United States Patent [19]

Woods et al.

[11] **3,831,728**

[45] **Aug. 27, 1974**

[54] **INK JET PRINTING APPARATUS WITH OVERRUN OF PRINTHEAD TO INSURE BETTER VISIBILITY**

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[73] Assignee: **International Business Machines Corporation,** Armonk, N.Y.

[22] Filed: **Dec. 11, 1972**

[21] Appl. No.: **313,886**

[52] **U.S. Cl.** ..... **197/1 R,** 346/75, 197/19, 197/66

[51] **Int. Cl.** **G01d 15/18**

[58] **Field of Search** ..... 101/DIG. 13; 346/75, 140, 346/1 R; 197/1 R, 19, 60, 62, 63–66, 68; 178/6.6 R

[56] **References Cited**

UNITED STATES PATENTS

2,909,935	10/1959	Dodge	197/66 X
3,260,340	7/1966	Locklar et al.	197/19
3,297,124	1/1967	Sims	197/19
3,562,761	2/1971	Stone et al.	346/75
3,595,994	7/1971	Whitman	346/75 X

OTHER PUBLICATIONS

A. B. Dick, "Videojet Printer," Techn. Description, 4–12–71.

Primary Examiner—Robert E. Pulfrey
Assistant Examiner—E. H. Eickholt
Attorney, Agent, or Firm—D. Kendall Cooper

[57] **ABSTRACT**

An ink jet printing apparatus has provision for both line printing and character-by-character printing. A directionally oriented grating and associated circuitry is provided to maintain a record of character and ink drop printing locations. Also, provision is made for over-shooting the printhead some distance past each character printed during an incremental mode and for stopping the printhead to enable better visibility of the character just printed. Upon printing of the next character, the printhead first moves to the left a sufficient distance to get past the character box to be printed and sweeps to the right with the overshoot and stopping as before.

