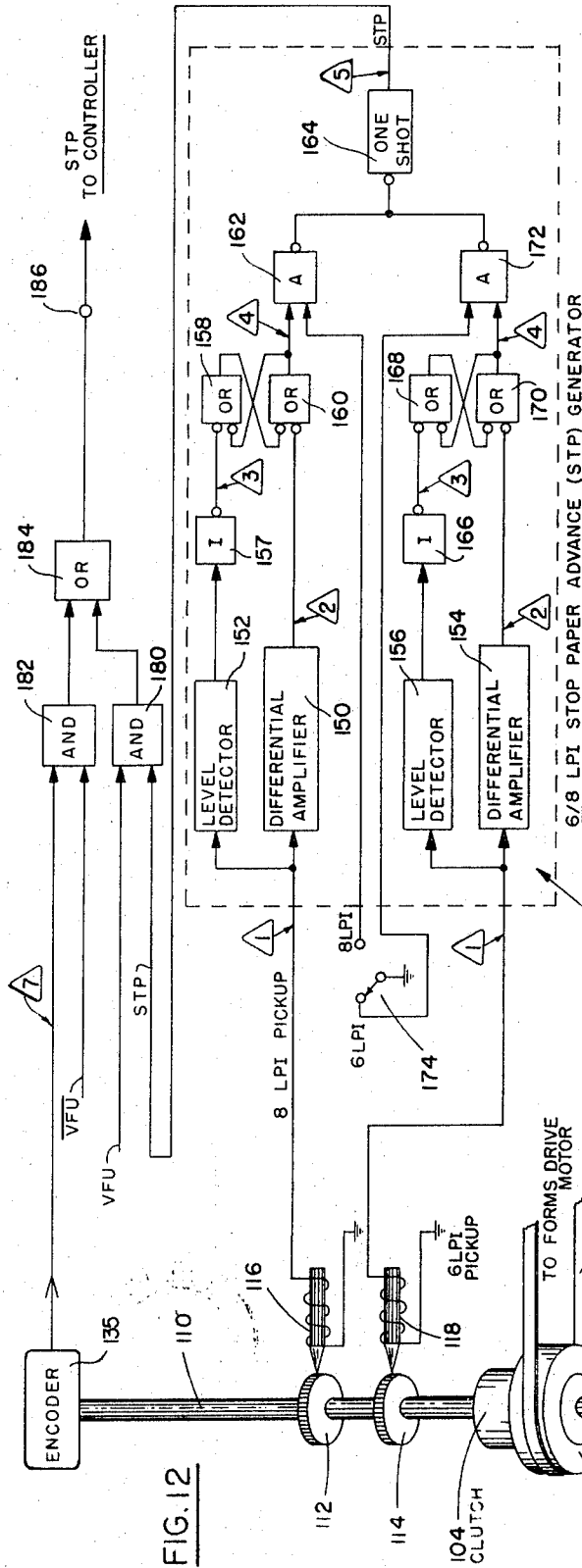
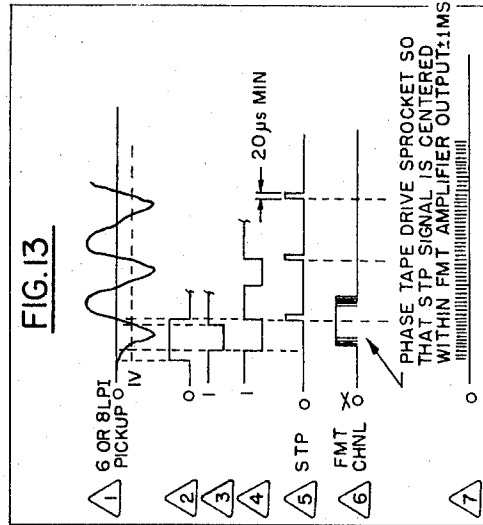
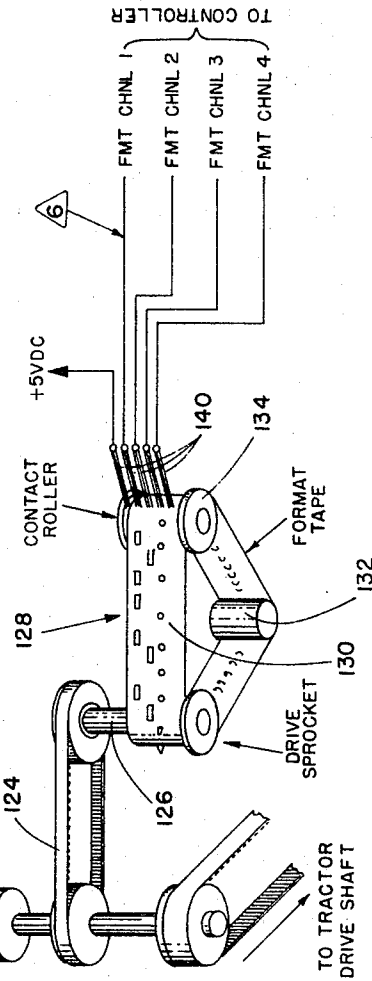


