

# United States Patent

**[11] 3,625,142**

- |      |           |                                                                       |
|------|-----------|-----------------------------------------------------------------------|
| [72] | Inventor  | <b>Aaron D. Bresler</b><br><b>Merrick, N.Y.</b>                       |
| [21] | Appl. No. | <b>45,008</b>                                                         |
| [22] | Filed     | <b>June 10, 1970</b>                                                  |
| [45] | Patented  | <b>Dec. 7, 1971</b>                                                   |
| [73] | Assignee  | <b>Datscript Terminal Equipment Corp.</b><br><b>Lindenhurst, N.Y.</b> |

- |           |         |                   |          |
|-----------|---------|-------------------|----------|
| 2,757,604 | 8/1956  | Von Glahn .....   | 101/93 C |
| 2,930,316 | 3/1960  | Hagen .....       | 101/93 C |
| 2,976,801 | 3/1961  | Dirks .....       | 101/93 C |
| 3,190,957 | 6/1965  | Foley et al. .... | 178/30   |
| 3,330,208 | 7/1967  | Eckel .....       | 101/93 C |
| 3,418,427 | 12/1968 | Jones .....       | 178/30   |
| 3,476,044 | 11/1969 | Wasserman .....   | 101/93 C |

*Primary Examiner*—William B. Penn  
*Attorney*—James and Franklin

- [54] HIGH-SPEED PRINTING APPARATUS HAVING  
SLIDABLY MOUNTED CHARACTER-FORMING  
ELEMENTS FORMING A DOT MATRIX  
47 Claims, 14 Drawing Figs.**

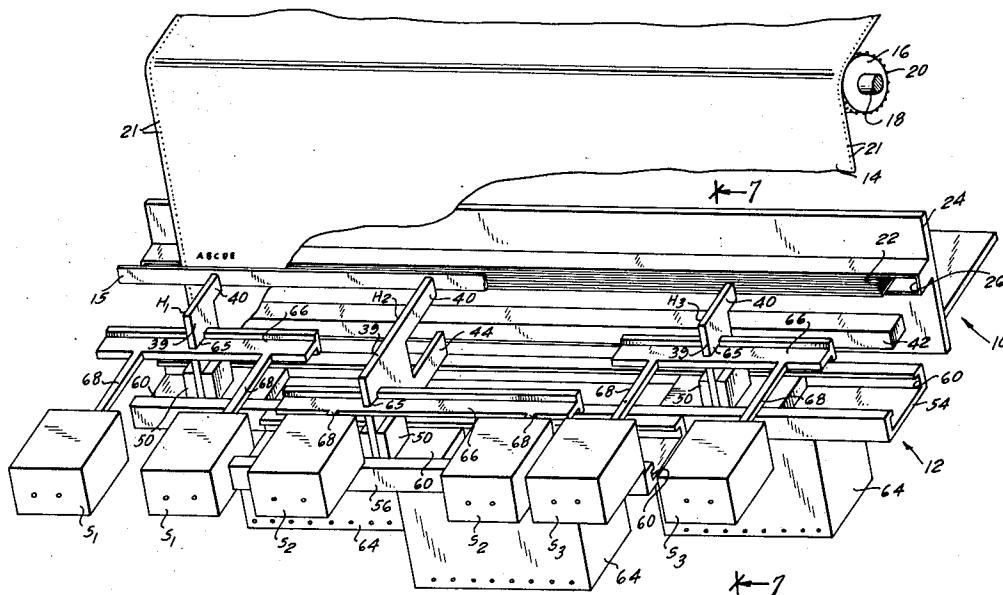
- |      |                      |                                                                 |
|------|----------------------|-----------------------------------------------------------------|
| [52] | U.S. Cl.....         | 101/93 C,<br>197/1, 346/78, 178/30                              |
| [51] | Int. Cl.....         | B41j 1/16                                                       |
| [50] | Field of Search..... | 101/93 C,<br>93 R, 109; 197/1, 17, 1.5, 1.6; 346/50, 78; 178/30 |

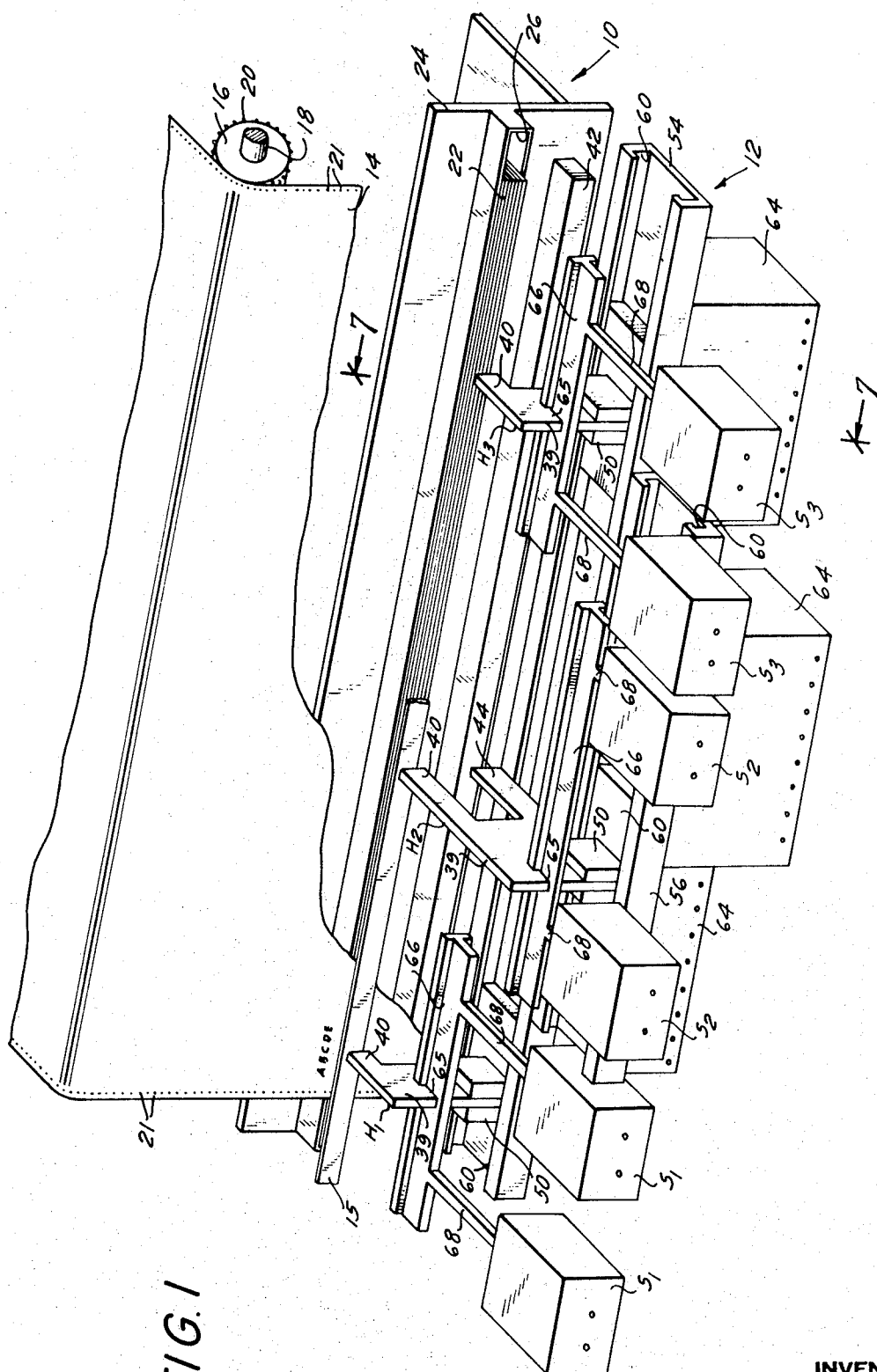
[56] **References Cited**

## UNITED STATES PATENTS

- |           |         |             |          |
|-----------|---------|-------------|----------|
| 2,681,614 | 6/1954  | Rast .....  | 101/93 C |
| 2,694,362 | 11/1954 | Paige ..... | 101/93 C |

**ABSTRACT:** A high-speed printer apparatus characterized by a font assembly having a plurality of slidably mounted character-forming elements forming a dot matrix. The dot projections are so arranged on said elements that any given character may be formed on said matrix at any given character position by small linear relative movements of such elements. Hammer means are mounted opposite the font assembly and are movable to said character positions and actuated to press the character image onto the paper by means of a ribbon. Logic means are provided to control the position of the character-forming elements and hammer means and the sequence of operation, all in response to data input signals.