3 Claims, 8 Drawing Figures

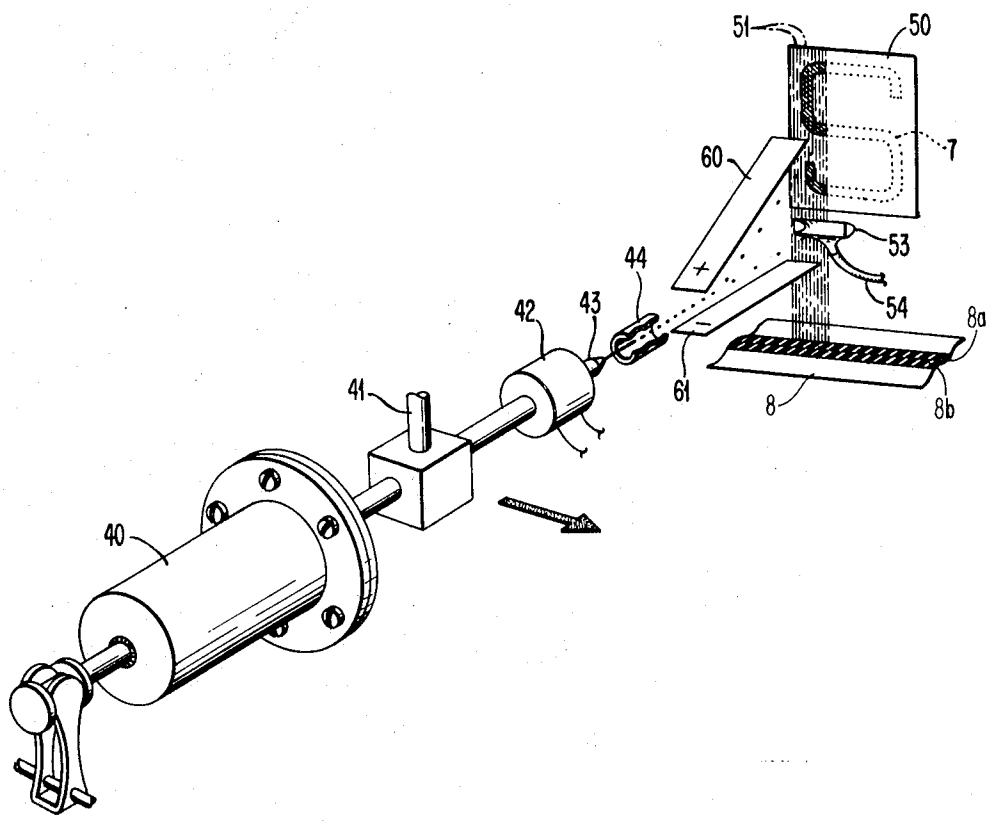


FIG. 1

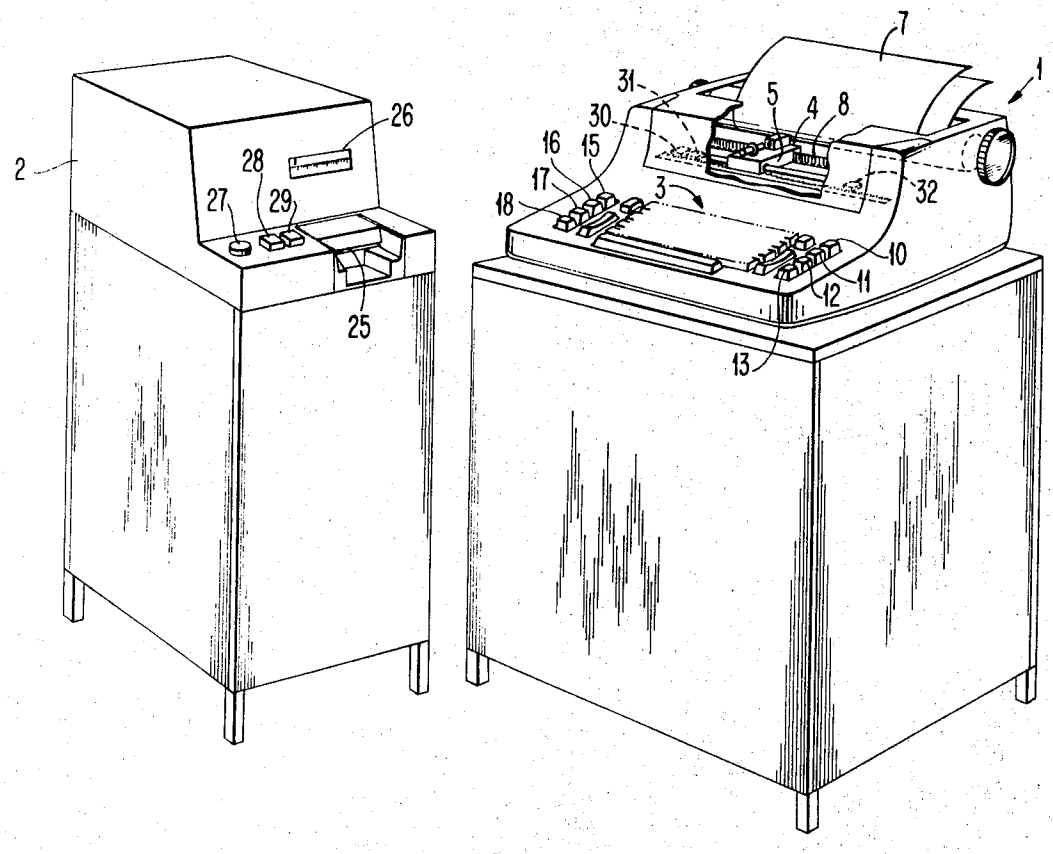

2
26
28
27
29
25
7
1
31
5
4
8
30
16
15
17
3
18
32
10
11
12
13

FIG. 2

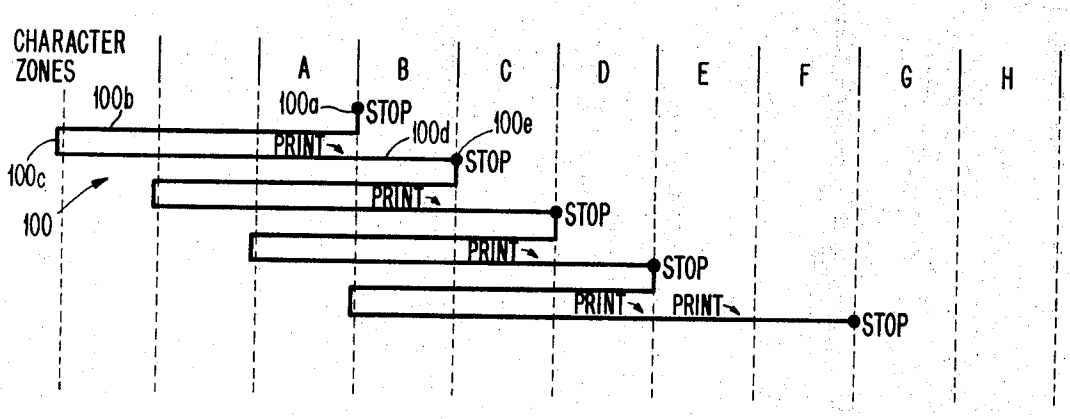

CHARACTER ZONES
A
B
C
D
E
F
G
H
100b
100a
STOP
100d
100e
PRINT
STOP
100c
100
PRINT
STOP
PRINT
STOP
PRINT
PRINT
STOP

FIG. 3a

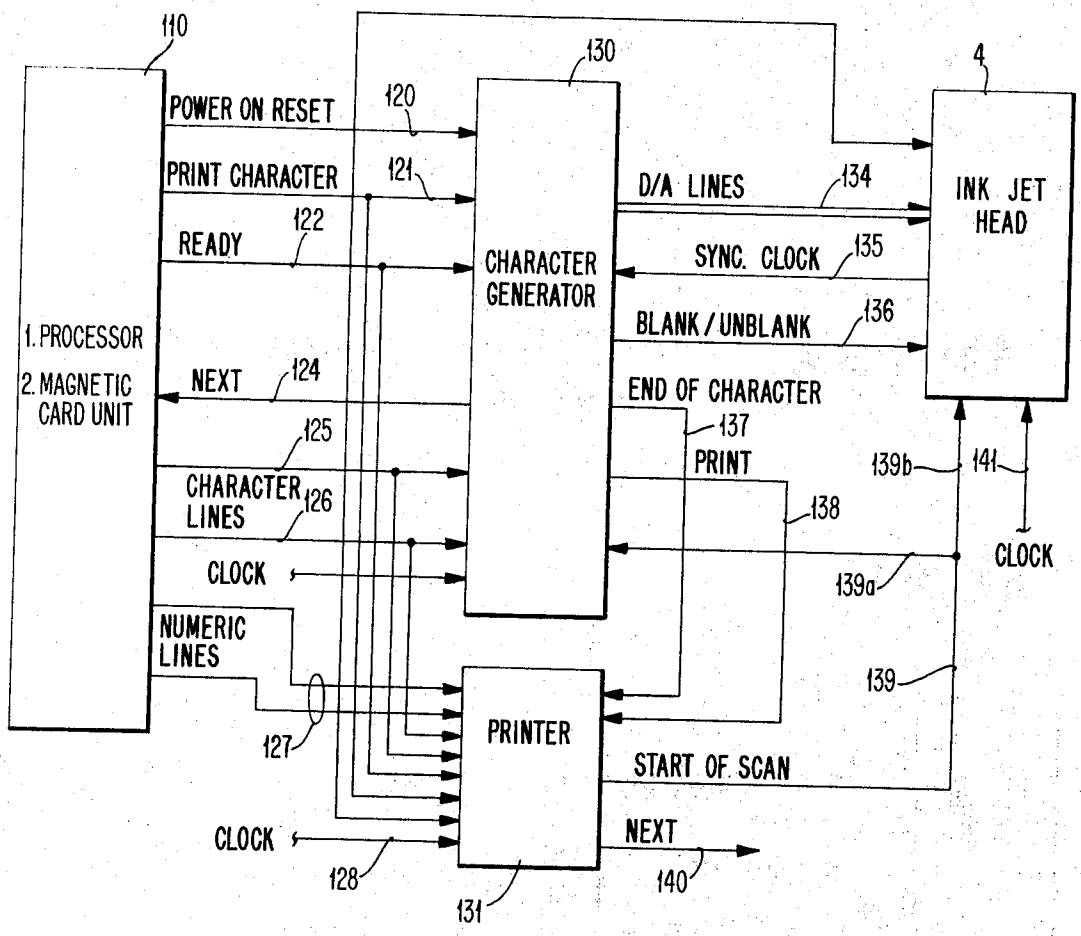

110
1. PROCESSOR
2. MAGNETIC CARD UNIT
POWER ON RESET
120
PRINT CHARACTER
121
READY
122