FIG. 10

SEQ.# CHARACTER		SEQ.# CHARACTER		SEQ.# CHARACTER		SEQ.# CHARACTER	
1	B.C. / SLASH	27	B.C. — DASH	53	U	79	<u>2</u>
2	B.C. / ..	28	B.C. — ..	54	L	80	<u>3</u>
3	B.C. : COLON	29	B.C. • PERIOD	55	D	81	<u>4</u>
4	B.C. : ..	30	B.C. • ..	56	H	82	<u>5</u>
5	B.C. B' OR N'	31	B.C. \$	57	R	83	<u>6</u>
6	B.C. B' OR N'	32	B.C. \$	58	S	84	<u>7</u>
7	B.C. C' OR *'	33	B.C. A' OR T'	59	E	85	<u>8</u>
8	B.C. C' OR *'	34	B.C. A' OR T'	60	% PER CENT	86	<u>9</u>
9	B.C. 9	35	B.C. O ZERO	61	1/2	87	• PERIOD
10	B.C. 9	36	B.C. O ..	62	9 COMA	88	C
11	B.C. 8	37	Z	63	A	89	* ASTERISK
12	B.C. 8	38	(LEFT PAREN.	64	T	90	B
13	B.C. 7	39	J	65	\$	91	N
14	B.C. 7	40	) RIGHT PAREN.	66	O ZERO	92	: COLON
15	B.C. 6	41	Q	67	1	93	/ SLASH
16	B.C. 6	42	X	68	2	94	= EQUALS
17	B.C. 5	43	; SEMI COLON	69	3	95	' SINGLE QUOTE
18	B.C. 5	44	V	70	4	96	? QUESTION MARK
19	B.C. 4	45	W	71	5		
20	B.C. 4	46	Y	72	— DASH		
21	B.C. 3	47	G	73	6		
22	B.C. 3	48	P	74	7		
23	B.C. 2	49	F	75	.8		
24	B.C. 2	50	M	76	9		
25	B.C. 1	51	+ PLUS	77	<u>Q</u>		
26	B.C. 1	52	K	78	<u>1</u>		