**INVENTOR**  
AARON D. BRESLER

BY  
*James J. Sullivan*  
ATTORNEY

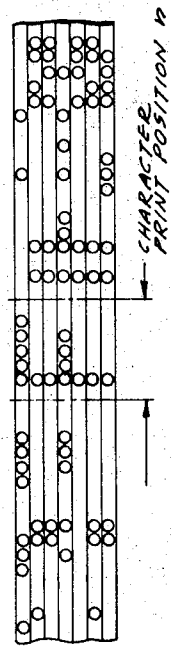
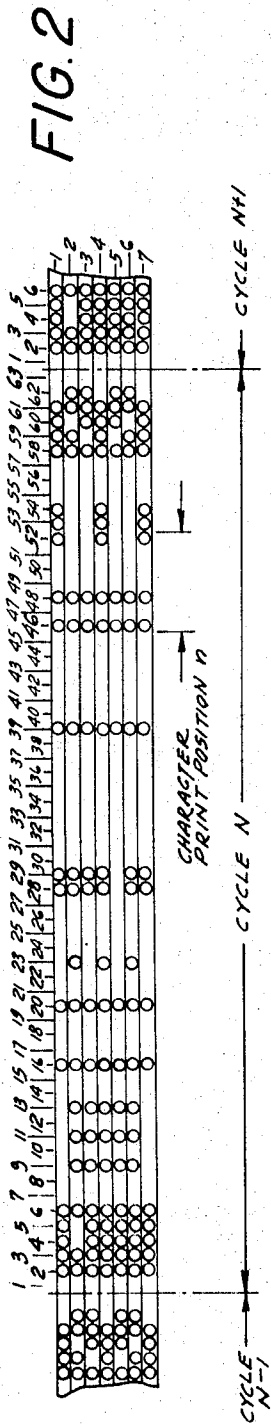


**FIG. 4**

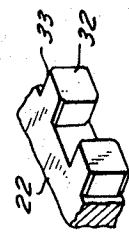
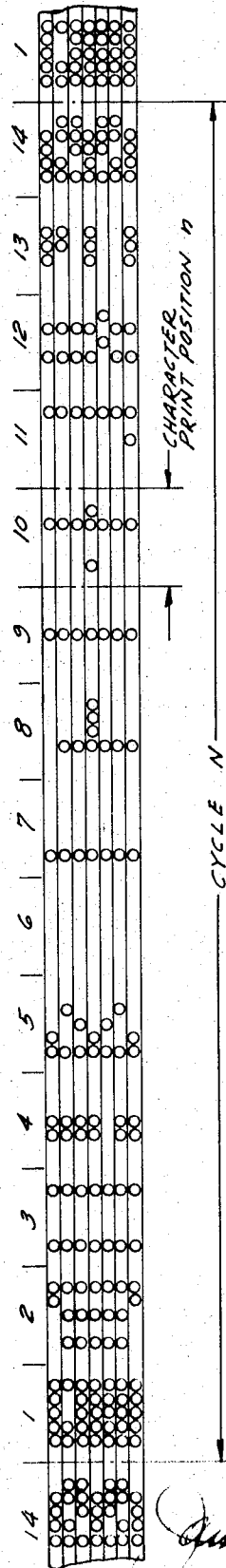