NEXT
124
125
CHARACTER LINES
126
CLOCK
NUMERIC LINES
127
CLOCK
128
131
130
CHARACTER GENERATOR
D/A LINES
134
SYNC. CLOCK
135
BLANK/UNBLANK
136
END OF CHARACTER
137
PRINT
138
PRINTER
START OF SCAN
NEXT
140
4
INK JET HEAD
139b
141
CLOCK
139a
139

FIG. 3b

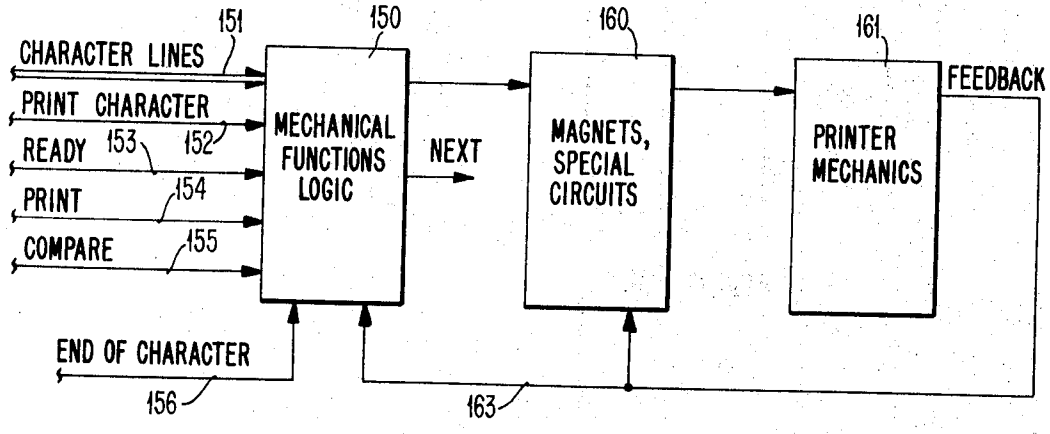

CHARACTER LINES
151
PRINT CHARACTER
READY
153
152
PRINT
154
COMPARE
155
END OF CHARACTER
156
MECHANICAL FUNCTIONS LOGIC
150
NEXT
MAGNETS, SPECIAL CIRCUITS
160
PRINTER MECHANICS
161
FEEDBACK
163