FIG. 11





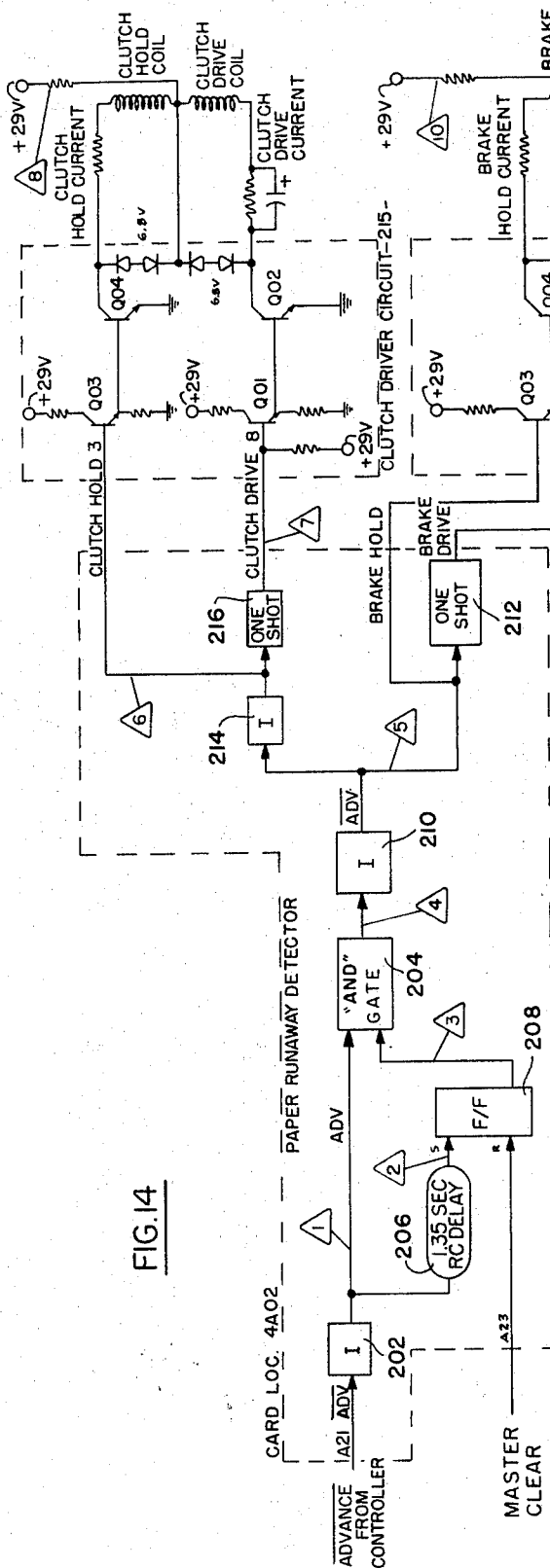


FIG. 14

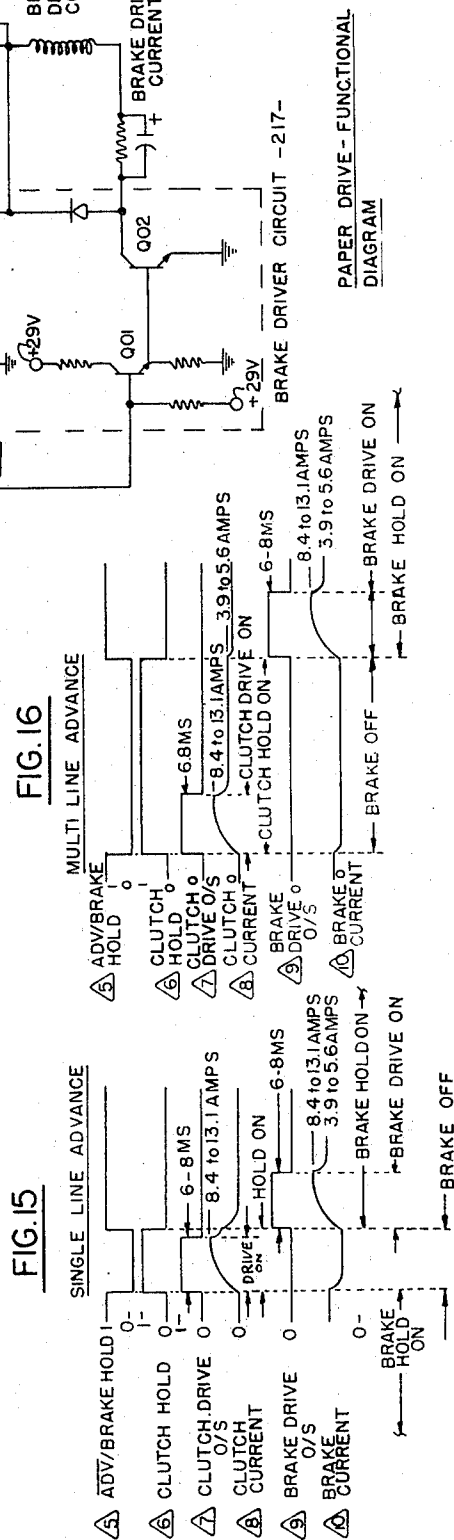


FIG. 15

FIG. 16

PAPER DRIVE - FUNCTIONAL
DIAGRAM

HIGH SPEED DATA PROCESSOR LINE PRINTER

BACKGROUND OF THE INVENTION

Line printers are the primary means for making information available for human inspection after it has been processed by electronic data processing systems. Most present day high speed printers use an on-the-fly printing technique, in which rapidly acting hammers impact a continuous paper strip against an inked ribbon and a moving type element, at the instant at which the selected characters (as represented by the different type elements) are in the appropriate position. The print elements of the particular printer with which the present invention is concerned are formed on a rotating drum. Speeds of 300-500 lines per minute are usual for the prior art on-the-fly line printers.

In a constructed embodiment of the rotating drum on-the-fly printer to be described, data is printed at a speed of 600 lines per minute, with 132 print positions (13.2 inches) per line. The printer in the constructed embodiment has a standard 96 character set in each print position, and this includes the human-readable alphanumeric and special characters, and a machine-readable code bar set of numeric and special control symbols. Because of the line width of 132 positions, a wide variety of tag and label sizes can be printed by the printer of the invention. The printer to be described may be used, not only for printing machine-readable code bar identification labels and tags, but also for usual human-readable alphanumeric printing.

The particular system in which the printer of the invention is incorporated includes a computer-type controller having programmable logic, and which responds to the input from a magnetic tape, as read by a tape deck which is included as part of the system. The output from the controller is interfaced with the printer itself by a suitable interface unit, so that the electrical controls of the printer may respond to the information recorded on the tape, in order to transform that information into appropriate machine-readable symbols, as well as human-readable alphanumeric characters.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective representation of an off-line printing system which incorporates the concepts and principles of the present invention;

FIG. 2 is a perspective representation of a printer which is included in the system of FIG. 1 and which is constructed in accordance with the invention;

FIG. 3 is a schematic representation of a ribbon drive mechanism which is included in the printer of FIG. 2;

FIG. 4 is a further schematic representation of the ribbon drive mechanism of FIG. 3;

FIG. 5 is a schematic block diagram of a drum drive mechanism which is included in the printer of FIG. 2 and which serves to drive the print drum of FIG. 2;

FIG. 6 is a schematic block diagram of an appropriate electronic system for controlling the print cycle and hammer operation of the printer of FIG. 2;

FIG. 7 is a series of curves useful in explaining the operation of the system of FIG. 6;

FIG. 8 is a representation of a print drum which may be incorporated into the printer of FIG. 2 in accordance with one embodiment of the invention;

FIG. 9 is a schematic representation of a column of characters of the print drum of FIG. 8;

FIG. 10 is a table of characters which may be engraved on the print drum of FIG. 8;

FIG. 11 is a representation of human-readable and machine-readable labels which may be imprinted by the printer of FIG. 2;

FIG. 12 is a schematic representation of a paper advance mechanism contained in the printer of FIG. 2 and associated electronic control circuitry;

