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[54] **THERMAL PRINTER-PLOTTER SYSTEM FOR MULTI-DIRECTIONAL PRINTING AND PLOTTING**

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Related U.S. Patent Documents

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[51] **Int. Cl.**[3] **G01D 15/10; H05B 1/00**

[52] **U.S. Cl.** ..... **346/76 PH;** 346/1.1; 219/216

[58] **Field of Search** ..... 346/76 R, 76 PH, 155, 346/1; 219/216

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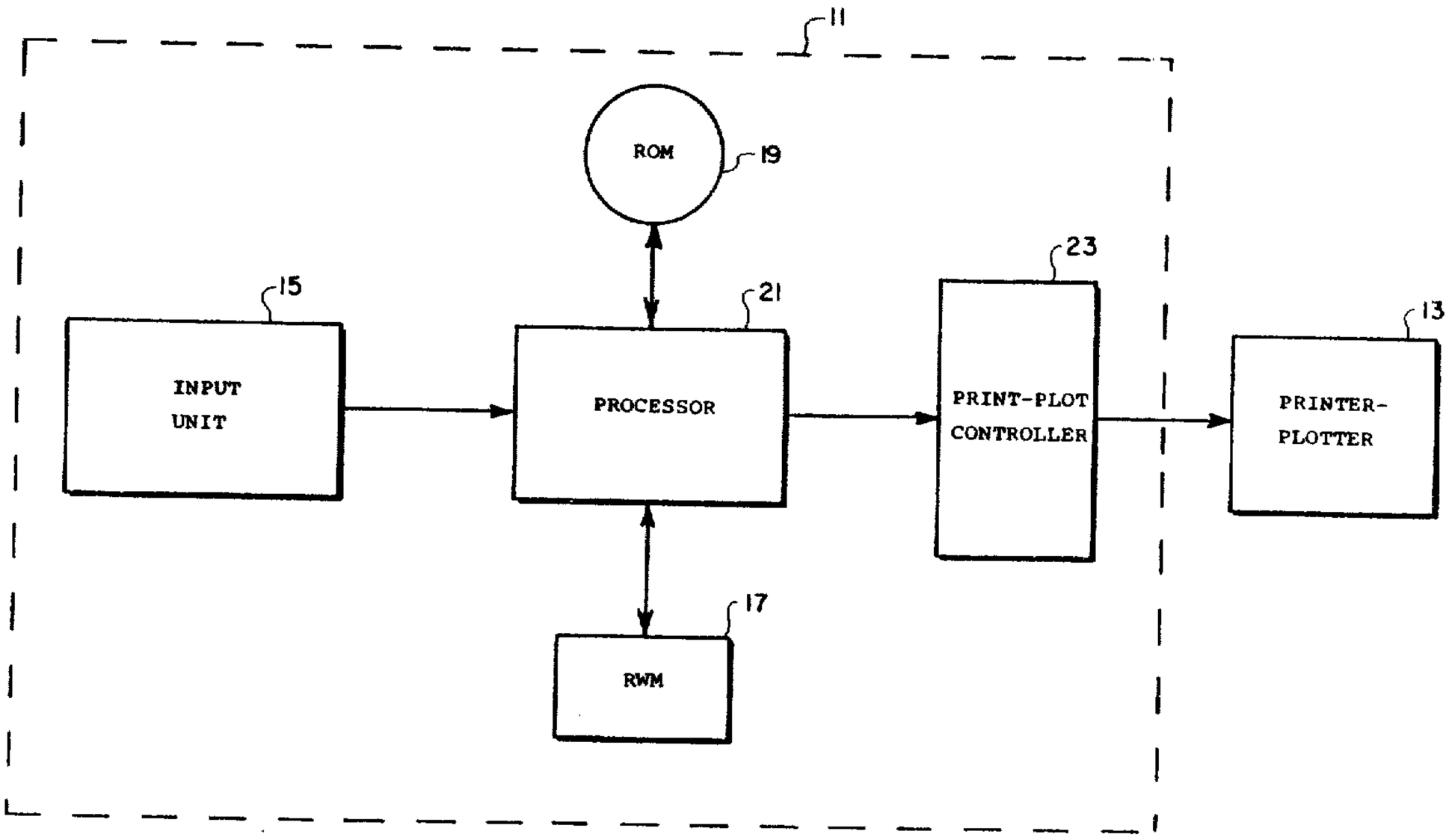
Primary Examiner—George H. Miller, Jr.

Attorney, Agent, or Firm—Allston L. Jones

[57] **ABSTRACT**

A printer-plotter system is provided having a single horizontally movable, print-plot head comprising geometrically arranged thermal resistor elements which are processor-controlled for plotting continuous multi-directional line segments and for printing, while plotting, upper and lower case alphanumeric characters and punctuation characters in four orthogonal directions. Characters are printed in 5-columns-by-7-rows dot matrix form, with neighboring dots partly overlapping each other in order to impart a continuous or drawn appearance rather than a discontinuous dot appearance to the printed characters. The geometric arrangement of the head elements also provides for varying the width of line segments plotted along selected orthogonal directions.