**FIG. 5**

INVENTOR  
AARON D. BRESLER

BY *[Signature]*  
ATTORNEY

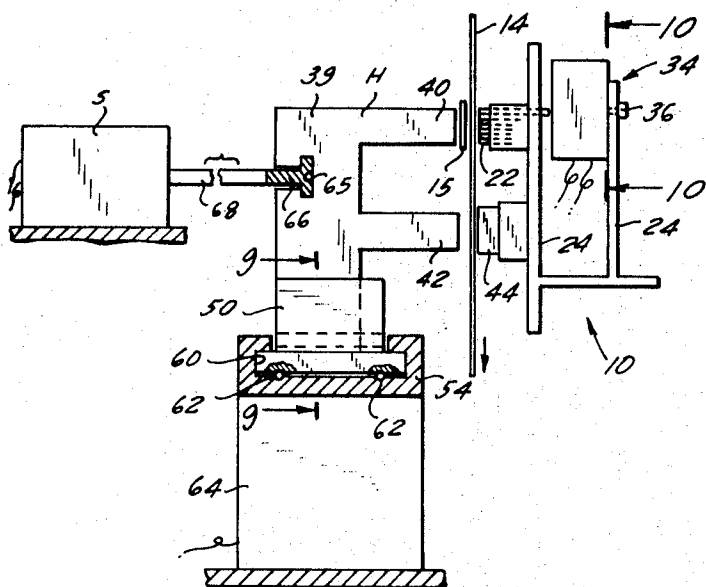


FIG. 7

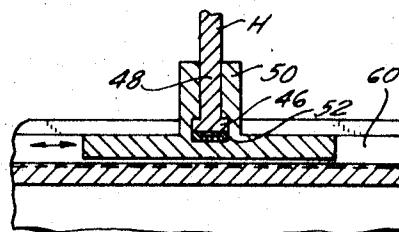


FIG. 9

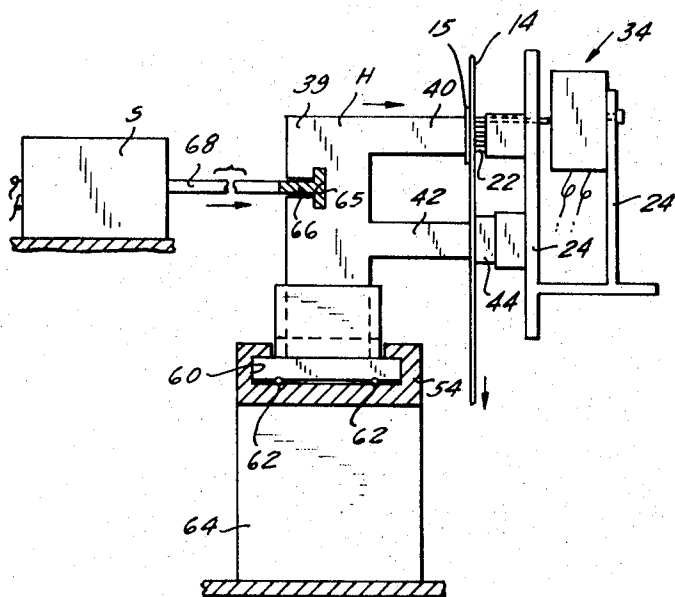


FIG. 8

INVENTOR  
AARON D. BRESLER

BY *James & Stanton*  
ATTORNEY

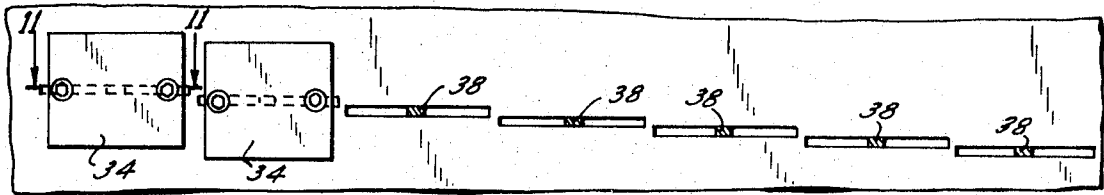


FIG. 10

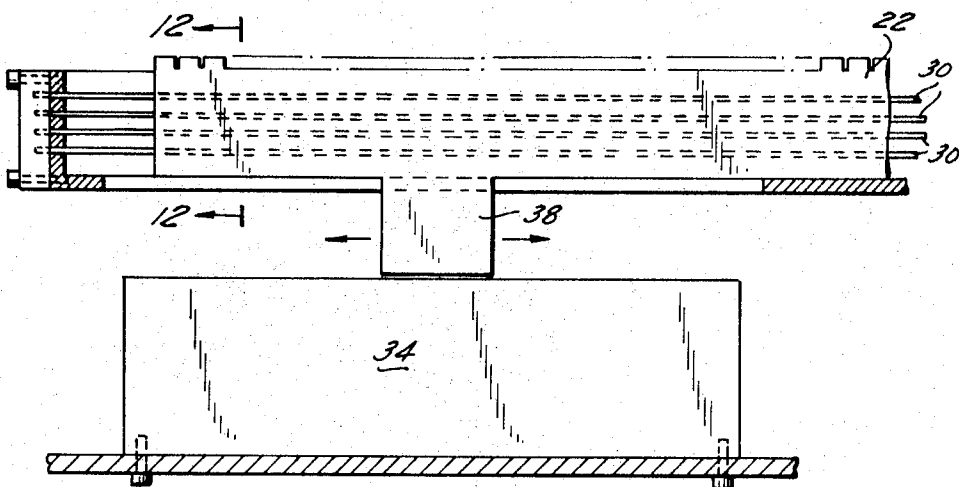


FIG. 11

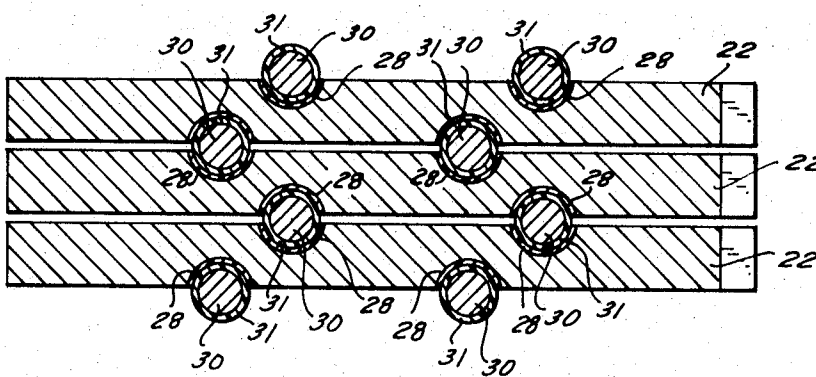
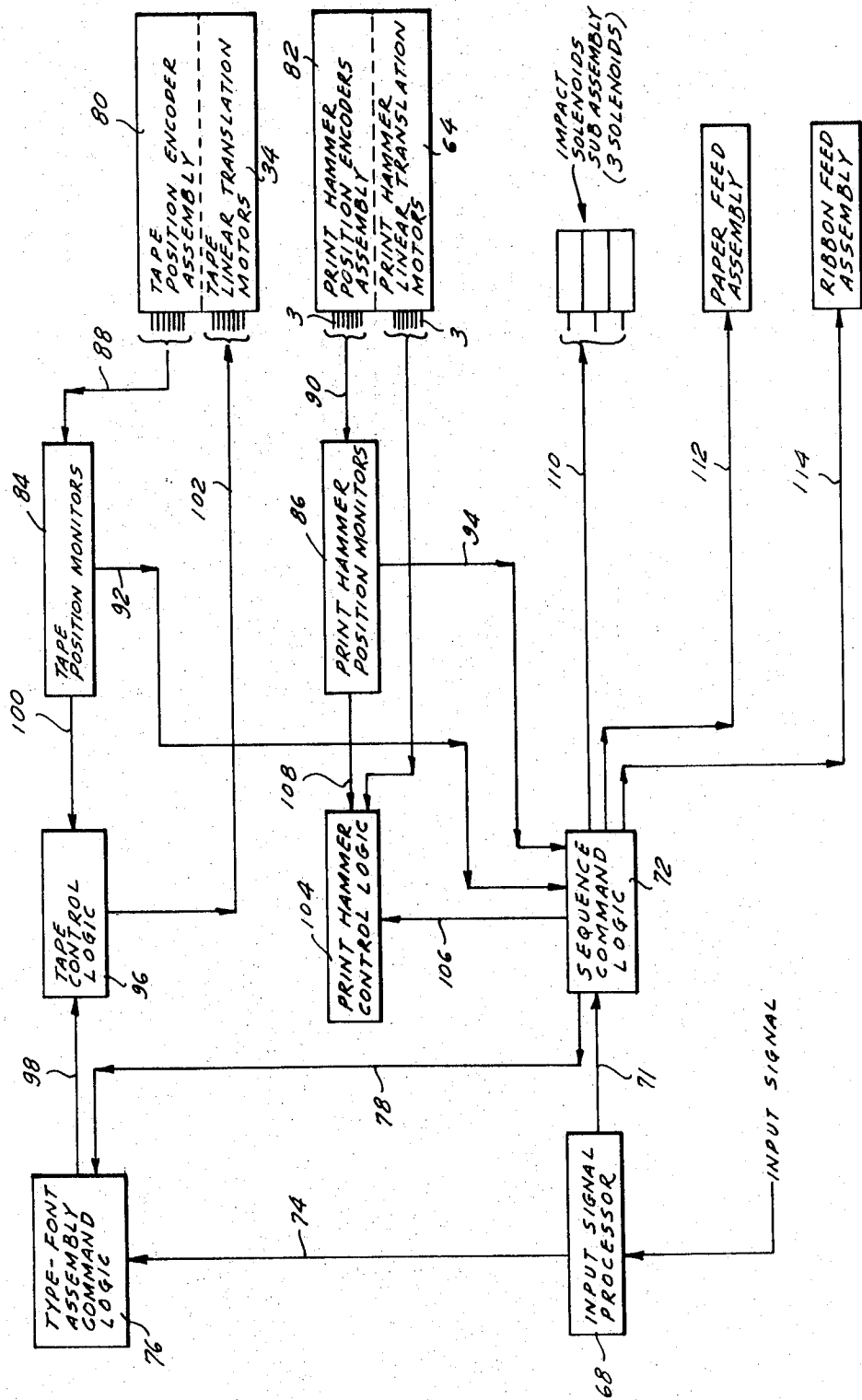


FIG. 12

INVENTOR  
AARON D. BRESLER

BY *James H. Hirsch*  
ATTORNEY

FIG. 13



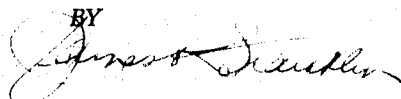
INVENTOR  
AARON D. BRESLER

BY *[Signature]*  
ATTORNEY

A B C D E F G H I J K L M  
N O P Q R S T U V W X Y Z  
0 1 2 3 4 5 6 7 8 9  
. , : ; ' " ! ? @ \$ % & \*  
/ \ ( ) [ ] + - = < > \* + =

*FIG. 14*

INVENTOR.  
AARON D. BRESLER

BY  
  
ATTORNEY

# **HIGH-SPEED PRINTING APPARATUS HAVING SLIDABLY MOUNTED CHARACTER-FORMING ELEMENTS FORMING A DOT MATRIX**

The present invention relates to high-speed printing apparatus, and particularly to such apparatus designed for use with high-speed data-processing equipment.