FIG. 13 is a series of curves useful in explaining the operation of the circuitry of FIG. 12;

FIG. 14 is a functional block diagram of further control circuitry for the paper advance mechanism of FIG. 12; and

FIGS. 15 and 16 are curves representing waveforms developed in the circuit of FIG. 14.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

The system shown in FIG. 1 includes a controller 10. The controller 10 may be in the form of a small computer having programmable logic, and it is operated by appropriate controls mounted on a control panel 12. The controller 10 is also controlled by information recorded on a magnetic tape which, in turn, is read by the components of a tape deck 14. The information recorded on the magnetic tape represents, for example, the output of a data processing system. It is the purpose of the system of FIG. 1 to transform the data processing system output, as recorded on the magnetic tape, into appropriate control signals for a printer 16. These control signals cause the printer to imprint alphanumeric human-readable data, as well as machine-readable coded symbols, on labels, tags, or other forms. The controller 10 is coupled to the printer 16 through an interface unit 18. The purpose of the interface unit is to transform the signals from the controller into a form acceptable by the control circuitry of the printer 16.

The details of the controller 10, the control panel 12, the tape deck 14, as well as of the interface unit 18, are known to the art. The present invention is concerned with the construction and electronic control circuitry of the printer 16, which enables the printer to print the desired machine-readable coded symbols and alphanumeric characters on appropriate forms in an accurate, rapid and precise manner. As mentioned above, a constructed embodiment of the printer is capable of printing at a speed of 600 lines per minute, and of achieving a high degree of accuracy and precision, and an extremely low rejection rate.

The printer 16 of FIG. 2 may be generally similar to the high speed printer presently being marketed by Control Data Corporation, Rochester Division, 1480 North Rochester Rd., Rochester, Mich. 48063, and presently designated by them as their CL4A8 Series Line Printer and Controller Equipment. The printer marketed by Control Data Corporation is an electro-mechanical on-the-fly impact, drum type, line printer. The printer 16, as shown in the perspective representation of FIG. 2, is supported in a cabinet which contains compartments for the actual printer mechanism 20, as well as for an appropriate power supply 22, and other components of a self-contained electronic controller, which converts into appropriate printing control signals, the electrical information bits received through the interface unit 18 from the external controller 10.

The printer mechanism 20 contains the mechanical and electrical systems required to move the paper and

ribbon, and to actuate the impact hammers, so as to drive the paper and ribbon against the print drum at the proper times to achieve the desired line printing. The printer mechanism consists of four main groups, namely, a ribbon drive mechanism and control system, a paper advance mechanism and control system, the print drum assembly and its associated drive system, and a hammer bank assembly and its associated control system.

The ribbon drive assembly and control system, as shown in FIGS. 3 and 4, includes an alternating current motor 40, two drive clutches 44 and 46, and a ribbon drive control circuit represented by the block 47. A ribbon 30, shaped as a continuous towel, is looped around an upper ribbon roll 32, over an upper reversing bar 36, and around a lower ribbon roller 38. The ribbon 30, for example, may be 15 inches wide and 25 feet long, and it may be formed of nylon, Mylar, or other suitable material.

The drive motor 40 runs continuously whenever the printer is energized. The ribbon drive control circuit 47 is used to provide control signals to the clutches 44 and 46. When the clutch 44 is energized, the roller 32 rotates to drive the ribbon in one direction, and when the clutch 46 is energized, the roller 38 rotates to drive the ribbon in the opposite direction. The control circuit 47 responds to an appropriate ribbon advance command signal from the controller to cause one of the clutches 44 and 46 to be engaged with a high current so as to drive the ribbon in a particular direction. At the same time, the other clutch is energized with a low current so as to act as a drag on the ribbon and thereby maintain the ribbon in a taut condition.

The ribbon advance command signal is active at the beginning of each print operation, and it remains active throughout the print operation. Upon the termination of the ribbon advance command signal, the control circuit 47 keeps the clutches engaged for a half second after the print operation, to move the ribbon into position for the next print operation. The direction of the ribbon feed is controlled by a flip-flop in the control circuit 47 which, in turn, is operated by limit switches in the ribbon drive mechanism. This flip-flop determines which of the two clutches 44 and 46 is to be energized at a high current level to move the ribbon in a particular direction, and which is to be energized at a low current to provide the desired drag on the ribbon.

The print drum assembly and associated control circuitry are shown in FIGS. 5 and 6. The print drum is designated 50 in FIG. 5. As will be described in more detail subsequently, the print characters are engraved on the drum in horizontal rows of like characters. As each row of characters rotates into a printing position, upon rotation of the print drum, the print hammers are actuated in the column positions at which characters are to be printed. The print drum 50 is driven by an electric motor 56 through a belt drive 58. The motor causes the drum to rotate continuously whenever power is supplied to the printer.