12 Claims, 5 Drawing Figures



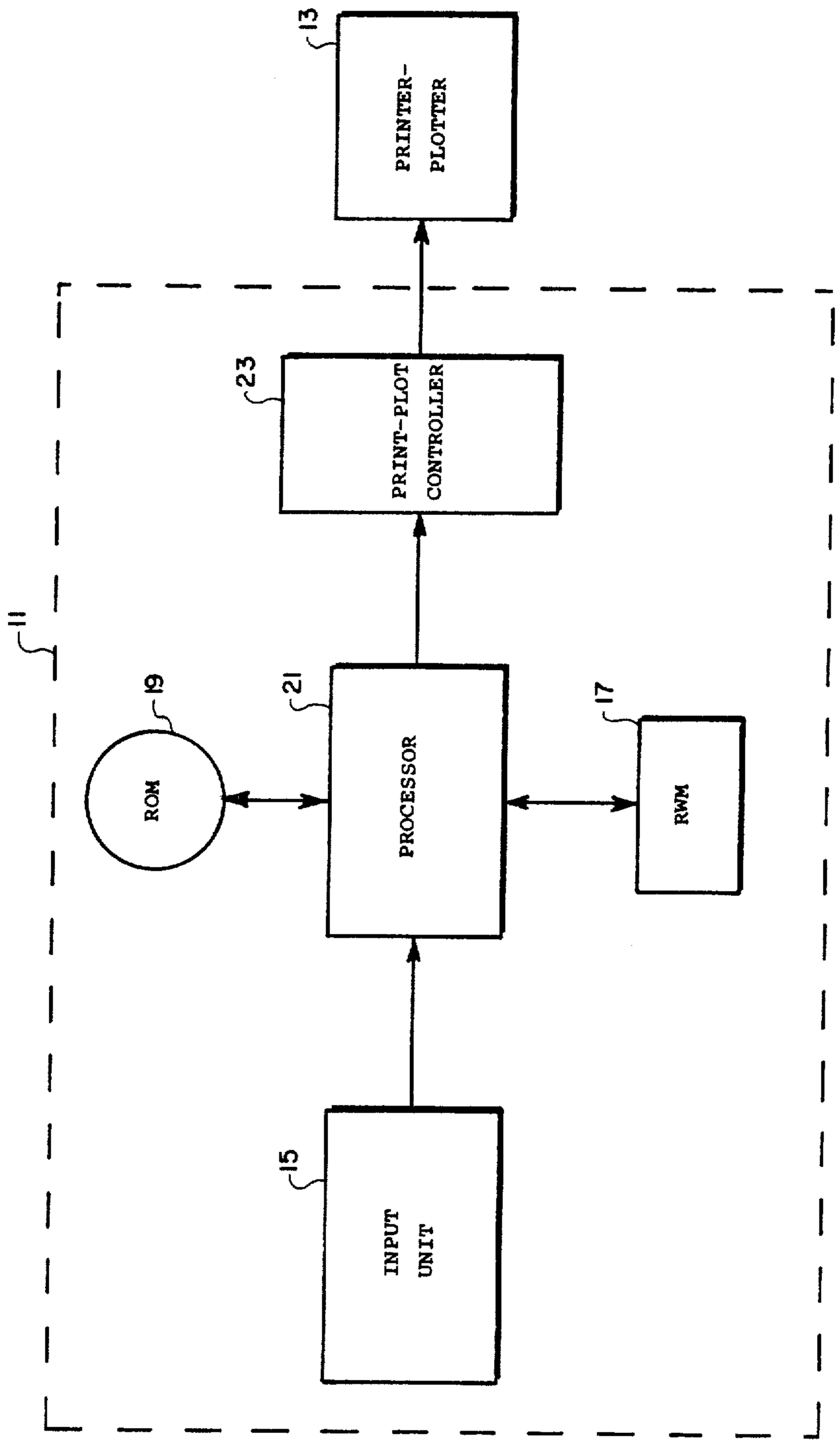

13
PRINTER-PLOTTER
23
PRINT-PLOT CONTROLLER
11
19
ROM
21
PROCESSOR
17
RWM
15
INPUT UNIT

Figure 1

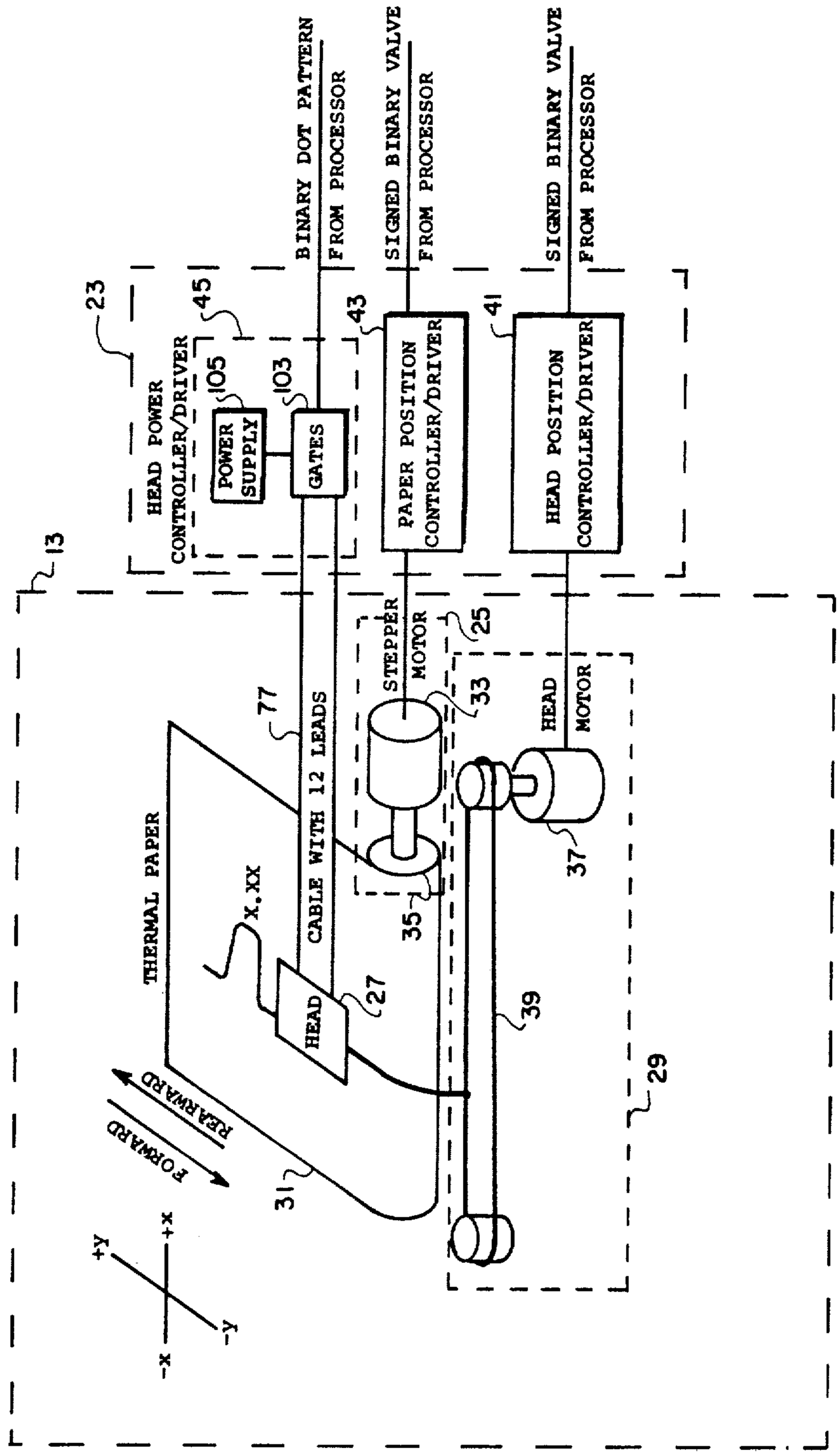

13
23
HEAD POWER CONTROLLER/DRIVER
45
105
POWER SUPPLY
103
GATES
BINARY DOT PATTERN FROM PROCESSOR
43
PAPER POSITION CONTROLLER/DRIVER
SIGNED BINARY VALVE FROM PROCESSOR
41
HEAD POSITION CONTROLLER/DRIVER
SIGNED BINARY VALVE FROM PROCESSOR
77
CABLE WITH 12 LEADS
STEPPER MOTOR
25
33
HEAD MOTOR
37
35
THERMAL PAPER
x.xx
HEAD
27
39
29
31
FORWARD
REARWARD
+x
-x
+y
-y