Known data printout mechanisms are of several types. The most common and oldest type utilizes a font assembly comprising individual elements each having a typeface corresponding to the desired character to be printed. Means are provided for positioning a given element opposite the space on the paper and impressing an image by means of an inked ribbon or the like on the paper by impact with the typeface of said element. This system is used in most high-speed typewriter readouts.

With the advent of high-speed data processing, it became obvious that the speed limitations on such apparatus would be determined by the available rate of data printout. Accordingly, mechanisms have been designed to increase the speed of positioning and actuation of single typeface elements of the foregoing type.

Data-processing equipment has now advanced to the point where such single typeface printout systems are no longer capable of operating at the speeds at which output data is produced. Accordingly, new methods have been devised to further increase the speed of data printout. One of these methods involves the use of so-called built-up characters, that is, the font assembly consists of a plurality of character-building elements and a particular character is formed on the sheet by moving said elements to a character-forming position either sequentially or simultaneously. These mechanisms have in the past been rather unsatisfactory due to their complexity of operation. In addition, such mechanisms are actuated by assemblies, such as complicated gearing and the like, which are space consuming, prone to failure, and expensive to manufacture and maintain.

Recently, in order to minimize the mechanical movement involved in data printout systems, alternate nonmechanical printing methods such as electrostatic or thermal printing and the like have been incorporated in such systems. Again, however, the expense of these mechanisms has proved prohibitive. Moreover, such mechanisms usually require the use of expensive paper and are unable to produce simultaneous multiple copies.

Accordingly, it is a primary object of the present invention to provide a high-speed printing apparatus which is simple in operation, inexpensive to manufacture and maintain and does not require the use of special paper.

More particularly, it is an object of the present invention to provide a high-speed printer of the built-up character type utilizing a novel dot matrix font assembly to provide simplicity and high speed of operation.

It is a still further object of the present invention to design a font assembly for a high-speed printing apparatus wherein the required movement of the character-forming elements is significantly reduced to provide higher speeds of operation.

It is still another object of the present invention to design a font assembly of the type described which may be housed in an extremely small space and which utilizes short high-speed movements to form any one of a variety of characters to be printed.

It is still another object of the present invention to provide a high-speed printing apparatus of the type described in which the character-forming elements and hammer means may be quickly and accurately moved to the desired character print position, the hammer actuated and the paper fed, all under the control of a high-speed logic means receiving an input command signal.

To these ends the apparatus of the present invention comprises a series of elongated character-forming elements each having a series of dot projections on their operative printing surfaces arranged to form a dot matrix. The character-forming elements are mounted for slidable movement relative to each

other and the arrangement of dot projections thereon is such that only a small linear movement of each element is necessary in order to realign said dot projections from a first matrix forming a given character at a given character print position to a second matrix forming the same or a different character at another character print position.

A hammer assembly comprises one or more hammers each movable a given number of character print positions and means to actuate said hammers to impact on a sheet of paper and ribbon means disposed between the font assembly and the hammer assembly. Logic means are provided for commanding the position of the character-forming elements and the hammers and controlling the sequence of movements thereof and of the paper and ribbon feed.

To the accomplishment of the above and to such other objects as may hereinafter appear, the present invention relates to a high-speed printing apparatus and font assembly therefor as defined in the appended claims and as described in this specification taken together with the accompanying drawings in which:

FIG. 1 is a perspective view of a high-speed printing apparatus in accordance with this invention;

FIG. 2 is a schematic illustration of a fragment of the operative surfaces of the character-forming elements of one embodiment of the font assembly of the present invention showing a dot matrix made up of one cycle of dot projections on each element;

FIG. 3 is a schematic view showing a portion of the dot matrix of FIG. 2, the character-forming elements having been moved to a position forming the character "F;"

FIG. 4 is a schematic illustration of the operative surfaces of the character-forming elements of a second embodiment of the font assembly of the present invention showing a dot matrix made up of one cycle of dot projections on each element;

FIG. 5 is a schematic view showing a portion of the dot matrix of FIG. 4, the character-forming elements having been moved to a position forming the character "F;"

FIG. 6 is a fragmentary perspective view, greatly enlarged, showing the individual dot projections on the character-forming elements;

FIG. 7 is a cross-sectional view taken generally along the line 7—7 of FIG. 1, showing the font assembly and hammer assembly with their associated actuating mechanisms, with the hammer in its cocked position;

FIG. 8 is a cross-sectional view similar to FIG. 7, showing the hammer in its impact position;

FIG. 9 is a cross-sectional view taken along the line 9—9 of FIG. 7 and showing the slidable hammer mounting;

FIG. 10 is a cross-sectional view taken along the line 10—10 of FIG. 7 showing the relative positions of the actuating mechanisms for the character-forming elements;

FIG. 11 is a plan view, partly in section, taken along the line 11—11 of FIG. 10;

FIG. 12 is an enlarged cross-sectional view taken along the line 12—12 of FIG. 11 and showing the support wires along which the character-forming elements are adapted to ride;

FIG. 13 is a schematic block diagram illustrating the logic means for controlling the position of the various elements and the sequence of operation.

FIG. 14 illustrates the 64 characters adapted to be printed by the apparatus of the present invention.

As best shown in FIG. 1, the high-speed printing apparatus of the present invention consists of a font assembly generally designated 10 and a hammer assembly generally designated 12. Paper 14 is fed through the apparatus between font assembly 10 and hammer assembly 12 by means of a sprocket feed mechanism comprising a roller 16 mounted on a shaft 18 rotatably driven by suitable means (not shown). The paper drive means is, of course, programmed to feed paper intermittently in increments corresponding to one or more character print lines. Roller 16 is provided with sprockets 20 at either end adapted to be received in mating holes 21 at the outer

edges of paper 14. Suitable means may be provided on the underside of the apparatus for receiving and processing the printed paper. For example, the paper may be initially folded and allowed to refold on the underside of the apparatus along the existing fold lines in a neat pile in a receptacle provided for that purpose. Moreover, the paper may be perforated into segments along lines perpendicular to the feed direction and the apparatus correspondingly programmed to print one cycle or segment of data on each segment of paper, the printed paper being subsequently separated into individual data sheets. The method of programming the apparatus in this manner will become more apparent in connection with the control logic means to be described hereinafter. An inked ribbon 15 is intermittently fed between the paper 14 and the hammer assembly 12 under the control of the same logic means.

The entire arrangement shown in FIG. 1 is, of course, mounted on a suitable frame (not shown).

The font assembly of the present invention comprises a plurality of character-forming elements 22 mounted in a suitable housing 24. As best shown in FIG. 1, character-forming elements 22 are in the form of thin metal strips or tapes mounted in stacked relation and having their operative print surfaces aligned and extending out from a slot 26 in housing 24.

As best seen in FIG. 2, the operative print surfaces of each tape 22 comprises a series of dot print positions along its lengthwise edge. Each dot print position is characterized by the presence or absence of a dot projection 32, two of such dot projections being shown in FIG. 6. As seen there, dot projections 32 are in the form of discrete squares jutting out from the edge of tape 22 and having their edges slightly chamfered at 33.

The operative print surfaces of tapes 22 cooperate to form a dot matrix, adapted upon relative movement of said tapes to form any one of a plurality of characters at any one of a number of character print positions along the length of housing 24.