As shown in FIGS. 5 and 6, a toothed character index timing wheel 52 is affixed to one end of the print drum 50. The timing wheel 52 has teeth corresponding one-for-one with each drum row character, and it also has a blank tooth index position corresponding to a blank character row on the drum. The teeth of the timing wheel 52 are sensed by a magnetic pick-up 54 which introduces a series of electric pulses to the circuit of

FIG. 6, as the print drum rotates. These input pulses cause the circuit of FIG. 6 to generate corresponding output pulses which are applied to a character counter in the controller so as to control the print cycle. The character counter generates a code signal for each angular print position of the print drum. The code signal corresponds to the particular character engraved on the drum at that print position. Print hammers at each column position identified by the controller by a corresponding code are then actuated.

As shown in FIG. 6, the output of the magnetic pickup 54 is introduced to a level detector 55 and to a differential amplifier 57. The pick-up is shunted by a capacitor CO3 which function as a low pass filter. The output of the level detector is connected to a capacitor CO4 which also serves as a low pass filter, and through an inverter I1 to a flip-flop OR1, OR2. The output of the differential amplifier 57 is connected to the input of a character phasing one-shot multivibrator 59, the output of which is connected to a second one-shot multivibrator 61. The output of the multivibrator 61 is connected through an inverter I3 to a first output terminal which develops drum row pulses for the controller, and through a second inverter 14 to an output terminal which develops enable pulses for the hammer drive mechanism.

The various waveforms developed within the circuit of FIG. 6 are shown in FIG. 7. The purpose of the circuit of FIG. 6 is to develop a DRP pulse for each line position of the print drum, as well as a HEP pulse for each angular position. The DRP pulses are used by the controller to advance the character counter and to set up a print cycle, as described above. The HEP pulses are used by the hammer control mechanism to enable the hammers to actuation at the proper times. As shown by the waveforms of FIG. 7, the pick-up signal generated by the sensor 54 has a generally sine wave form, and is generated as each gear tooth of the timing wheel 52 passes the magnetic reluctance pickup

The level detector 53 is made conductive when the sine wave signal swings in a positive direction, and it remains conductive until the negative swing of the sine wave signal passes the -1 volt level.

The flip-flop OR1, OR2 is set, therefore, only during the negative swing of the sine wave signal. As the sine wave signal swings positive, the differential amplifier 57 is made conductive, and it serves to reset the flip-flop. Thus the flip-flop will remain reset during the positive portion of the sine wave signal, and it will be set during the negative portion. The character phasing one-shot multivibrator is triggered each time the flip-flop resets. The length of the output pulse from the one-shot is adjustable through a phasing control knob mounted on the control panel. As the character phasing pulse drops to zero, the one-shot 61 is triggered. The output from the flip-flop is, for example, a 50 microsecond pulse which is introduced to the two inverters to develop the DRP and HEP outputs. As mentioned above, the hammer control mechanism utilizes the HEP output to cause the impact hammers to be operated at the proper time.

The drum 50 shown in FIG. 8, in a particular embodiment of the invention, has a diameter of 4.890 inches, and it is 136 columns in length. The illustrated drum, for example, has 96 character rows spaced around its periphery. Eighteen bar code symbols are displayed in the first 36 rows, as shown in FIG. 9, and as listed in the

table of FIG. 10. The bar code symbols are arranged in a checkerboard manner on the drum, in that the same symbols appear, in each instance, in two adjacent rows, with the symbols appearing in the odd numbered columns in one of the rows, and in the even numbered columns in the other of the rows, such as shown in FIG. 8. An alphanumeric character, such as a "." may be positioned in the otherwise vacant positions between the checkerboard bar code symbols, as shown in FIG. 8. The checkerboard design is carried throughout the 36 bar code sequence in rows 1-36. All the other alphanumeric and special characters are displayed in all 136 column positions across their respective rows. The reason for the checkerboard arrangement of the code bars is to prevent shadowing, in that when the code bars are closely adjacent to one another, the print hammers have a tendency to move the ribbon against an adjacent symbol which has not been selected for printing.

When the printer is commanded to print a bar code, the program in the controller determines which column and row is to be impacted by the print hammers and, if a full row of bar code zeros, for example, were to be printed, the controller would cause the printer to fire selected odd columns in row 35 and selected even columns in row 36, thereby printing a full line of bar code zeros adjacent to one another and without shadowing. In the case of the alphanumeric and special characters, the tendency for shadowing does not occur, and the program in the controller causes such characters to be printed in any column for which they are selected.

The purpose of the bar code symbols is to permit items identified thereby to be read automatically by a hand held wand. The wand is electrically connected to appropriate apparatus, so that signals generated by the wand as it is swept across an imprinted bar code symbol are received and sensed by the apparatus. The symbols, for example, may be affixed to merchandise, and the wand may be held by a check-out clerk, automatically to control the cash register.

To print readable bar code symbols of sufficient height to be read by a hand-held wand, which should have a height of at least 0.260 inches, in a high speed line printer which has hammer faces of the order of 0.150 inches in height, and characters of the order of 0.100 inches in height, it is necessary to move the paper a small enough increment during the bar code symbol printing to allow for an over-printing technique to be employed so that a continuous vertical line can be printed on the paper for each element of the individual bar code symbols. The normal vertical paper movement spacing of six or eight lines per inch, which is standard in conventional high speed line printers, will not provide the appropriate paper control for the printing of the bar code symbols. Therefore, some means must be provided for controlling the paper movement to something less than 0.100 inches.