Figure 2

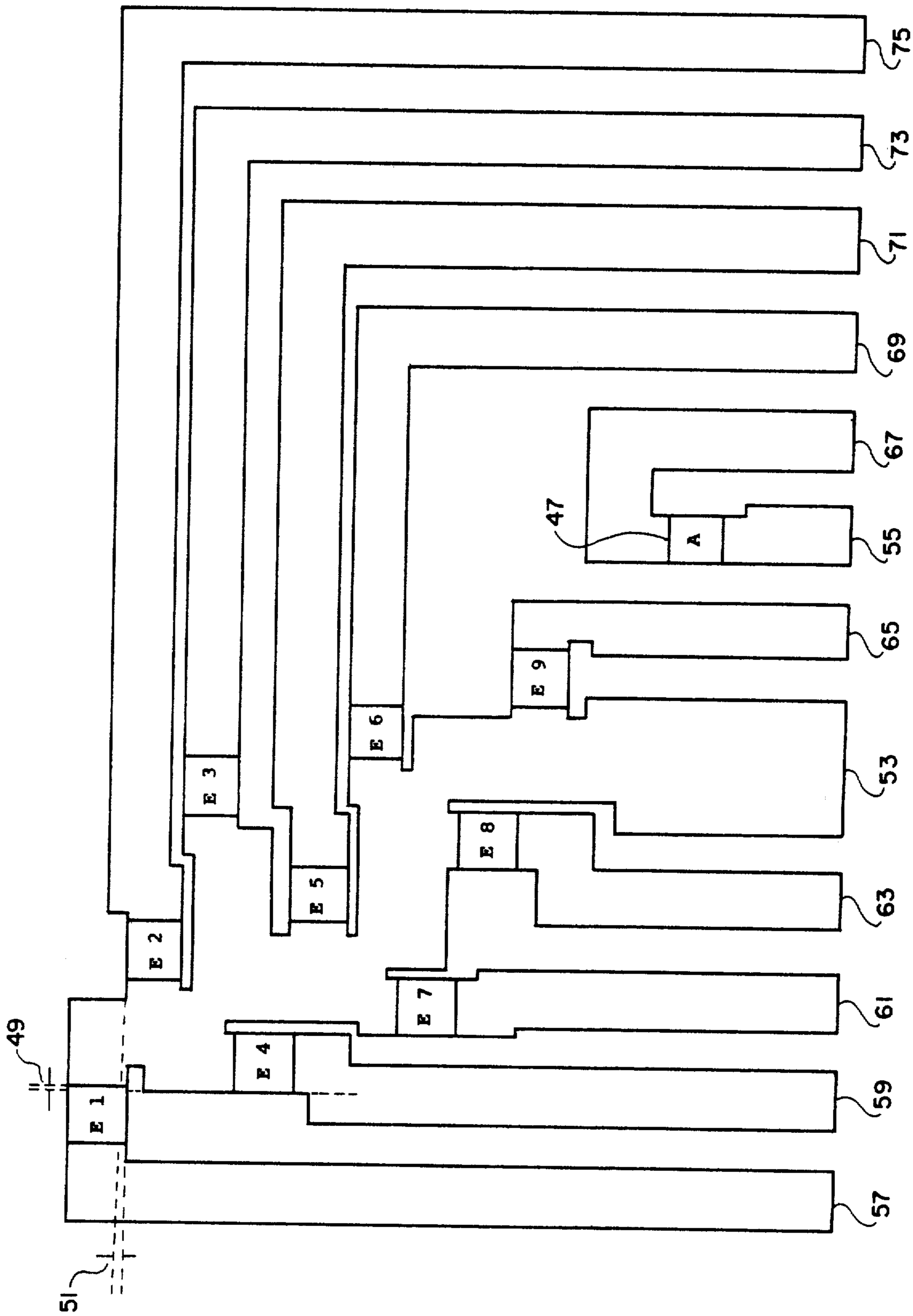


Figure 3

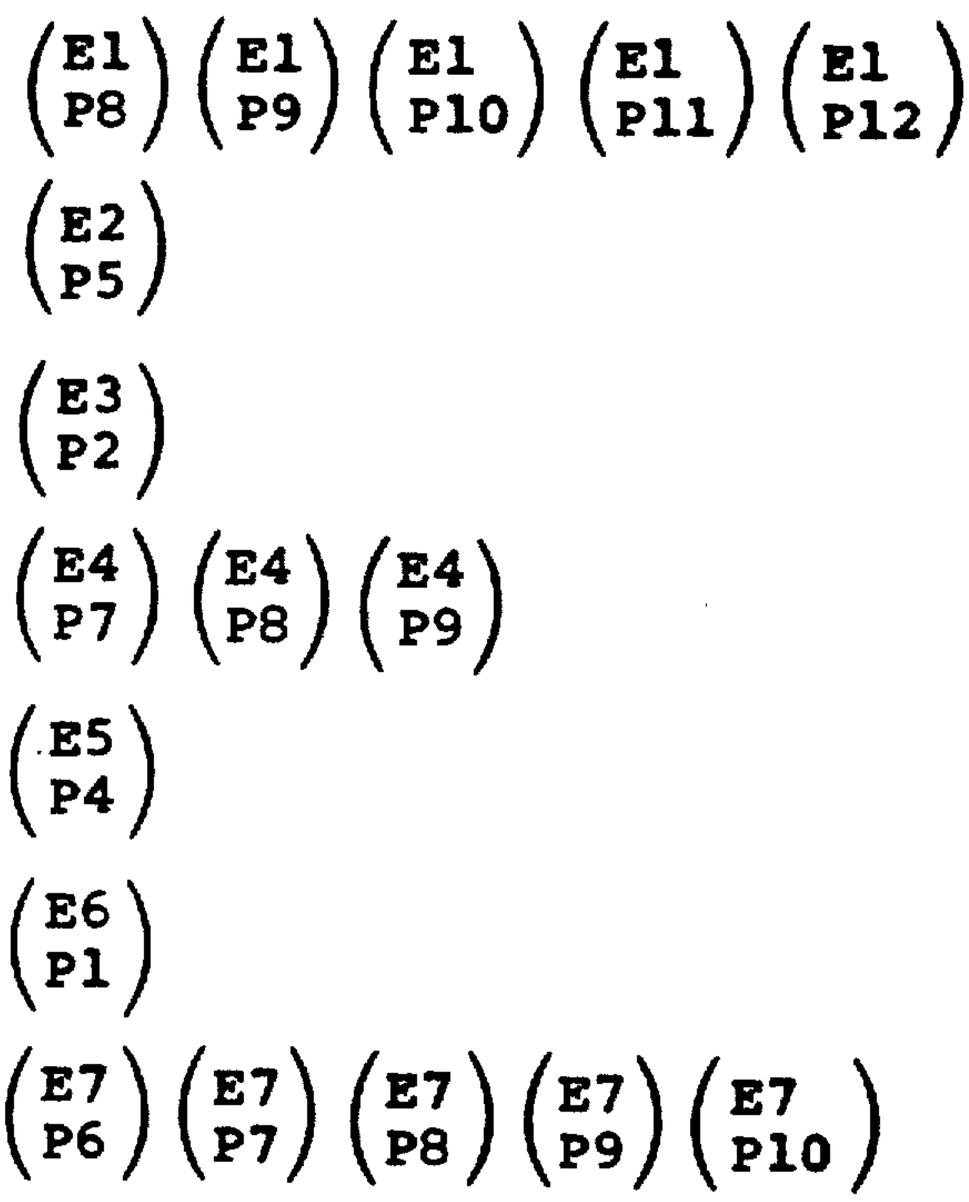

(E1 P8) (E1 P9) (E1 P10) (E1 P11) (E1 P12)
(E2 P5)
(E3 P2)
(E4 P7) (E4 P8) (E4 P9)
(E5 P4)
(E6 P1)
(E7 P6) (E7 P7) (E7 P8) (E7 P9) (E7 P10)