FIG. 4

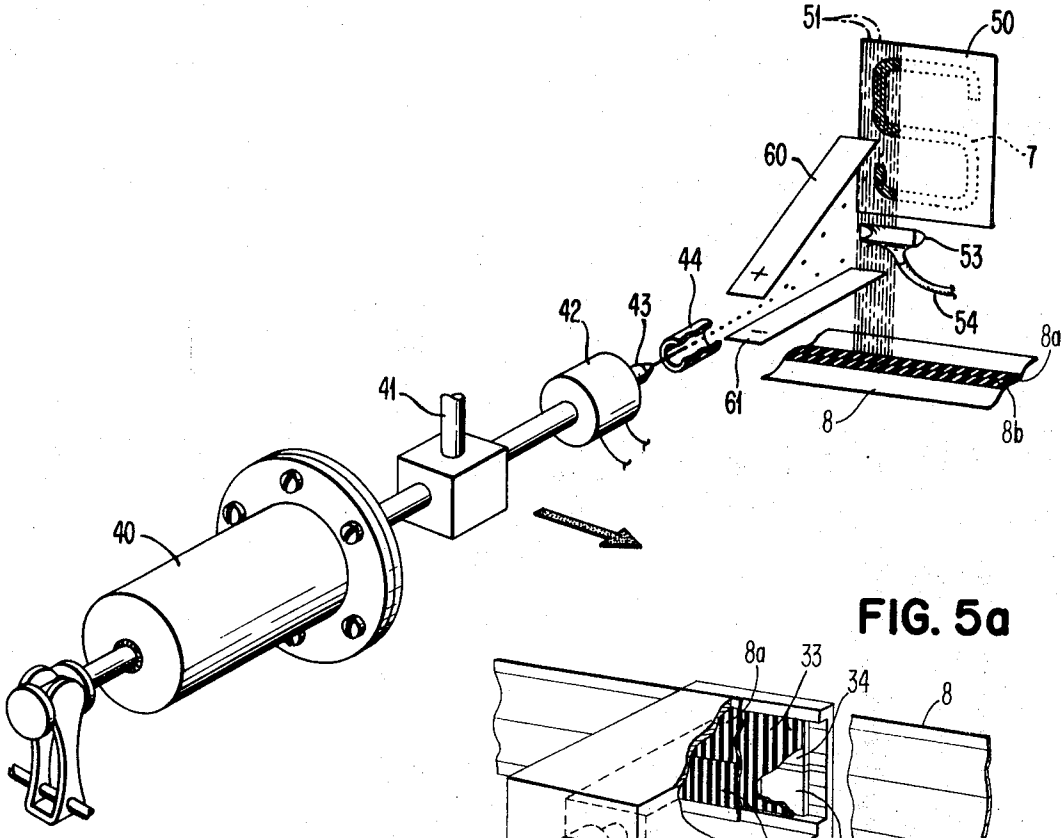
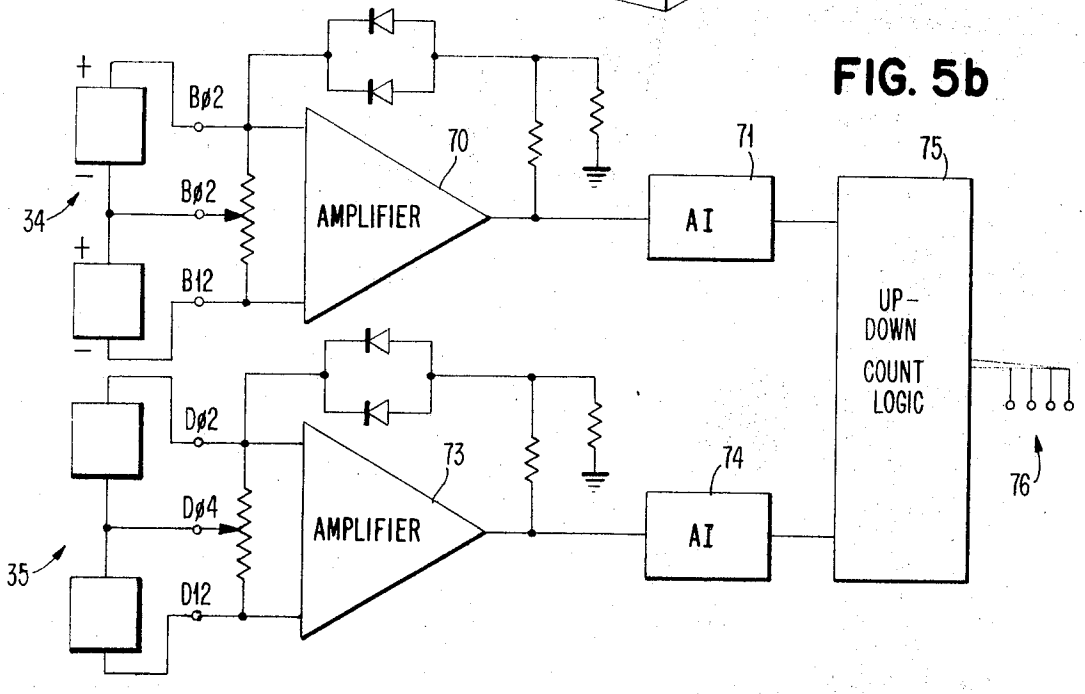