In the apparatus of the present invention, a disc encoder is used to control the vertical movement of the paper. The disc encoder produces output control pulses, each of which corresponds, in a constructed embodiment, to 0.02003 inches of paper movement. Therefore, by selecting the proper number of pulses from the encoder for any desired program, virtually any desired paper movement can be achieved.

The drum 50 in a constructed embodiment rotates at 600 rpm, or 100 milliseconds for each complete revolution. It takes one character block (0.1598 inches)

1.0416 milliseconds to pass any given point. The paper movement time is controlled to be 25 milliseconds for a single space advance. However, to print the bar code symbols, three space advances are used for each symbol, and the printing time is then 41.8 milliseconds for each three space moves.

In the operation of the printer, and as shown in FIG. 11, all alphanumeric and special characters are printed on the first line of the form, or label; up to nine spaces are moved from the first line printed to the first bar code line; the bar code is printed in three strikes, overlapping approximately 0.020 inches; the printer then moves one space to the last line to be printed which comprises all numerics, all underlined numerics, and certain special characters. Then, as shown in FIG. 11, the printer moves two spaces to the first line location on the succeeding form, and will wait for the first character in the alphanumeric section of the drum to be in print position.

When the sequence shown in FIGS. 8, 9 and 10 is used for imprinting forms of the type shown in FIG. 11, a time saving is achieved in that the print drum in each instance is in proper position to proceed from the alphanumeric line to the bar code line and from the bar code line to the numeric line on the label with a minimum of rotational movement of the print drum.

After each line of the form of FIG. 11 is printed, proper spacing occurs in accordance with a received vertical format instruction. The vertical format instructions are derived from a vertical format tape assembly, to be described, as well as from encoder signals derived from an encoder, which will also be described. The vertical format tape signals are used to move the paper from one form to the next, and the encoder signals are used to space the printer to the various lines within the individual forms themselves. To obtain a full format tape capability, a six or eight line option is used in the constructed embodiment, and the format tape is punched to match the six or eight line per inch spacing mode, as selected by the operator.

The paper transport mechanism, and associated circuitry, as shown in FIG. 12, includes a flywheel 100 which is coupled to a drive motor through a belt 102. The drive motor rotates the flywheel at a constant speed as long as main power is supplied to the printer. The flywheel shaft is coupled to a clutch and brake assembly designated 104 and 106. A paper advance signal causes the clutch 104 to engage the drive shaft 110 at the same time the brake 106 releases, causing the paper to advance. A pair of toothed pulse wheels 112 and 114 are keyed to the shaft 110, and these wheels contain teeth spaced to correspond respectively to six and eight inches per length formatting. A corresponding pair of electromagnetic reluctance pick-ups 116 and 118 are associated with the respective wheels 112 and 114, and these pick-ups introduce pulses to a logic control circuit 120.

The drive shaft 110 is also coupled through a belt 124 to a drive sprocket 126 of a format tape system 128. The format tape system 128 includes a format tape 130 which extends around an idler roller 132, around the drive sprocket 126 and around a further roller 134. An encoder 135 is also coupled to the drive shaft. This encoder may be of the type presently marketed by Disc Instruments, Inc. of 2701 South Halladay St., Santa Ana, Cal. 92705, and designated by them as their Rotaswitch incremental shaft encoder, Model 832-144-

18-1BLP. The drive shaft 110 also drives a belt 136, which is connected to the tractor driven shaft of the paper advance mechanism.

As shown in FIG. 12, the pick-up 116 is connected to a differential amplifier 150 and to a level detector 152 in the circuit 120, whereas the pick-up 118 is connected to a differential amplifier 154 and to a level detector 156. The level detector 152 is connected through an inverter 15 to the set input terminal of a flip-flop 158, 160; whereas the differential amplifier 150 is connected to the reset input terminal. The reset output terminal of the flip-flop is connected through an "and" gate 162 to the input of a one-shot multivibrator 164.

Likewise, the level detector 156 is connected through an inverter 166 to the set input terminal of a flip-flop 168, 170. The differential amplifier 154 is connected to the reset input terminal of the flip-flop. The reset output terminal of the flip-flop is connected to an "and" gate 172, the output of which is connected to the one-shot multivibrator 164. A switch 179 is provided on the control panel, which is operated by the operator to select either a six line per inch or an eight line per inch format. When the eight line per inch format is selected, the "and" gate 162 is enabled, and when the six line format is selected, the "and" gate 172 is enabled.

The output of the one-shot 164 is introduced to an "and" gate 180. The output of the encoder 135 is introduced to an "and" gate 182. The "and" gates 180 and 182 are connected through an "or" gate 184 to the output terminal 186 of the circuit. A VFU command signal is applied to the "and" gate 180, and its complement is applied to the "and" gate 182. The VFU command signal when true, causes the output from the circuit 120 to be applied to the controller. However, when the complement of the command signal (VFU) is true, the output of the encoder 135 is applied to the controller.