Figure 4

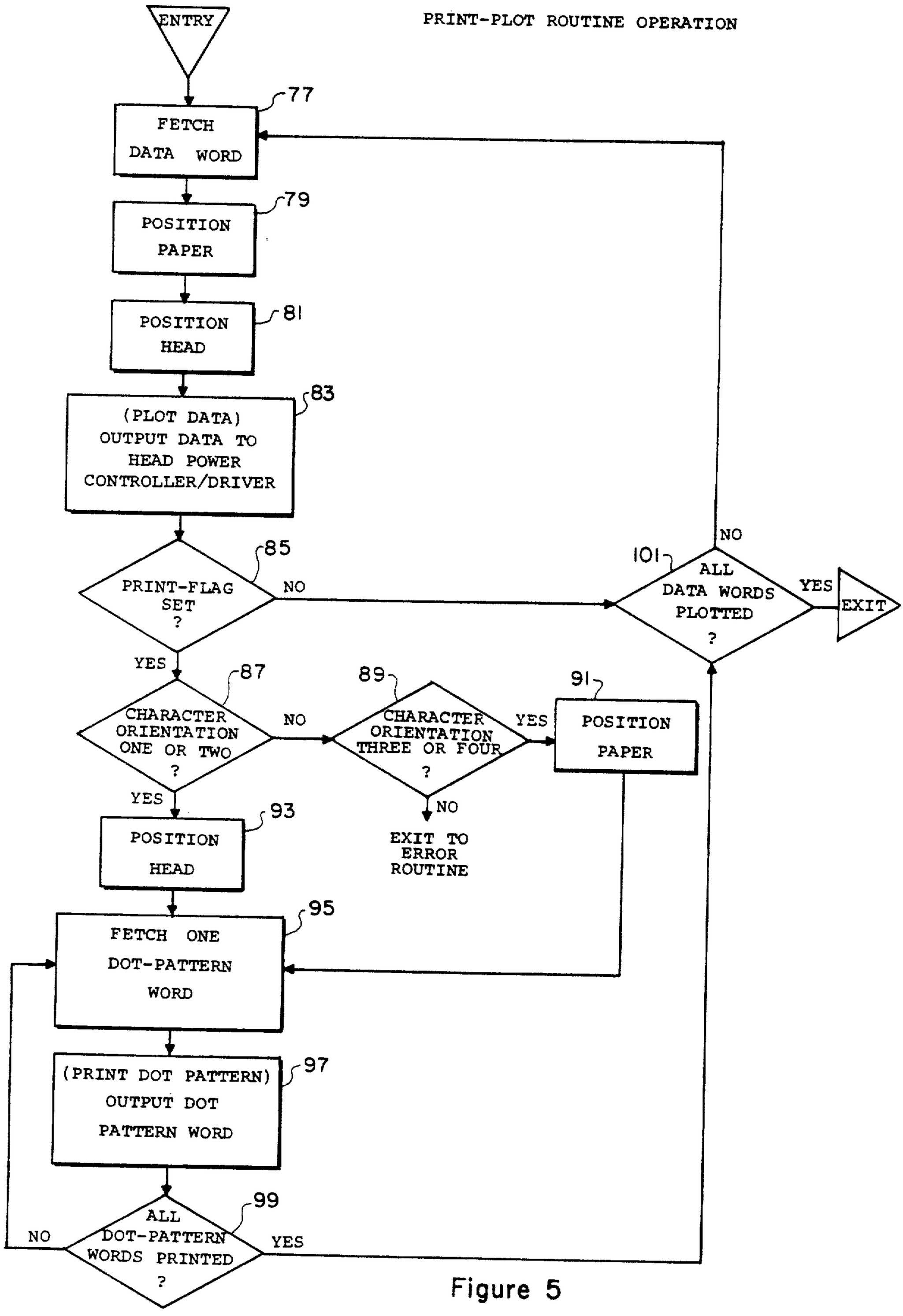

PRINT-PLOT ROUTINE OPERATION
ENTRY
77
FETCH DATA WORD
79
POSITION PAPER
81
POSITION HEAD
83
(PLOT DATA) OUTPUT DATA TO HEAD POWER CONTROLLER/DRIVER
85
PRINT-FLAG SET ?
NO
YES
87
CHARACTER ORIENTATION ONE OR TWO ?
NO
YES
89
CHARACTER ORIENTATION THREE OR FOUR ?
YES
NO
91
POSITION PAPER
93
POSITION HEAD
EXIT TO ERROR ROUTINE
95
FETCH ONE DOT-PATTERN WORD
97
(PRINT DOT PATTERN) OUTPUT DOT PATTERN WORD
99
ALL DOT-PATTERN WORDS PRINTED ?
NO
YES
101
ALL DATA WORDS PLOTTED ?
NO
YES
EXIT

Figure 5

THERMAL PRINTER-PLOTTER SYSTEM FOR MULTI-DIRECTIONAL PRINTING AND PLOTTING

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

The present invention relates generally to printer-plotter systems and, more particularly, to dot-matrix thermal printer-plotters. Thermal printer-plotters are known which have thermal resistive elements (dots) arranged in matrix form, each column and each row of matrix having multiple resistive elements.

However, to form the vertical portion of a character, the column elements of the matrix are sometimes energized simultaneously. This often results in non-uniformity of contrast between portions of the character formed by a given number of the matrix elements energized simultaneously and other portions of the character formed by a different number of simultaneously energized elements. This non-uniformity in contrast is caused by parasitic losses, such as are produced by a battery return lead and resistance, which reduce the amount of power supplied to each element as a function of the number of simultaneously energized elements.

To avoid this problem of non-uniformity in contrast associated with simultaneously energized elements, a printer-plotter with individually energizable print and plot elements is needed. Also, for purposes of compactness and simplicity, the elements should be arranged in a single print-plot head in such a manner that, to print a selected character, the same elements may be used to print the character in one direction as to print the character in other directions.

SUMMARY OF THE INVENTION

According to the illustrated preferred embodiment of the present invention, a print-plot system is provided having a central processing unit (CPU), a memory unit containing a stored program, and a printer-plotter unit with a print-plot head. The print-plot head comprises ten geometrically-arranged thermal resistive elements, one of which is used to plot lines and nine of which are used to print upper and lower case alphanumeric characters in four orthogonal directions, under program control.

The geometric arrangement of the character-printing elements enables these elements to be individually energized when printing a character, thereby eliminating the problem of non-uniformity of contrast associated with simultaneously energized contiguous printing elements. Any of the printing elements may be energized simultaneously with the plotting element in order to print characters while plotting selected line segments. The arrangement of the elements also diminishes the dot appearance of the printed characters and improves character appearance by printing the dots in slightly overlapped fashion. Furthermore, the arrangement of the elements provides for varying the thickness of a character or orthogonal line segments by selectively energizing one or more individual elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of the printer-plotter system of the present invention.

FIG. **2** is a combined perspective view and block diagram illustrating the printer-plotter and controller of the system of FIG. **1**.

FIG. **3** is a top view of the elements of the print-plot head employed in the system of FIG. **1**.

FIG. **4** is a diagrammatic illustration of elements of the print-plot head of FIG. **3** used to print a character.

FIG. **5** is a logic flow diagram of a routine stored in a ROM of the system of FIG. **1**, illustrating one mode of operation of the system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** shows a printer-plotter system having a logic unit **11** and a printer-plotter unit **13**. The logic unit **11** comprises an input unit **15** such as a keyboard, optical reader or magnetic tape device for entering data into the system, a read-write memory (RWM) unit **17**, a read-only memory (ROM) unit **19** having a stored routine, a processing unit **21** and a print-plot controller **23**. The processing unit **21** stores the data from input unit **15** into RWM **17**, processes the stored data under control of the ROM routine, and applies the processed data via controller **23** to printer-plotter **13** for plotting and printing.