For this purpose, tapes 22 are mounted in slidable relationship within slot 26 in housing 24. As best shown in FIGS. 11 and 12, each tape 22 is provided with grooves 28 in its top and bottom surfaces adapted to receive support wires 30 which are suspended at either end on housing 24 within slot 26. Each wire is disposed between two adjacent tapes and is seated in matching grooves 28 on the top and bottom surfaces thereof respectively. As best shown in FIG. 12, grooves 28 are formed in the shape of a circular arc slightly shallower than a semicircle so that wires 30 (having a circular cross section) serve to separate the surfaces of adjacent tapes. Wires 30 and grooves 28 preferably are each coated with a low-friction material 31 such as Teflon or the like. Thus wires 30 function as both support bearings and guide wires along which tapes 22 are adapted to slide within slot 26 in housing 24. As seen in FIG. 1, slot 26 is somewhat longer than tapes 22 to accommodate such slidable movement.

It will be apparent that the arrangement of dot projections on each character-forming element will be determined in accordance with the particular characters sought to be produced by the font assembly.

Both embodiments of the font assembly of the present invention have been designed to produce 64 characters comprising the dense subset of the American Standard Code for Information Interchange (ASCII). As shown in FIG. 14, these consist of the letters A through Z, Arabic numerals "0" through "9" and various other symbols.

FIG. 2 illustrates schematically one embodiment of the font assembly of the present invention. As there shown, a dot matrix is formed from seven character-forming elements or tapes 22 individually designated 1-7, in stacked relationship. The arrangement of dot projections on each tape 22 is cyclic, 1 cycle comprising 63 dot print positions, i.e., the arrangement there shown is repeated every 63 dot print positions. Thus, if each tape 22 is considered a row and the vertically aligned dot print positions on each of the seven tapes is considered a column, 1 cycle of the dot matrix of this embodiment

comprises 7 columns and 63 rows or 441 dot print positions. Each character is adapted to be formed from a portion of said matrix 5 columns wide, i.e., 7 dot print positions high and 5 dot print positions across. In practice, a space of 2 dot print positions is left between two successive characters on a print line. Thus, each character print position is effectively 7 dot print positions or dot widths wide, the first and last dot print position being blanked. In a typical case, the apparatus will be designed to print 81 characters on a line or, in other words, each printed line will comprise 7×81 or 567 dot print positions. In this first embodiment each tape 22 is adapted to slide along wires 30 in increments of 1 dot print position or multiples thereof.

It will be apparent that the particular arrangement of dot projections on each of the seven tapes 22 adapted to form the desired characters is a matter of choice. The arrangement shown in FIG. 2 is believed to be the most desirable from the standpoint of overall speed of operation, taking into account the particular dot makeup of each character to be printed.

It will also be apparent that with the above arrangement each tape will theoretically never be more than 31 dot print positions away from its desired or next commanded position. Thus, by utilizing that applicable portion of each tape 22 (comprising 5 operative dot print positions) nearest to the appropriate character print position regardless of which cycle said nearest applicable portion occurs in, the maximum movement of tapes 22 will be 31 dot print positions. However, this theory is based on a mode of operation which for linear tapes has proved to be quite impractical. With this mode of operation, tapes 22 would have to be realigned periodically or tapes of infinite length (or an endless tape) would be needed since there would be no limit to the total movement of a tape to the right or left of a reference position and such tapes might stray in either direction indefinitely.

Accordingly, the contemplated mode of operation is to limit each tape 22 to a total net movement within 1 cycle. For this purpose a reference or standby position for each tape is established such that the combined movements of a tape to the left and right of its reference position never exceeds 62 dot print positions. For purposes of the following illustration it will be assumed that the tapes as shown in FIG. 2 are each in their extreme left-hand position with respect to their reference positions. Thus, the maximum movement of any given tape 22 necessary to form any given character starting from the positions shown in FIG. 1 at any given character print position is 62 dot print positions. Accordingly, in order for the font assembly to print 81 characters (567 dot print positions or 9 cycles) to a line, each tape 22 is provided with 10 cycles (630 dot print positions) on its operative printing surface.

By way of example, FIG. 3 illustrates the formation of the character "F" from the dot matrix of FIG. 2. Referring to each of the 63 dot print positions in a cycle by number, it can be seen that the operative print positions for the character "F" consists of positions 1-7 on tape 1, positions 57-63 on tape 4 and positions 38-44 on tapes 2, 3, 5, 6 and 7. In practice, the initial position of each tape 22 will be determined by the previously printed character and its character print position. The logic is accordingly programmed to move tapes 22 from their initial positions to bring the aforementioned dot print positions into alignment at the desired character print position. For the present example, however, it is assumed that the initial position of tapes 22 is that shown in FIG. 2.

Referring now to FIGS. 2 and 3 the character "F" is formed at a character print position *n* which is arbitrarily shown corresponding to dot print positions 46-52 on all seven tapes 22 in their initial positions (FIG. 2). Thus, the nearest applicable portion of each tape 22 will be moved to character print position *n* without, however, moving any tape beyond its 1-cycle total movement limit. In the present example this means all tapes must be moved to the right. Accordingly, tape 1 will be moved 45 dot widths to the right, tape 4 will be moved 52 dot widths to the right, and tapes 2, 3, 5, 6 and 7 will each be moved 8 dot widths to the right to form the character "F" il-

lustrated in FIG. 3. It will be noted that the nearest applicable portion of tapes 1 and 4 occurred in cycles  $N+1$  and  $N$  respectively. However, utilization of these nearest portions would have involved a movement of such tapes to the left which, in accordance with our example, is prohibited by the rule limiting total tape movement. Thus, the corresponding portions of tapes 1 and 4 in cycles  $N$  and  $N-1$  respectively were utilized.

In practice, each dot print position is typically 0.014 inch wide so that the largest movement involved in the transition from the dot matrix shown in FIG. 2 to that shown in FIG. 3 is 52 dot widths or 0.728 inch ( $52 \times 0.014$  inch). The maximum possible movement of any tape for any given formation using the foregoing mode of operation is thus  $62 \times 0.014$  or 0.868 inch.

Accordingly, it can be seen that the dot matrix font assembly of FIG. 2 is designed to provide a high-speed formation of any one of 64 discrete characters with a maximum linear movement of less than 1 inch for each character-forming element 22.

FIG. 4 illustrates a second embodiment of a dot matrix for use with the font assembly of the present invention. As there shown, the dot print positions on each tape 22 are arranged in groups of 7, the first and last position of each group being blanked. Thus, in contrast to the first embodiment described above, the tapes 22 are adapted to be moved in increments of 7 dot widths (i.e. 1 character width) or multiples thereof so that each character is formed by the alignment of a given group of dot print positions on each tape 22. As shown in FIG. 4, 1 cycle of dot projections consists of 14 such groups of 7 or 98 dot print positions. Again the maximum movement of each tape 22 from an established reference position is limited to a combined movement to the right and left of a reference position of 13 groups (91 dot widths). Accordingly, to print 81 characters to a line, each tape is provided with 95 such groups or 1 cycle more than the width of a printed line.

For the purposes of this example it will again be assumed that each tape is shown in FIG. 4 in its extreme left-hand position the net movement (combined movements to the left and right of a reference position) of each tape being limited to 13 groups (91 dot print positions). FIG. 5 shows the character "F" formed from the dot matrix of FIG. 4. Referring to each group by number, it will be seen that the character "F" requires the alignment of group 1 on tape 1, group 14 on tape 4 and group 7 on tapes 2, 3, 5, 6, and 7. Thus, for example, if the character position  $n$  is arbitrarily picked to be that corresponding to the initial position of group 10 on all tapes as shown in FIG. 4, tape 1 would be moved 9 groups (63 dot widths) to the right, tape 4 would be moved 10 groups (70 dot widths) to the right and tapes 2, 3, 5, 6, and 7 would be moved 3 groups (21 dot widths) to the right. Again it will be noted that, in accordance with the rule limiting total tape movement, groups 1 and 14 in cycles  $N$  and  $N-1$  respectively, rather than the nearest corresponding groups in cycles  $N+1$  and  $N$  respectively, were utilized.