The format drive assembly 128 includes a brush reader unit containing a plurality of metal brushes 140 which sense holes in the various channels of the format tape 130, as selected by the controller. A strobed stop signal is allowed to take effect when a hole in the format tape enables a brush to strike the metal contact roller 134. When the VFU command signal is true, the format assembly determines when the pulse will be generated which will disengage the clutch 104 and engage the brake 106 to stop the paper movement.

However, when the complement of the command signal VFU ($\overline{\text{VFU}}$) is true, the encoder 135 determines when a pulse will be generated that will disengage the clutch 104 and engage the brake 106 to stop paper movement. When the term VFU is true, the pulse from the format control system determines which of the pulses from the pick-up 116 or from the pick-up 118 will be used to stop the paper advance mechanism. On the other hand, when the VFU signal is true, the pulses from the encoder 135 will determine when the paper advance mechanism is to be stopped. The various waveforms generated within the system of FIG. 12 are represented by the curves of FIG. 13.

Therefore, the sequence is such in the printing of a form, such as shown in FIG. 11, for example, that a paper advance signal is received from the controller to advance the paper to the first line of the form. Upon receipt of the paper advance signal, the brake 106 releases and the clutch 104 engages, as described above, so that the drive shaft 110 drives the paper and associ-

ated controls to the first line. At that time, the $\overline{\text{VFU}}$ signal is true, and the first line is designated by the first pulse from the encoder 135. The printer then prints the alphanumeric characters on the first line of the form.

When the printing operation is completed, the controller again introduces four pulses of the paper advance signal to the mechanism, and the paper advances a desired distance, still under the control of the encoder 135. The first portion of the bar code signals are then printed. Then, the controller introduces two pulses of the advance signal to the mechanism, and under the control of the encoder 135, and the paper advances a further desired amount, and the next portion of each bar code character is printed. The operation is repeated, still under the control of the encoder 135, and the paper advances another two pulse distance so that the third portion of each bar code character may be printed.

The next operation is for the controller to advance the paper a two-pulse distance to the last line of the form, in which the numeric symbols are printed. The VFU signal now becomes true, so that the control of the paper advance mechanism is switched to the format control system 128. The paper is then advanced a further two-pulse distance to the first line of the next form, at which position the paper is stopped, under the control of the signal from the format tape system 28.

When the sequence shown in FIGS. 8-10 is used for engraving the various symbols and characters on the drum, the drum rotation is minimized, because the angular position of the drum at the end of each print operation is such that the angular displacement for the next characters is minimized. This sequence arrangement optimizes the speed at which the printing operation can be carried out.

Therefore, control of the vertical line spacing is accomplished by the holes punched in the format tape of the format tape system 128, and by the pulses derived from the encoder 135. The format tape itself is formed into a loop, and it is punched at six and eight lines per inch segments in the particular embodiment. As each frame passes the read station, a stop pulse is generated by the pick-ups 116 or 118, and the particular stop pulse which occurs coincidentally with the sensing of a hole in the format tape is supplied to the controller, for the purpose described above. As also described, the two reluctance pick-ups 116 and 118 sense the position of the respective timing wheels 112 and 114 for generating the stop pulses. Both pick-ups drive identical pulse shaping circuits in the circuit 120, as described. Each pulse shaping circuit is composed of a common base differential amplifier, voltage level detector, and an RS flip-flop. The line select switch 179 located on the control panel permits the operator to select either the six or eight LPI-shaped signal to trigger the one-shot 164 to generate the STP pulse.

As described above, the vertical movement of the forms of FIG. 11 through the printer, and the resulting spacing from one print line to the next, is controlled by alternately energizing a magnetic clutch 104 and a brake 106, which transmit torque from the drive motor to the forms drive tractor and to the vertical format brush reader 128. The circuits which drive the clutch and brake receive their inputs from the printer controller, as also described above. The controller acts upon advance commands received from the data source. The controller monitors the output of the vertical format

tape reader 128, and of the logic circuitry of FIG. 12, to determine when each form has reached a specified number of line spaces for a print operation to be initiated. The controller then commands the clutch/brake circuits to start and stop the motion of the forms, as described.

The motion of the forms through the printer is controlled by the advance signal from the controller, as described. When the advance signal is at logic 1, the forms move through the printer, but when the bar advance signal is at logic 1, the motion of the forms is stopped. The forms are driven when the advance signal goes to a logic 1 level and continue until the bar advance signal goes to a logic 1 level. If the bar advance signal remains at a zero level for more than 1.35 seconds, a flip-flop 200 in FIG. 14 is set to indicate a paper runaway condition. Under this latter condition, the motion of the forms is automatically terminated to prevent unwanted slewing of the forms.

In the circuit of FIG. 14, the advance signal from the controller is passed through an inverter circuit 202 to an "and" gate 204. The output of the inverter is also applied through a delay network 206 to the set input of the runaway flip-flop 208. The flip-flop 208 is reset by a "master clear" input received from the controller. The reset output of the flip-flop 208 is applied to the "and" gate 204. The output from the "and" gate is applied through an inverter 210 to a one-shot multivibrator 212, and through a second inverter 214 to a one-shot multivibrator 216.