FIG. **2** shows the printer-plotter **13** comprising a web or paper drive unit **25**, a print-plot head **27** engaging the web, and a coordinate actuator or head drive unit **29** for moving the print-plot head **27**. The paper drive unit **25** includes a stepper motor **33** coupled to a platen **35** for moving paper **31** forward (from $+y$ to $-y$) or rearward (from $-y$ to $+y$). The head drive unit **29** includes a head motor coupled to head **27** by means of a guide wire **39** for moving the head **27** from left to right (from $-x$ to $+x$) or from right to left (from $+x$ to $-x$). FIG. **2** also shows print-plot controller **23** comprising a head position controller/driver **41**, a paper position controller/driver **43**, and a head power controller/driver **45**. Upon application of a signed, binary value from processor **21** to head position controller/driver **41** (the sign of the binary value specifying the direction of movement of the head **27** and the magnitude of the binary value indicating the number of steps that the head **27** is to be moved), the controller/driver **41** converts the signed binary value to two signals with a $+90°$ phase delay between the two signals when the sign is negative, and to two signals with $-90°$ phase delay between the signals when the sign is positive, and applies the two signals to head motor **37**. Head motor **37** moves head **27** a distance corresponding to the number of cycles of the signals, in the direction from $-x$ to $+x$ when the applied signals are out of phase by $+90°$, and from $+x$ to $-x$ when the applied signals are out of phase by $-90°$. In similar manner, a signed binary value applied by processor **21** to paper position controller/driver **43** causes controller/driver **43** to apply two signals with $+90°$ or $-90°$ phase delay between them to stepper motor **33**. Stepper motor **33** rotates a sprocketed portion of platen **35**, moving paper **31** a distance corresponding to the number of cycles of the applied signals. Paper **31** is moved forward ($+y$ to $-y$) when the signals applied to motor **33** are out of phase by $+90°$, and moved rearward ($-y$ to $+y$) when the signals applied to motor **33** are out of phase by $-90°$. A binary pattern of ten bits is applied, in parallel, by processor **21** to head

power controller/driver **45** specifying the thermal elements of head **27** that are to be energized.

FIG. **3** shows a top view of the thermal resistive elements of head **27**. (In an alternative embodiment of the present invention the thermal elements of the head may be arranged along a single diagonal.) Seven elements are used for printing upper and lower case characters, at least two elements used for printing punctuation characters, and one element **47** is used to plot lines. For example, when the head **27** is moved from left (−x) to right (+x), to print upper and lower case, characters E and e, thermal elements **E1**, **E2**, **E3**, **E4**, **E5**, **E6** and **E7** are used, to print a lower case character with a "descending portion" such as "p", elements **E3**, **E4**, **E5**, **E6**, **E7**, **E8** and **E9** are used, and to print a punctuation mark such as a comma, elements **E7**, **E8** and **E9** are used. Each printing element partly overlaps its neighboring element in a column-wise and row-wise fashion as indicated by reference numerals **49** and **51** of FIG. **3**. This overlapping arrangement permits the printing of contiguous, partly-overlapping dots, forming characters having a non-dot-like appearance. The elements are connected to twelve leads, one lead being a ground lead **53** common to elements **E1**–**E9**, nine lead being conductor leads **57**–**63**, **65** and **69**–**75**, each connected to one of the nine elements **E1**–**E9**, and one grounded lead **55** and one conductor lead **67** connected to plot element **47**. The twelve leads to the head **27** are, in turn, connected to head power controller/driver **45** of printer-plotter controller **23** via a flexible cable **77**. Processor **21**, under control of the routine shown in FIG. **5** and Table 2 following, moves the head **27** or paper **31**, or both, to a selected position and applies a binary pattern to head **27**, energizing selected elements to plot a point or to print one or more points as part of a character.

FIG. **4** shows the elements E1–E7 used to print the character "E," and the particular move or position of the head (**p1** being a first position, **p2** being a second position, and so on) at which each element is energized. The elements **E8** and **E9** are not used to print portions of the E, instead, these two elements are used to print punctuation marks and the lower portions of lower-case characters when such characters are oriented in the same direction as the E. For example

$$\begin{pmatrix} E6 \\ p1 \end{pmatrix}$$

means that at an initial positioning of head **27** element **E6** is energized to form a portion of character E,

$$\begin{pmatrix} E3 \\ p2 \end{pmatrix}$$

means that at the next positioning of the head (i.e., at head position two), element **E3** is energized to form another portion of the E,

$$\begin{pmatrix} E4 \\ p7 \end{pmatrix} \begin{pmatrix} E7 \\ p7 \end{pmatrix}$$

means that at head position seven, elements **E4** and **E7** are energized to form two other portions of the E, and so on. Note that at head position three, elements **E8** is in position for forming a punctuation character or lower portion of a lower-case character (if such a character were needed) and, hence, is not energized to form a portion of the E. Table 1 shows the element used to print upper-case character "P," punctuation character "," and lower-case character "p."

TABLE 1

Orientation of character	Example of character orientation	Character orientation (Cartesian)	Direction of head movement	Direction of paper movement	Element used to form character in order of use, from left to right	Element used to form descender portion (in order of use)
First orthogonal	P,	+y to −y	−x to +x	No movement	E6,E3,E5,E2, E7,E4,E1	E9,E8
Second orthogonal		−y to +y	+x to −x	No movement	E4,E7,E5,E8, E3,E6,E9	E1,E2
Third orthogonal		−x to +x	No movement	+y to −y	E1,E2,E3,E4, E5,E7,E8	E6,E9
Fourth orthogonal		+x to −x	No movement	−y to +y	E9,E8,E7,E6, E5,E3,E2	E4,E1
First orthogonal	P	+y to −y	−x to +x	No movement	E9,E6,E3,E8, E5,E7,E4	None

A flow chart of the operations performed by processor **21** under control of the routine stored in ROM **19** (FIG. **1**) is shown in FIG. **5**. Each block of the flow chart represents an operation performed by processor **21**. For a given sequence of input data received and stored by logic unit **11**, or generated by processor **21** (pursuant to calculation operation) and stored in RWM **17** for plotting and printing, the print-plot routine as shown by block **77** accesses the first data word to be plotted, positions the paper and head as shown by blocks **79** and **81**, and plots the contents of the accessed data word. As shown by block **83**, plotting is achieved by applying the accessed data to head power controller/driver **45** (FIG. **2**) where the data is used to gate power from a power supply **105** to plot element **47** of head **27**. Following the plotting operation as block **85** shows, a test is made to determine if printing is to be performed. If no printing is to be performed (indicated by a print flag not having been preset), control is transferred to block **101**. If a print flag has been present indicating that character data are to be printed, the orthogonal orientation of the character is determined as shown by blocks **87** and **89**, and head **27** or paper **31** is moved to a selected coordinate as shown by blocks **93** and **91**, causing selected elements of the head to occupy selected positions over the paper **31** corresponding to