It will be apparent that the dot arrangement of FIG. 4 involves a greater maximum movement of tapes for forming a sequence of characters. Thus, the maximum movement in this case is 91 dot widths ( $0.014 \times 91$ ) or 1.274 inches. However, by providing only 14 discrete selectable positions in each cycle (as opposed to 63 in the previous embodiment) the complexity and cost of the control logic may be reduced considerably. This embodiment, therefore, sacrifices some speed for simplicity of operation.

As best shown in FIG. 7, the font assembly is actuated by a drive mechanism generally designated 34 mounted on housing 10 directly behind slot 26 by fastening means 36. While several types of drive mechanisms may be used, it has been found that mechanisms of the type known as linear translation motors are most effective for this purpose. Motors of this type are adapted to rapidly position a metallic member by selectively actuating a plurality of electromagnets under a magnetic platen. One advantage of motors of this type is that there need be no mechanical connection between the motor and the

driven part. In addition, such motors are adapted to produce extremely small, accurate, incremental linear movements with the number of increments of each discrete movement being variable by electronic control signals. An example of one such motor is that disclosed in U.S. Pat. No. 3,376,578 issued on Apr. 2, 1968 to Bruce A. Sawyer. Each tape 22 is driven by its own motor 34, only one such motor (driving the top tape 22) being illustrated in FIGS. 7 and 8 for the sake of simplicity.

As best shown in FIGS. 10 and 11, each tape 22 is provided with a tongue 38 which is suitably positioned with respect to motor 34 in operative driving relationship (see arrows in FIG. 11). As illustrated in FIG. 10, tongues 38 extend from the rear of each of the seven tapes 22 in staggered relationship to accommodate seven motors in correspondingly staggered relationship. In the event the motors used are too large to be accommodated by the arrangement shown, they may be staggered in depth or in any other convenient manner. It should be noted that each motor 34 must be adapted to move its corresponding tape 22 within 1 cycle of its reference position.

Once tapes 22 are in a position forming the desired character at a given character print position, the printing surface of the operative portion of the matrix is adapted to be impacted against paper 14 and inked ribbon 15 to produce the character image on paper 14. For this purpose hammer assembly 12 comprises a plurality of hammers H, three such hammers being shown in the preferred embodiment and designated H1, H2 and H3, respectively. As best shown in FIG. 7, each hammer is "F"-shaped and comprises a base portion 39 and two legs 40 and 42 extending horizontally toward font assembly 10. The upper leg 40 comprises the operative impact or hammerhead adapted to engage ribbon 15 and press it against paper 14 and the operative printing surfaces of tapes 22. Housing 24 is provided with a bumper strip 44 of resilient material such as hard rubber or elastic metal below slot 26, aligned with the lower legs 42 of hammers H. Bumper strip 44 serves two purposes: first, it provides an impact force on leg 42 to counterbalance the impact force exerted by tapes 22 on leg 40 which would otherwise result in a damaging torque on hammer H and its actuating mechanisms; second, the resiliency of bumper strip 44 assists in rapidly returning hammers H to their cocked positions after impact.

Referring to FIG. 9 the base portion 39 of hammer H is provided with a flange 46 and is slidably mounted within a correspondingly shaped slot 48 in a mounting in the form of an inverted "T"-shaped shoe 50. The bottom surface of slot 48 is lined with a low-friction material such as Teflon or the like to provide a low-friction bearing surface 52 upon which hammer H is adapted to rapidly reciprocate to intermittently impact against font assembly 10 at the desired character print position.

Each hammer is adapted to be moved longitudinally (as viewed in FIG. 1) along a given portion of font assembly 10, the hammer H2 taking over where hammer H1 leaves off and hammer H3 taking over where hammer H2 leaves off. In this manner, during the printing of a given line each hammer H will have sufficient time to return to its initial left-hand position in preparation for printing of the next line. Since a line is printed from left to right and since a printed line may terminate short of the 81st character position, it is desirable to design the left-hand hammer H1 to travel a substantially smaller distance along font assembly 10 than hammers H2 and H3. Thus, if a printed line terminates after a character printed by hammer H1, the return time of hammer H1 will be small and there will be little or no delay in the commencement of the next line of print.

In order to provide for the longitudinal movement of hammers H, a track 54 is mounted below the hammers parallel to font assembly 10. As best shown in FIGS. 7 and 8, track 54 is provided with a channel or slot 60 adapted to slidably receive the base of shoe 50. Bearing means 62 are provided between shoe 50 and the lower surface of slot 60 to facilitate rapid sliding engagement. As best seen in FIG. 1, shoes 50 carrying hammers H1, and H3 are both slidably mounted on track 54

in this manner. A second track 56 identical to track 54 is provided forwardly (out of the paper as viewed in FIG. 1) of track 54 and is adapted to mount shoe 50 carrying the middle hammer H2 in the same fashion. Legs 40 and 42 of hammer H2 are accordingly designed longer than their counterparts on hammers H1 and H3 so as to span track 54. With this arrangement, hammers H2 and H3 are adapted to take over printing from hammers H1 and H2, respectively, in the next character position without interference of their respective shoes 50.

The positions of hammers H1, H2 and H3 along tracks 54 and 56 are controlled by individual linear drive means generally designated 64 (see FIG. 7). Drive means 64 are preferably linear translation motors of the type already described with respect to the actuation of character-forming tapes 22. As illustrated in FIG. 7, motor 64 is mounted directly under track 54 and is adapted to move shoe 50 along track 54 by means of selectable actuation of electromagnets as previously described. In the case illustrated track 54 and shoe 50 would be made of suitable material to provide such magnetic actuation. Alternatively, shoe 50 might be provided with a tongue extending through a longitudinal slot in track 54, the tongue being actuated magnetically or by suitable physical drive means. In either case, shoes 50 and thus hammers H must be movable in accurate increments of 1 character width (7 dot widths) and multiples thereof.

Each hammer H is provided with a "T"-shaped slot 65 at its base portion 39 slidably receiving a correspondingly "T"-shaped impact bar 66 which is adapted to reciprocate its respective hammer within shoe 50 toward and away from font assembly 10. Impact bars 66 are in turn actuated through arms 68 by a pair of solenoids S, three such pairs of solenoids S1, S2 and S3 being shown in FIG. 1 adapted to actuate hammers H1, H2, and H3, respectively. Two solenoids are provided for each impact bar 66 to produce a balanced impact force on such bars to thereby prevent an undesirable torque which might produce binding between slots 65 and bars 66. As shown in FIG. 7, the impact heads on hammers H are spaced only a very small distance from the operative printing surface of font assembly 10. Accordingly, solenoids S are designed to produce an extremely rapid short reciprocating stroke, the impact position of hammers H being illustrated in FIG. 8.

The operation of the foregoing apparatus will now be apparent. When a character is to be printed at any one of the 81 character positions on paper 14, each of the seven tapes 22 is moved by means of motors 34 a distance such that the applicable dot arrangement appears at such character position, the aligned dot projections on each tape forming the desired dot matrix. At the same time the hammer H operating along the applicable span of character positions is moved by means of motors 64 along track 54 or 56 and impact bars 66 to the applicable character position opposite the operative portion of the dot matrix. The hammer H is then rapidly reciprocated by solenoid S within slot 48 in shoe 50 to impact against ribbon 15, paper 14, and the operative dot matrix on font assembly 10. The desired character is thus imprinted on paper 14. This process is repeated for the next character to be printed. As each hammer reaches its terminal right-hand position, it is rapidly returned to its initial left-hand position by means of its drive motor 64 and the next hammer, already disposed in the next adjacent character position, begins actuation. Ribbon 15 is fed periodically in any desired manner to provide a fresh ribbon portion at the applicable character print position during each impact. As the end of a printed line is reached, paper 14 is fed by sprocket roll 16 the desired number of lines and hammer H1 begins printing the next line.