FIG. 5a

FIG. 5b



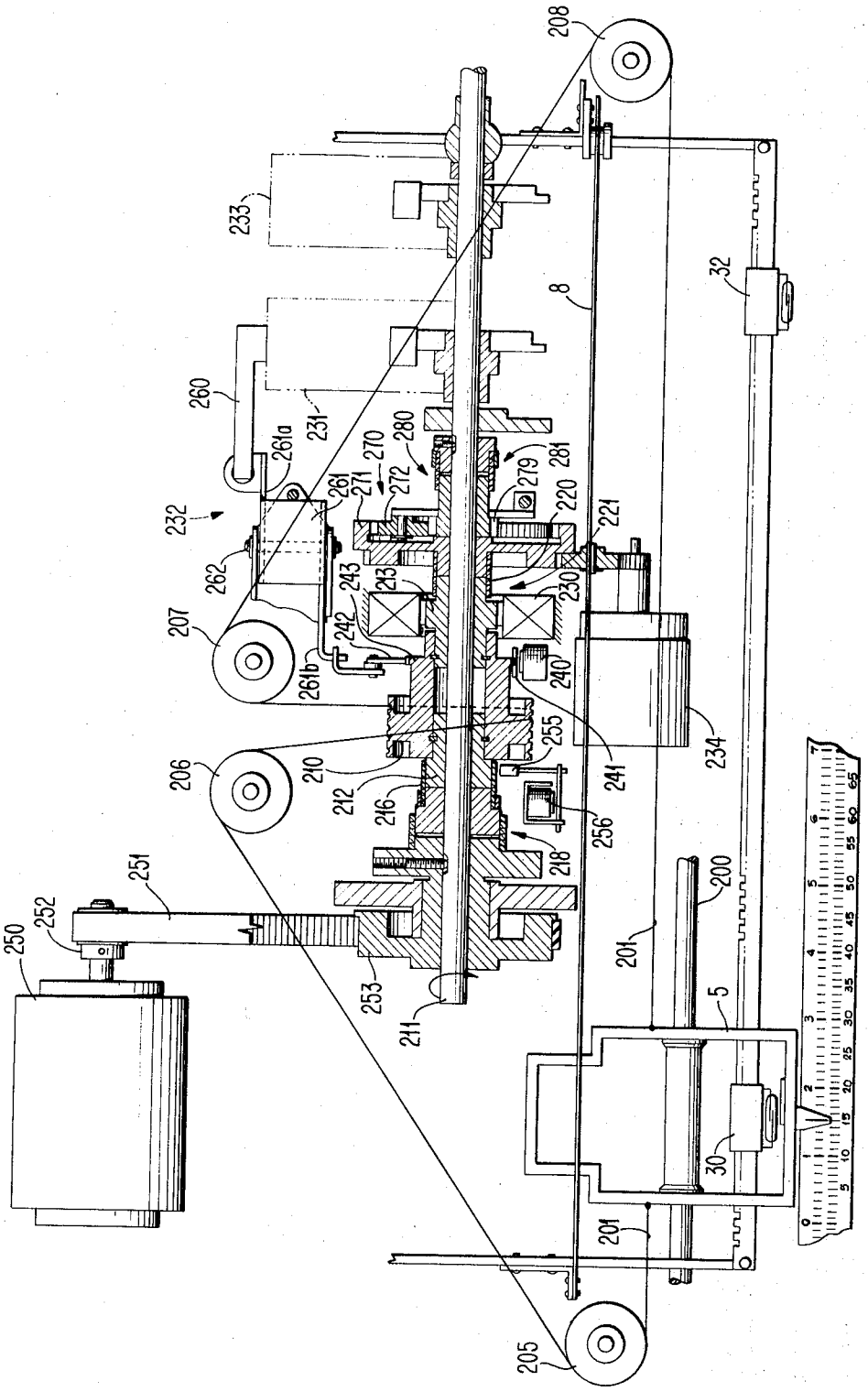

208
233
8
32
260
231
261a
270
280
281
279
220
221
232
262
261
271
272
243
233
230
207
242
261b
240
255
234
241
206
210
212
216
256
218
251
252
250
253
211
200
201
5
30
205

FIG. 6

INK JET PRINTING APPARATUS WITH OVERRUN OF PRINTHEAD TO INSURE BETTER VISIBILITY

RELATED PATENT APPLICATION

U.S. Patent application Ser. No. 313,919 entitled, "Ink Jet Printing Apparatus with Line Sweep and Incremental Printing Facilities," filed Dec. 11, 1972 and having Raymond L. Fowler, et al, as inventors.

BACKGROUND OF THE INVENTION AND PRIOR ART

The Rossetto patent describes photocomposing apparatus making use of a grating for determination of character increments. The Stabler patent describes a shaft position indicator for recognizing direction of rotation of a shaft and having an associated counting means. The Woodhead patent describes a counter for keeping track of printer position.

The Sims patent describes a power typing system incorporating an IBM "Selectric" printer with an associated magnetic tape storage unit with recording and reading facilities. Line readjustment capabilities are also described. The Locklar, et al, patent describes an apparatus similar to the Sims system with provision for selection of information on a character, word, and line basis. The Jones, et al, patent describes an automatic typing system incorporating an IBM "Selectric" Typewriter together with an associated magnetic card storage unit having recording and reading facilities. The Hayes patent describes an electrical keyboard unit.

The Burdick, et al, and Dorius, et al, publications described Reed Switch Assemblies.

The various IBM Customer Engineering Manuals describe the "Selectric" printer, the "Selectric" Model II printer, and the "Selectric" printer and magnetic card unit in the IBM MC/ST.

REFERENCES OF INTEREST

The following U.S. Pat. Nos. are of general interest: Rossetto, et al, Reissue 25,354; Stabler, 2,656,106; Woodhead, 2,954,860; Sims, 3,297,124; Locklar, et al, 3,260,340; Jones, et al, 3,512,137; Hayes, et al, 3,494,550.

The following IBM publications are of interest:

"Reed Switch Contact Block" authors, R. L. Burdick, et al, IBM Technical Disclosure Bulletin, October 1966, page 512.

"Toggle and Momentary Reed Console Switch Assembly," authors, L. F. Dorius, et al, IBM Technical Disclosure Bulletin, May 1967, pages 1,702 and 1703.

The following IBM Customer Engineering Manuals are of interest:

"Selectric" Printer Instruction Manual, January, 1966, Form No. 241-5032.

"Selectric" Typewriter, Service Manual, November, 1970, Form No. 241-5615.

"Selectric" II Typewriter, Service Manual Supplement, Form No. 241-5615 (Supplement).

Magnetic Card "Selectric" Typewriter, Self Teach Course Summary, July, 1969, Form No. 241-5581.

Magnetic Card "Selectric" Typewriter, Self Teach Instruction Manual, Vol. II, June, 1969, Form No. 241-5580.

Parts Catalog, Magnetic Card "Selectric" Typewriter, August, 1969, Form No. 241-5584.

Pictorial Reference/Adjustment Manual, Magnetic Card "Selectric" Typewriter, July, 1969, Form No. 241-5593.