the data word to be printed. To accomplish the head and paper movement indicated by blocks **93** and **91**, for a given character orientation determined from blocks **87** and **89**, signed binary values are applied to head-position and paper-position controller/drivers **41**, **43**. Bit patterns (dot patterns in binary form) of alphanumeric characters printable by the system are pre-stored in word groups in ROM **19**, each word group containing the dot (bit) pattern corresponding to one character. For a given character stored in RWM **17**, the group of words from ROM **19** containing the dot pattern corresponding to the stored character are accessed. This access operation is shown by block **95**, after which the contents of each word are applied to head power controller/driver **45** (FIG. **2**) as shown by block **97**. As shown by gates **103** and power supply **105** of FIG. **2**, the contents of each dot-pattern word serve to gate power from power supply **105** to those elements of the head for which there is a matching "1" bit in the dot-pattern. As block **99** shows, after each dot-pattern word is provided, control is returned to blocks **95** and **97** for successive dot-pattern words to be output. When all of the dot-pattern words (preselected for annotating a plotted data value) have been printed, control is transferred to block **101** which, in turn, returns control to block **77** if additional data values remain to be plotted, or terminates the print-plot operation if no data values remain to be plotted. To plot lines having a selected thickness, a plot element **47** of selected size may be used, or individual elements may be energized selectively to produce, along a selected orthogonal direction, a line made up of a desired number of contiguous dots. To print characters having a selected thickness, selected dot patterns may be used. Table 2 shows a listing of the individual instructions of the print-plot routine.