The aforementioned procedure is carried out at extremely high speeds under the control of electronic logic means. FIG. 13 illustrates schematically the operation of a preferred embodiment of such logic means, the detailed circuitry being apparent to those skilled in the art and, therefore, omitted for the sake of simplicity. As there shown, the logic is adapted to control all the aforementioned operations in accordance with a data input signal.

It should be noted that additional logic may be needed to incorporate the printing apparatus of the present invention into a complete communications terminal. However, the present description is limited to the operation of the printer itself as many possibilities of such incorporation will be apparent to those skilled in the art.

When, as will usually be the case, the present apparatus is used in connection with the printout from high-speed electronic data-processing equipment the input signal will usually be in the form of a plurality of binary data signals representing the data to be printed in the desired sequence. This raw data signal must be processed and converted into a form intelligible for the purpose of commanding the various operations of the printing apparatus. Accordingly, an input signal processor 68 is provided for this purpose. Processor 68 is adapted to receive and store incoming data and translate such data into appropriate command signals. In the present embodiment the command signals are classified into two types: (1) mechanical commands, involving a positioning of the hammers (i.e. carriage return, space, tab, etc.) or paper (line feed) but not a printing operation, and (2) print commands, involving the printing of a particular character at a given character print position. The processed mechanical and print command signals are transmitted via lead 71 to a sequence command logic means 72. Sequence command logic 72 is the master command logic and is programmed to accept processed input signals and to transmit control signals to the appropriate control logic systems in the proper sequence. In addition, the print command signals are transmitted via lead 74 to the type font assembly command logic 76. At this point the print command signals are further broken down into character commands and location commands. Thus command signals transmitted via lead 74 are character commands, i.e., they contain instructions only as to the character to be printed. The location or character print position at which such character is to be printed (location command) emanates from sequence command logic 72 which is programmed to provide spacing between individual words, align columns of numerical data, paragraph, etc.

In practice, the type font assembly control logic, in response to character commands, is programmed to read out from memory data corresponding to the required position of each of the seven tapes for forming a given character at a reference character print position. This data signal is then amended by means of a shift register under the control of the sequence command logic to add or subtract that number of character print positions defining the difference between the reference character print position and the commanded character print position. While it is possible for all commands to be directly transmitted to the proper control logic systems through sequence command logic 72, the system illustrated permits the initiation of print commands simultaneously with the execution of mechanical commands. Thus, input processor 68 is adapted to store up to four or five sequential data input signals. If the next command to be executed is a mechanical command, the processor will "look ahead" to the next subsequent print command and transmit the corresponding character command via lead 74 to the type font assembly command logic 76. Sequence command logic 72 will in turn transmit the appropriate location command to font assembly command logic 76 which initiates the appropriate tape-positioning commands required to print the commanded character at the desired location.

The motor assemblies for both the tapes 22 and hammers H are provided with position-encoding subassemblies 80 and 82 respectively, comprising position encoder means for each tape and hammer respectively. These position signals are transmitted to tape and hammer position monitors 84 and 86, respectively, via leads 88 and 90, respectively. These position monitors are adapted to provide continuous reference data on current tape and hammer position and in addition to transmit an initiation signal to the sequence command logic 72 via leads 92 and 94, respectively, when the tapes and hammers have reached their commanded positions.

Tape movement is controlled by the tape control logic designated 96, which receives tape position command signals from type font assembly command logic 76 via lead 98 and current tape position signals from tape position monitors 92 via lead 100. The commanded position is compared to the current position of each tape 22 and a tape control signal is transmitted via lead 102 to tape linear translation motors 34 to move each of the seven tapes to their commanded positions.

Hammer positioning is controlled by hammer control logic 104 which receives hammer position command signals from sequence command logic 72 via lead 106 and current hammer position signals from hammer position monitors 86 via lead 108. The commanded position is compared to the current position and a hammer control signal is transmitted to hammer linear translation motors 64.

If the command is a print command, the sequence command logic 72, upon receipt of initiation signals from tape and hammer position monitors 84 and 86, will transmit an impact signal via lead 110 to the impact solenoid assembly to actuate the proper impact solenoid.

Sequence command logic 72 is also adapted to control the paper and ribbon feed assemblies in any desired manner via leads 112 and 114, respectively. For example, the sequence command logic 72 would normally be programmed to initiate ribbon feed a given number of character print positions when a particular character print position is reached. Likewise, paper 14 would normally be fed one line after the 81st character print position but this would be variable in accordance with the input data.

It will be apparent from the foregoing that a printing apparatus has been designed to print data at extremely high speeds utilizing a reliable and accurate mechanical mode of operation. By utilizing a dot matrix font assembly, it is possible to print any desired sequence of characters utilizing a maximum mechanical movement in the order of 1 inch. Because each character is formed from a series of dots, the individual character-forming elements each containing one row of dot projections are extremely thin and thus light. This small mass and small maximum distance enables said elements to be moved at extremely high speeds with low-power drive equipment. Thus an average line of 81 characters may be printed, utilizing the apparatus of the present invention, in less than 1 second.

The utilization of linear motion and magnetic drive means reduces wear and likelihood of mechanical breakdown. Moreover, by reducing the number of moving parts, maintenance costs are reduced considerably.

The present apparatus is particularly suited for printing data emanating from high-speed electronic data-processing equipment.

While only two embodiments of the present invention have been here specifically described, it will be apparent that many variations may be made therein, all within the scope of the instant invention as defined in the following claims.

I claim:

1. A font assembly for a high-speed printer apparatus for forming characters from a dot matrix, comprising a housing, a plurality of character-forming elements mounted in said housing and each having a series of dot print positions extending along their lengths, said dot print positions each characterized by a dot pattern and some of said dot print positions having a different dot pattern from some of the others of said dot print positions, said elements being arranged to form a dot matrix, means for moving said elements relative to each other along their lengths so as to align at least some of said dot print positions on each of said elements in a direction generally perpendicular to the lengths of said elements, whereby at least a portion of said dot matrix is effective to display a particular character made up of dot projections.

2. The font assembly of claim 1, wherein said character-forming elements comprise thin, elongated members extending in a first direction and stacked in a second direction generally perpendicular to said first direction and having said dot print positions extending in said first direction on aligned

end surfaces thereof, said members being slidable relative to each other in said first direction.

3. The font assembly of claim 2, further comprising bearing means disposed between said stacked members for facilitating the sliding engagement thereof.

4. The font assembly of claim 3, wherein said bearing means comprises wire means mounted on said housing and said members are provided with groove means extending in said first direction and adapted to operatively slidably engage said wire means, whereby said members are guided along said wire means in said first direction.

5. The font assembly of claim 1, further comprising hammer means disposed opposite said dot print positions on said character-forming elements, means for feeding paper between said character-forming elements and said hammer means, ribbon means between said hammer means and said elements adjacent said paper, and impact means for actuating said hammer means to press said ribbon means and said paper against said dot matrix formed by said character-forming elements.

6. The font assembly of claim 5, wherein said character-forming elements comprise thin, elongated members extending in a first direction and stacked in a second direction generally perpendicular to said first direction and having said dot print positions extending in said first direction on aligned end surfaces thereof, said members being slidable relative to each other in said first direction.

7. The font assembly of claim 6, further comprising bearing means disposed between said stacked members for facilitating the sliding engagement thereof.

8. The font assembly of claim 7, wherein said bearing means comprises wire means mounted on said housing and said members are provided with groove means extending in said first direction and adapted to operatively slidably engage said wire means, whereby said members are guided along said wire means in said first direction.

9. The font assembly of claim 5, further comprising means to move said hammer means along the lengths of said character-forming elements.