The output from the converter 214 is applied through a clutch driver transistorized circuit 215 to a hold coil in the clutch 104; whereas the output from the one-shot 216 is applied through the circuit 215 to a drive coil of the clutch 104. Likewise, the output from the inverter 210 is applied through a transistorized driver circuit 217 to a hold coil of the brake 106, whereas the output from the one-shot 212 is applied through the driver circuit 217 to a hold coil in the brake. The various waveforms appearing throughout the circuit of FIG. 14 for a single line advance are shown in FIG. 15, and for a multi-line advance are shown in FIG. 16.

The clutch 104 and the brake 106 each have two modes of operation, namely "drive" and "hold." For clutch drive, a high current is applied to the low resistance clutch coil for six to eight milliseconds duration to cause rapid acceleration of the tractor drive shaft. The clutch drive is turned on by a 0-1 transition of the ADV signal. At the same time, a low current is applied to the high resistance hold coil of the clutch to sustain tractor shaft velocity following initial acceleration from a dead stop. The hold current remains on until a specified number of lines have been moved.

A high current is applied to the low resistance brake drive coil of six to eight milliseconds duration to cause rapid deceleration of the tractor drive shaft when the ADV signal changes from 1 to 0. At the same time, a low current is applied to the high resistance brake hold coil to prevent motion of form while the printer is idle, or printing a line of data. Brake hold current is applied as soon as the power is turned on, and also by the 1-0 transition of the ADV signal.

As shown in the diagram of FIG. 1, the ADV fed to the circuit is first inverted by the inverter 202. The inverter output is "anded" with the paper runaway output from the flip-flop 208, and is inverted again by the inverter 210. In addition, the inverter 202 drives a 1.35

second RC time delay circuit. If the output from the inverter 202 remains at logic 1 level for 1.35 seconds, the delay circuit generates a logic 1 at its output which sets the paper runaway flip-flop 208. With the flip-flop 208 set, the "and" gate 204 is disabled, and the resulting output from the inverter 210 activates the brake and disengages the clutch.

A single line advance as shown in FIG. 15 is initiated when the controller drops the ADV signal to a logic 0 level. This causes the brake hold current to turn off and the clutch hold and drive currents to flow through the clutch coils. For a single line advance, the first STP pulse from the system of FIG. 12 causes the controller to switch the ADV signal back to logic 1, turning off the clutch hold and turning on the brake hold, and triggering the one-shot 212. Hence, the brake hold and drive currents are turned on. The brake drive current turns off after six to eight milliseconds. However, the brake hold current remains on until the next form advance command is received.

For a multi-line advance, the controller switches the ADV signal back to logic 1 (as shown in FIG. 16) after more than one STP pulse is sensed by the system of FIG. 12; that is, two pulses for two line advance, three pulses for three line advance, and so on. The clutch hold current remains turned on until the specified number of lines have moved, and then the above-described braking operations are initiated.

The invention provides, therefore, an improved high speed data processor line printer, which is capable of accurately and quickly printing bar codes on labels, or other forms, in a simple, precise and straightforward manner, and in a minimum of time. While a particular embodiment of the invention has been shown and described, modifications may be made. It is intended in the claims to cover the modifications which fall within the spirit and scope of the invention.

What is claimed is:

1. In a high speed line printer system which includes a frame; a print drum rotatably mounted on said frame and having a plurality of different bar code symbols engraved on the peripheral surface thereof in a plurality of different longitudinal rows angularly spaced around the periphery from one another, and with each row containing identical bar code symbols; a paper drive mechanism mounted on said frame for moving forms on a line-to-line basis past said print drum to be imprinted by said bar code symbols; impact hammer means mounted on said frame; control circuitry coupled to said impact hammer means for causing said impact hammer means to drive said forms against the bar code symbols on said print drum at controlled times; electrical signal generating means coupled to said paper advance mechanism for producing electric pulses representative of each line advance of said paper drive mechanism with respect to a first predetermined line per inch reference standard; a format control system mechanically coupled to said paper drive mechanism and to said generating means for generating electrical control signals indicative of advances of said forms by said paper drive mechanism through predetermined numbers of lines; the combination of an encoder mechanically coupled to said paper advance mechanism for generating an electric signal representative of each line of advance of said paper drive mechanism with respect to a second predetermined line per inch reference standard; logic circuitry electrically con-

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nected to said format control system and to said encoder for generating electric output signals selectively representative of the electrical control signals from said format control system and of said electric signal from said encoder; and control means coupled to said paper drive system and responsive to the output signals from said logic circuitry to stop the paper drive system at predetermined positions of the forms under the control of the format control system during one operating mode and under the control of the encoder during a second operating mode.

2. The high speed line printer system defined in claim 1, in which said control means responds to signals from

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said logic circuitry during the first operating mode to move the paper drive mechanism from one form to the next, and in which said control means responds to the output signals from said logic circuitry during the second operating mode to move the paper drive mechanism to selected lines within the individual forms.

3. The high speed line printer system defined in claim 1, in which said control means responds to output signals from said logic circuitry during the second operating mode to cause each of said bar code symbols to be imprinted in an overlapping manner during each of a plurality of successive print operations.

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