SUMMARY OF THE INVENTION

The present ink jet printing system has provision for both line printing and incremental printing with structures involving considerably less hardware than some other printing apparatus. As an example, with the present system, the escapement rack, backspace rack, escapement and tab bracket assembly, escapement triggering device and associated hardware including the tab torque bar is eliminated. The carrier motion is accomplished by actuation of carrier return and tab solenoids in correct time intervals. A single character is printed under control of the electronics which senses a grating for positioning of the character to be printed. The grating has two sets of markings displaced from one another and an associated counter circuit keeps track of carrier location in relation to a document to be printed by counting up and down as appropriate.

Provision is made to insure improved visibility of the printing line during printing operations, particularly when printing is performed on a character-by-character basis.

OBJECTS

Accordingly, a paramount object of the present invention is to provide an ink jet printing apparatus having line and incremental printing capabilities.

Another object of the present invention is to provide a directionally oriented grating and associated counting circuitry for maintaining character and drop locations during printing operations.

A further object of the present invention is to establish improved visibility of the printing line during printing operations.

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of the preferred embodiment of the invention as illustrated in the accompanying drawings.

DRAWINGS

In the Drawings:

FIG. **1** illustrates an ink jet printing system incorporating a printer and having an associated magnetic card recording/reproducing unit with both line printing and character-by-character printing facilities.

FIG. **2** illustrates various carrier motions encountered during incremental printing.

FIG. **3***a* is a block diagram of the ink jet printing apparatus of FIG. **1** showing a number of significant control lines and possible data sources. FIG. **3***b* is a block diagram illustrating some of the printer mechanical signals involved.

FIG. **4** illustrates structures in the ink jet printer head assembly with associated grating.

FIG. **5***a* illustrates a sensor assembly useful with the grating shown in FIG. **4**, while FIG. **5***b* illustrates a sensing circuit fulfilling an amplifier function.

FIG. **6** illustrates various mechanisms involved in producing relative motion of the ink jet head assembly and carrier in relation to a document to be printed.

DETAILED DESCRIPTION

FIG. **1** illustrates an ink jet printing system incorpo-

rating a typewriter **1** with an associated magnetic card recording/reproducing unit **2.** Card unit **2** is shown for convenience only since by inspection of FIG. **4***a*, it is apparent that other kinds of storage units, recording-/reproducing units, and the like, may be used in the system. Typewriter **1** has the usual keyboard **2** which preferably is of the electrical type referred to in some of the IBM Customer Engineering Manuals listed previously. It may also be of the type described in the Hayes, et al, patent. Printer **1** incorporates an ink jet head assembly **4** arranged for travelling movement from left to right (and conversely) adjacent a document **7** to be printed. Assembly **4** has an ink drop nozzle and an associated grating **8** with an upper incremental column location scale and a lower character scale as shown in greater detail in FIG. **4.** Printer **1** may be provided with various control buttons **10, 11, 12** and **13** for automatic, line, word, and character printing, respectively. Other keybuttons **15–18** concern mode selection, that is, record, playback, adjust, and skip, respectively.

Reference is made to the various "Selectric" typewriter manuals referred to previously for description of other keyboard facilities and other features of the printer. The magnetic card unit **2** has a load slot **25** and a track indicator **26.** Also provided on unit **2** is a card eject button **27,** a track stepdown button **28** and a track stepup button **29** for relocating the scanning transducer with respect to the various tracks on the card. Reference is made to the various magnetic card manuals and the Jones, et al, patent for a description of facilities in the card unit. It is understood, of course, that other kinds of storage facilities, card units, tape units, processors, and the like can be substituted for unit **2** including as an example, the magnetic tape unit set forth in the Sims and Locklar, et al, patents.

Printer **1** incorporates a left margin reed switch **30,** a drop carrier return reed switch **31** and a right margin reed switch **32.** These may be of the type set forth in the Burdick, et al, and Dorius, et al, publications.

FIG. **2** illustrates the mechanical motion of the carrier in relation to the character boxes during predominately incremental, that is, character-by-character printing. Reference is also made to FIGS. **5***a* and **5***b* which shows the grating, sensing, and counting circuits. Referring to FIG. **2,** character zones or boxes designated A thru H are shown. It is assumed that the printer is in the incremental mode of printing as determined by appropriate depression of keybutton **15** on the keyboard of the printer. Initially, it is also assumed that carrier **5** and head assembly **4** are located at the stop position **100***a* in the printing motion line **100.** It is seen that carrier **5** and head assembly **4** are actually past the character location A that is the next one to be printed. Upon initiation of printing of a character as by depression of a keybutton in keyboard **3,** various mechanisms to be described are activated to move carrier **5** and head assembly **4** to the left along line portion **100***b* to a point represented at **100***c* prior to character box A. Thereafter, the mechanisms are operable to sweep head assembly **4** and carrier **5** to the right along line **100***d* ultimately to a stop location **100***e* in readiness for the next character. As the assemblies **4** and **5** pass through character box A, appropriate signals are developed to propel ink drops toward document **7** in order to print the character required in character box A. No printing occurs in boxes B, C, or D.

The foregoing motions and movement of structures **4** and **5** occur for the printing of the subsequent characters in boxes B, C, D, etc., with the exception that in the case of characters D and E, continued movement of carrier **5** and head assembly **4** occurs. This is assumed to be due to the fact that the signals necessary for formation of the characters in those boxes are provided to the system during the latter portion of the character box D so that the printer need not stop but may continue on and print the characters in character boxes D and E.