TABLE 2

Print-Plot Routine

Sequence no.	ROM Address (in octal)	Object code	Subroutine label	Operation code (instructions)	Remarks
0674	03054	001055	NXTPO	DEF *+1-.	
0675	03055	001346		LDA DEFG	CHECK DECELERATION FLAG
0676	03056	072402		SZA *+2	SET DECELERATE
0677	03057	066275		JMP DECEL	
0678	03060	025317		LDB CHMOD	
0679	03061	014043		CPB 01	ACCELERATE?
0680	03062	066262		JMP ACCEL	YES
0681	03063	031353		LDA SCNTR	
0682	03064	072402		SZA *+2	TIME TO PRINT
0683	03065	066252		JMP KPSLW	NO. JUST SLEW
0684	03066	014106		CPB 07	CRUISE?
0685	03067	066212		JMP LSTCH	YES
0686	03070	024123		ADB N4	
0687	03071	176002		SBP *+2	
0688	03072	066145		JMP FETDT	
0689	03073	024117		ADB N2	
0690	03074	176002		SBP *+2	
0691	03075	066210		JMP SPCE	
0692	03076	001322	NEWCH	LDA TBUFF	FETCH NEW CHARACTER
0693	03077	072005		RZA FETAS	IF *0 THEN DO CHAR.
0694	03100	045317		ISZ CHMOD	SET CVHMOD = 7
0695	03101	000141		LDA M12	SET
0696	03102	031354		STA CLCNT	CRUISE COUNT
0697	03103	066212		JMP LSTCH	AND JUMP
0698	03104	035322	FETAS	STB TBUFF	CLEAR TBUFF
0699	03105	050055		AND 0177	MASK OFF EXTRA BITS
0700	03106	010074		CPA EOTCH	EOT?
0701	03107	066124		JMP EOTPT	YES
0702	03110	010051		CPA 017	HANDSHAKE?
0703	03111	066126		JMP HSPRT	YES
0704	03112	020124		ADA N40	ADD OFFSET
0705	03113	030001		STA B	MULTIPLY
0706	03114	173006		SAL 1	BY
0707	03115	024000		ADB A	3
0708	03116	000002		LDA P	

```
0709   03117 050061          AND 0176K
0710   03120 022454          ADA BLKAD
0711   03121 024000          ADB A           ADD TO TABLE OFFSET
0712   03122 035355 STCAD    STB CLDAD       CURR. LETTER DOT ADDR.
0713   03123 066130          JMP MODCG       CHANGE MODE AND CONTINUE
0714   03124 006763 EDTPT    LDB EOTAD
0715   03125 066122          JMP STCAD
0716   03126 006764 HSPRT    LDB HSAD
0717   03127 066122          JMP STCAD
0718   03130 000070 MODCG    LDA 03          SET
0719   03131 031317          STA CHMOD       CHMOD TO 3
0720   03132 000125          LDA N5          SET
0721   03133 031354          STA CLCNT       FOR 5 COLUMNS
0722   03134 004135          LDB P30
0723   03135 040471          JSM DCHEK       CHECK D PARAMETER
0724   03136 024115          ADB M10
0725   03137 024115          ADB M10
0726   03140 024115          ADB M10
0727   03141 026330          ADB MAK1        CALCULATE START OF MASK
0728   03142 035356          STB MSKST
0729   03143 000042          LDA OCT0
0730   03144 031360          STA FLOP        INITIALIZE FLOP
0731   03145 045354 FETDT    ISZ CLCNT       INCREMENT CLCNT
0732   03146 066150          JMP *+2         IF #0 CONTINUE
0733   03147 045317          ISZ CHMOD       IF =1 THEN SET FOR SPACE
0734   03150 105355          LDB CLDAD,I
0735   03151 001360          LDA FLOP
0736   03152 170140          CMA
0737   03153 031360          STA FLOP
0738   03154 072003          RZA *+3         SKIP IF -1
0739   03155 174007          RBR 8           PUT BITS IN LEFT BYTE
0740   03156 045355          ISZ CLDAD       INCREMENT CLDAD AND CONTINUE
0741   03157 174007          SBR 8
0742   03160 077003          SLB *+3         SKIP IF REFERENCED TO TOP
0743   03161 024113          ADB N1          CLEAR TOP OR BOTTOM BIT
0744   03162 174601          SBL 2
0745   03163 174500          SBR 1
0746   03164 040471          JSM DCHEK       CHECK D PARAMETER
0747   03165 000000          NOP
0748   03166 066203          JMP SKPRV       D= 1 OR 2
0749   03167 000000          NOP             ELSE
0750   03170 000150          LDA M9          SET
0751   03171 031361          STA RVCNT       REVERSE COUNT
0752   03172 000042          LDA OCT0
0753   03173 174600          SBL 1           INITIALIZE REVERSE
0754   03174 174533 CONRV    SBR 1
0755   03175 170600          SAL 1
0756   03176 077002          SLB *+2
0757   03177 020043          ADA D1
0760   03200 045361          ISZ RVCNT
0761   03201 066174          JMP CONRV
0762   03202 030001          STA B
0763   03203 040471 SKPRV    JSM DCHEK       CHECK D PARAMETER
0764   03204 056217          JMP PRT
0765   03205 042401          JSM SWAP
0766   03206 056217          JMP PRT
0767   03207 042401          JSM SWAP
0768   03210 045317 SPCE     ISZ CHMOD
0769   03211 056216          JMP ZEROS
0770   03212 045354 LSTCH    ISZ CLCNT
```

```
0769  03213 066216        JMP ZEROS      STILL CRUISING
0770  03214 045346        ISZ DEFG       DONE CRUISING, DECELERATE