10. The font assembly of claim 6, further comprising means to move said hammer means in said first direction.

11. The font assembly of claim 7, further comprising means to move said hammer means in said first direction.

12. The font assembly of claim 8, further comprising means to move said hammer means in said first direction.

13. The font assembly of claim 9, wherein said hammer means comprises a plurality of hammers spaced along the lengths of said character-forming elements.

14. The font assembly of claim 10, wherein said hammer means comprises a plurality of hammers spaced along said first direction.

15. The font assembly of claim 11, wherein said hammer means comprises a plurality of hammers spaced along said first direction.

16. The font assembly of claim 12, wherein said hammer means comprises a plurality of hammers spaced along said first direction.

17. The font assembly of claim 1, wherein said means for moving said character-forming elements comprises magnetically actuated linear translation means.

18. The font assembly of claim 17, wherein said character-forming elements comprise thin, elongated members extending in a first direction and stacked in a second direction generally perpendicular to said first direction and having said dot print positions extending in said first direction on aligned end surfaces thereof, said members being slidable relative to each other in said first direction.

19. The font assembly of claim 18, further comprising bearing means disposed between said stacked members for facilitating the sliding engagement thereof.

20. The font assembly of claim 19, wherein said bearing means comprises wire means mounted on said housing and said members are provided with groove means extending in

said first direction and adapted to operatively slidingly engage said wire means, whereby said members are guided along said wire means in said first direction.

21. The font assembly of claim 17, further comprising hammer means disposed opposite said dot print positions on said character-forming elements, means for feeding paper between said elements and said hammer means, ribbon means between said hammer means and said element adjacent said paper, and impact means for actuating said hammer means to press said ribbon means and said paper against said dot matrix formed by said character-forming elements.

23. The font assembly of claim 13, wherein said means for moving said hammer means comprises magnetically actuated linear translation means.

22. The font assembly of claim 20, further comprising hammer means disposed opposite said dot print positions on said character-forming elements, means for feeding paper between said elements and said hammer means, ribbon means between said hammer means and said elements adjacent said paper, and impact means for actuating said hammer means to press said ribbon means and said paper against said dot matrix formed by said character-forming elements.

24. The font assembly of claim 16, wherein said means for moving said hammer means in said first direction comprises magnetically actuated linear translation means.

25. The font assembly of claim 1, wherein said character-forming elements are adapted to be moved with respect to said housing along their lengths in increments corresponding to one dot print position and multiples thereof.

26. The font assembly of claim 17, wherein said character-forming elements are adapted to be moved with respect to said housing along their lengths in increments corresponding to one dot print position and multiples thereof.

27. The font assembly of claim 1, wherein the arrangement of said series of dot projections on each character-forming element is cyclic.

28. The font assembly of claim 27, wherein one cycle of dot projections comprises 63 discrete dot print positions.

29. The font assembly of claim 27, wherein one cycle of dot projections comprises 98 discrete dot print positions.

30. The font assembly of claim 1, wherein said character-forming elements are adapted to be moved along their lengths in increments corresponding to said effective portion of said dot matrix and multiples thereof.

31. The font assembly of claim 17, wherein said character-forming elements are adapted to be moved in said first direction in increments corresponding to said effective portion of said dot matrix and multiples thereof.

32. The font assembly of claim 30, wherein said effective portion of said dot matrix extends 7 dot print positions.

33. The font assembly of claim 31, wherein said effective portion of said dot matrix extends 7 dot print positions.

34. The font assembly of claim 32, wherein said first and last dot print positions of said effective portion of said dot matrix are blanked.

35. The font assembly of claim 33, wherein said first and last dot print positions of said effective portion of said dot matrix are blanked.

36. The font assembly of claim 9, wherein the particular character to be formed and its position in relation to said housing is determined by an input signal, and further comprising font assembly command logic means responsive to said input signal for commanding the position of each of said character-forming elements, character-forming element position-monitoring means for monitoring the current position of each of said character-forming elements, and character-forming element control logic means operatively connected to said font assembly command logic means and said character-forming element position-monitoring means for comparing the current position of said character-forming elements with the commanded position thereof and actuating said means for moving said character-forming elements to move said elements to the commanded position.

37. The font assembly of claim 36, further comprising hammer position monitoring means for monitoring the position of said hammer means, hammer control logic means responsive to said input signal and said hammer-monitoring means for comparing the position of said hammer means with the position of said particular character and actuating said means for moving said hammer means to position said hammer means in alignment with said particular character on said dot matrix.

38. The font assembly of claim 37, further comprising sequence command logic means responsive to said input signal, said character-forming element-monitoring means and said hammer-monitoring means, for controlling the sequence of hammer actuation, character-forming element movement, and hammer movement.

39. The font assembly of claim 38, wherein said sequence command logic means also controls the sequence of paper feed.

40. The font assembly of claim 4, wherein said wire means comprises a plurality of wires suspended at their ends from said housing and said groove means comprises a plurality of grooves provided in both surfaces of said thin members and adapted to receive said plurality of wires respectively, an individual wire engaging the grooves of each of two adjacent members, thereby to adapt said members to slide relative to each other along said wires only in said first direction.

41. The font assembly of claim 20, wherein said wire means comprises a plurality of wires suspended at their ends from said housing and said groove means comprises a plurality of grooves provided in both surfaces of said thin members and adapted to receive said plurality of wires respectively, an individual wire engaging the grooves of each of two adjacent members, thereby to adapt said members to slide relative to each other along said wires only in said first direction.

42. The font assembly of claim 6, wherein said hammer means comprises a plurality of hammers, each said hammer movable in said first direction from a starting position along a given portion of the length of said elements, said given portions being contiguous to one another, and means for moving said hammers back to their starting positions upon spanning said given portion, whereby one of said hammers is returned to its starting position while another hammer begins moving along its portion of the length of said character-forming elements.

43. The font assembly of claim 9, wherein said hammer means comprises a plurality of hammers, each said hammer movable in said first direction from a starting position along a given portion of the length of said elements, said given portions being contiguous to one another, and means for moving said hammers back to their starting positions upon spanning said given portion, whereby one of said hammers is returned to its starting position while another hammer begins moving along its portion of the length of said character-forming elements.

44. The font assembly of claim 10, wherein said hammer means comprises a plurality of hammers, each said hammer movable in said first direction from a starting position along a given portion of the length of said elements, said given portions being contiguous to one another, and means for moving said hammers back to their starting positions upon spanning said given portion, whereby one of said hammers is returned to its starting position while another hammer begins moving along its portion of the length of said character-forming elements.

45. The font assembly of claim 11, wherein said hammer means comprises a plurality of hammers, each said hammer movable in said first direction from a starting position along a given portion of the length of said elements, said given portions being contiguous to one another, and means for moving said hammers back to their starting positions upon spanning said given portion, whereby one of said hammers is returned to its starting position while another hammer begins moving along its portion of the length of said character-forming elements.

13

46. The font assembly of claim 12, wherein said hammer means comprises a plurality of hammers, each said hammer movable in said first direction from a starting position along a given portion of the length of said elements, said given portions being contiguous to one another, and means for moving said hammers back to their starting positions upon spanning said given portion, whereby one of said hammers is returned to its starting position while another hammer begins moving along its portion of the length of said character-forming elements.

47. The font assembly of claim 1, wherein the particular character to be formed and its position in relation to said housing is determined by an input signal, and further compris-

14

ing font assembly command logic means responsive to said input signal for commanding the position of each of said character-forming elements, character-forming element position-monitoring means for monitoring the current position of each of said character-forming elements, and character-forming element control logic means operatively connected to said font assembly command logic means and said character-forming element position-monitoring means for comparing the current position of said character-forming elements with the commanded position thereof and actuating said means for moving said character-forming elements to move said elements to the commanded position.

\* \* \* \* \*

15

20

25

30

35

40

45

50

55

60

65

70

75