SYSTEM BLOCK DIAGRAM

FIG. **3***a* is a system block diagram incorporating a processor, card unit, tape unit **110,** or the like and having various control lines **120–128** interconnected with a character generator box **130** and printer control circuits **131.** Other lines **134–141** interconnect the character generator **130** and printer **131** with the head assembly **4.**

In FIG. **3***b* the logic **150** representing various mechanical functions has inputs on lines **151–156** providing control for various operational circuits **160** and ultimately to the printer mechanisms **161** with feedback on line **163.**

Referring to FIG. **4,** various structures incorporated in head assembly **4** are illustrated. This includes a pump **40** for directing ink from an ink supply conduit **41** on demand as a crystal **42** is energized, that is, pulsed at high frequencies. The rate of impulsing crystal **42** may be in the range of 100 kiloHertz for example. Ink drops are emitted from nozzle **43** and pass through a charge electrode **44** for variable charging in accordance with the output of a charge amplifier to deflect the drops in a column an amount representing the vertical height of the drop location in any given character. As illustrated the letter capital "S" designated **50** comprises a number of vertical columns **51.** The printing is such that a sequence of vertical columns, each comprising a plurality of drops, such as **40** in number, is propelled from nozzle **43** toward document **7** for the printing of the character involved. If drops are not required for printing, they are directed to a gutter **53** for passage by means of a conduit **54** back to the ink supply, customarily. A pair of deflection plates **60** and **61** is positioned in the path of travel of the drops leaving the charge electrode **44.** A constant high potential is applied across plates **60** and **61** and this in cooperation with the variable charge on the individual drops determines the amount of deflection as the drops are directed toward document **7.** Grating **8***a* in this instance is shown as being positioned horizontally rather than vertically as in FIGS. **1** and **5***a*, but the positioning is immaterial.

Mounted on head assembly **4** for translational movement adjacent grating **8** is a sensor assembly such as that shown in FIG. **5***a*. This comprises a supporting structure **30** incorporating a light emitting diode **32** arranged to direct light thru grating **8** and a master grating **33** to a pair of solar cells **34** and **35.** Grating **8** has the two portions **8***a* and **8***b*.

Grating **8** is typically of a stiff transparent base and is guided through a slot in the assembly body to maintain a reasonably constant proximity to master grating **33.**

Master grating **33** is mounted to the face of the solar cells **34** and **35.** Master grating **33** is arranged in such a manner that the D.C. output signals of the two cells

cancel while the A.C. signals are additive. This is accomplished by making the grating lines of one cell 180°out of phase with respect to those of the other cell. The purpose is to reduce the effects of light level shift which may occur from aging or voltage change on the light emitting diode.

The two channels, as described above, produce signals that have a 90°phase relation skip. This is to permit up-down counting. One channel, FIG. 5*b*, comprises cell **34** coupled through amplifier **70** to And-Invert (AI) block **71**, while the other channel comprises cell **35** coupled through amplifier **73** to And-Invert **74.** Outputs of AI blocks **71** and **74** are provided to up-down counter logic **75** with outputs at **76** being used to determine print-head location.

As indicated, the individual characters are located within character boxes comprising perhaps **40** drop locations in height and 24 drop locations in width, that is 24 columns wide.

If it is assumed that the printer **1** is in a line mode and the system is in a playback mode, appropriate positioning of a card, not shown, results in card unit **2** furnishing signals to the printer **1** to determine the printing of characters. An output indicating "print" is provided and remains at an up level until an end of line signal is received from the card unit.

As indicated on charge electrode **44,** FIG. **4,** the charge determines at what drop location a drop will ultimately arrive within a given column of drops in the character box on document **7.** If no drop is required, that is, it is to be directed to gutter **53,** FIG. **4,** then a blank signal results in no charge on the drop and it lands in gutter **53.**

TRANSPORT MECHANISMS FOR RELATIVELY MOVING CARRIER AND DOCUMENT

FIG. **6** illustrates various transport structures incorporated in the present apparatus that enable line printing, character-by-character incremental printing, and carrier return operations, as well as tabulation operations, backspacing operations, and the like.

Carrier **5** is mounted for travelling movement from left to right adjacent document **7** on a shaft **200.** Attached on either side of carrier **5** is a cable **201** that is illustrated as passing around pulleys **205–208** in FIG. **6.** Cable **201** is wound on a cord drum **210.** Cord drum **210** is mounted on an operational shaft **211.** Associated with drum **210** is a hub member **212,** fixedly mounted therewith and another hub member **213.** The entire assembly of elements **210, 212,** and **213** being freely mounted on shaft **211.** Surrounding hub member **212** is a spring element **216** forming part of a spring clutch assembly **218** while surrounding a portion of hub member **213** is a spring element **220** forming part of a spring clutch assembly **221,** which disengages the planetary gear system during carrier return operations to prevent gear noise. Clutch assembly **218** is involved in carrier return operations, that is, movement of carrier **5** from right to left in printer **1** while spring clutch **281** is involved in a governing action when carrier **5** is moved from left to right in the tab or forward spacing direction.

Other primary structures associated with the transport mechanisms include the main spring **230,** the backspace clutch assembly **231** and associated elements arranged in a train for mechanical control designated **232,** an index assembly **233,** and a tab governor **234.**

It is assumed that carrier **5** is at the left margin location indicated by reed switch **30.** If printing of a line is desired, a backspace operation is first anticipated by arm **231** and pawls **241** and **242** shown more particularly in FIG. **6** are disengaged from ratchet **243.** This enables driving movement by main spring **230** through hub member **213** and cord drum **210** to pull cable **201** and carrier **5** in a direction from left to right in relation to document **7.** Movement of carrier **5** continues until a line ending code is received from the data source or reed switch **32** is encountered indicating the right margin. Thereupon, a carrier return drive is initiated, when motor **250** is coupled through hub element **212** and cord drum **210** by engagement of spring element **216** of clutch assembly **218** by means of a shoe **255** activated by carrier return magnet **256.** Accordingly, carrier **5** is moved from right to left in the carrier return direction until left margin switch **30** is encountered indicating termination of the carrier return operation. While the carrier is in operation, main spring **230** is being wound up in preparation for escapement and tabulation movements in a succeeding line.

INCREMENTAL PRINTING

If printing of information is required on a character-by-character basis, then motion of the carrier and associated head assembly **4** is as shown and discussed previously in connection with FIG. **2***a*. Referring to FIG. **2***a*, it is assumed that carrier **5** has stopped at point **100***a*.

The logic is operative to initiate a backspacing operation of 0.3 inch corresponding to three characters, assuming a 10 pitch character increment. The backspacing operation is initiated by energization of the backspace clutch **231** which by means of actuator **260** moves an arm assembly **261** pivotally mounted on pivot **262.** The arrangement is such that portion **261***a* moves into the figure, that is, away from the viewer, while portion **261***b* moves upwardly from the surface of the figure, that is, toward the viewer. The motion of member **261** is such that pawl **242** moves ratchet **243** in a counterclockwise direction when viewed from the right end of shaft **211.** Ratchet **243** is directly associated with cord drum **210** and this effects movement of carrier **5** three character spaces back to point **100***c* in FIG. **2***a*.

Thereafter, escapement magnet **240** is energized to release ratchet **243** so that cord drum **210** may be moved in a clockwise direction as viewed from the right end of shaft **211** under influence of main spring **230.**

During any tabulation movement under influence of main spring **230,** speed of the movement is controlled by the tab governor **234** by means of a planetary gear assembly **270** including a ring gear **271,** a planetary gear **272** and a sun gear **279.** The control is exerted through the spring clutches **221** and **280** as well as governor **234** to insure that excessive speeds are not encountered.

With activation of main spring **230,** and rotation of cord drum **210,** carrier **5** and head assembly **4** move in a left to right direction as illustrated by portion **100***d* in FIG. **2***a* with the electronics controlling the printing of a character in character box A as required taking into account the character and columnar positions of ink drops by monitoring counter **90** during movement of

carrier **5**. Escapement magnet **240** is de-energized in time for the carrier **5** to stop at point **100***e*, FIG. **2***a*.

Succeeding characters are printed in the incremental mode in this manner as long as required.

It is evident by inspection of FIG. **2***a* that with carrier **5** and head assembly **4** displaced a considerable distance to the right past any character location that has just been printed, visibility is quite improved and the character just printed is readily inspected by the operator of the system.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. In a printing apparatus having provision for successively incrementally printing customarily under control of an operator individual characters or symbols by means of a printhead in predefined locations on a receiving member, each of said characters or symbols comprising components between and including a starting position and a termination position, said apparatus being operable to print all components of each individual character or symbol during a single print cycle, each said print cycle comprising first, second and third cycle portions, a method for establishing better visibility of characters and symbols as they are printed, comprising:

1. during the first cycle portion of each said print cycle, relatively moving said printhead and said receiving member from a position beyond the termination position of the character or symbol presently to be printed in order to relatively locate said print head and said receiving member prior to the starting position of the individual character or symbol to be printed;

2. during the second cycle portion of each said print cycle, relatively moving said receiving member and said printhead in a printing direction, said printhead having facilities and being operable to print components of said character or symbol during said relative movement;

3. during the third cycle portion of each said print cycle of each individual character or symbol incrementally printed, overbounding and invariably stopping said printhead past the termination positon of said individual character or symbol into at least the next succeeding character or symbol location so that said printhead is out of the normal sight line of an operator of said apparatus and each character and symbol printed on said receiving member is readily visible.

2. Printing apparatus for establishing better visibility of characters and symbols as they are printed, and having provisions for successively incrementally printing customarily under control of an operator individual characters or symbols by means of a printhead in predefined locations on a document, each of said characters or symbols comprising character components between and including a starting position and a termination position, said apparatus being operable to print all components of each individual character or symbol during a single symbol print cycle, each said print cycle comprising first,

second and third cycle portions, comprising:

1. means for positioning a document for printing;

2. printhead means positioned adjacent said document for selectively forming, propelling, charging and deflecting marking components for selective deposition on said document;

3. first means operable during the first cycle portion of each said print cycle to relatively move said printhead and said receiving member from a position beyond the termination position of the character or symbol presently to be printed in order to relatively locate said printhead and said receiving member prior to the starting position of the individual character or symbol to be printed;

4. second means operable during the second cycle portion of each said print cycle to relatively move said document and said printhead in a printing direction and for operating said printhead to print components of a said character or symbol during said relative movement;

5. third means operable during the third cycle portion of each said print cycle of each individual character or symbol incrementally printed to invariably stop said printhead past the termination position of said individual character or symbol into at least the next succeeding character or symbol location so that said printhead is out of the normal sight line of an operator of said apparatus and each character and symbol printed on said receiving member is readily visible.

3. The apparatus of claim **2** wherein said printhead means is operable during the second cycle portions to selectively propel and deposit ink drops on said document serving as said marking components.

* * * * *