0771  03215 045345        ISZ DTEMP
0772  03216 004042 ZEROS  LDB OCT0       DO COLUMN OF ZEROS
0773  03217 135337 PRT    STB BUFPT,I
0774  03220 004042        LDB OCT0
0775  03221 031356        LDA MSKST
0776  03222 031357        STA MSKPT
0777  03223 066231        JMP MK2
0778  03224 101337 MK1    LDA BUFPT,I
0779  03225 151357        AND MSKPT,I
0780  03226 060001        IOR B
0781  03227 030001        STA B
0782  03230 045357        ISZ MSKPT
0783  03231 045337 MK2    ISZ BUFPT
0784  03232 000113        LDA N1
0785  03233 111337        CPA BUFPT,I
0786  03234 042240        JSM MK3
0787  03235 111357        CPA MSKPT,I
0788  03236 056244        JMP DONE
0789  03237 066224        JMP MK1
0790  03240 030205 MK3    LDA BUFST
0791  03241 031337        STA BUFPT
0792  03242 000113        LDA N1
0793  03243 170201        RET 1
0794  03244 174003 DONE   SBL 4          POSITION BITS FOR
0795  03245 035123        STB HEDWD      PRINTING AND STORE
0796  03246 000217        LDA PRTST      SET
0797  03247 031323        STA STROB      STROB
0798  03250 000123        LDA N4         RESET
0799  03251 031353        STA SCNTR      SCNTR
0800  03252 000102 KPSLW  LDA 06
0801  03253 030001        STA B
0802  03254 045353        ISZ SCNTR
0803  03255 066307        JMP OTPT
0804  03256 174600        SBL 1
0805  03257 011317        CPA CHMOD
0806  03260 066313        JMP OTPT1
0807  03261 066307        JMP OTPT
0808  03262 045345 ACCEL  ISZ DTEMP      INCREMENT DTEMP
0809  03263 045347        ISZ TACCT      IF TACCT #0 THEN
0810  03264 066307        JMP OTPT       KEEP ACCELERATING
0811  03265 004220        LDB SLWCT      ELSE DO ONE SAMPLE OF SLEW
0812  03266 035345        STB DTEMP
0813  03267 024043        ADB 01
0814  03270 000042        LDA OCT0       SET
0815  03271 031353        STA SCNTR      SCNTR TO PRINT
0816  03272 000102        LDA 06         SET CHMOD TO FETCH
0817  03273 031317        STA CHMOD      NEW CHARACTER
0818  03274 066313        JMP OTPT1      OUTPUT
0819  03275 055345 DECEL  DSZ DTEMP      IF STILL DECELERATING
0820  03276 056307        JMP OTPT       OUTPUT
0821  03277 000042        LDA OCT0       ELSE
0822  03300 031111        STA USER       CLEAR USER
0823  03301 031345        STA DEFG       CLEAR DEFG
0824  03302 011320        CPA DEFFG
0825  03303 165127        JMP INRET,I
0826  03304 001112        LDA XPRES
0827  03305 031316        STA LSTCX
0828  03306 165127        JMP INRET,I
0829  03307 005345 OTPT   LDB DTEMP
0830  03310 001323        LDA STROB
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0831   003311 072402          SZA *+2
0832   003312 044001          ISZ B
0833   003313 040471 OTPT1    JSM DCHEK
0834   003314 006324          JMP MTROT
0835   003315 056323          JMP *+6
0836   003316 173301          SUC *+1,S
0837   003317 000064          LDA SNBIT
0838   003320 060001          IOR B
0839   003321 030001          STA B
0840   003322 173602          SUS *+2,C
0841   003323 174007          SBL B
0842   003324 034000 MTROT    STB A
0843   003325 031200          STA XYOUT
0844   003326 141121          JSM OUTXY,I
0845   003327 165127          JMP INRET,I
0847   003330 003331 MAK1     DEF *+1
0848   003331 000001          OCT 1,10,100,2,20,200,4,40,400,-1
       003332 000010
       003333 000100
       003334 000002
       003335 000020
       003336 000200
       003337 000004
       003340 000040
       003341 000400
       003342 177777
0849   003343 000400          OCT 400,200,100,40,20,10,4,2,1,-1
       003344 000200
       003345 000100
       003346 000040
       003347 000020
       003350 000010
       003351 000004
       003352 000002
       003353 000001
       003354 177777
0850   003355 000400          OCT 400,40,4,200,20,2,100,10,1,-1
       003356 000040
       003357 000004
       003360 000200
       003361 000020
       003362 000002
       003363 000100
       003364 000010
       003365 000001
       003366 177777
0851   003367 000001          OCT 1
0852   003370 000002 MSK2     OCT 2
0853   003371 000004 MSK3     OCT 4
0854   003372 000010 MSK4     OCT 10,20
       003373 000020
0855   003374 000040 MSK6     OCT 40
0856   003375 000100 MSK7     OCT 100
0857   003376 000200 MSK8     OCT 200,400,-1
       003377 000400
       003400 177777
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We claim:

1. A system for forming visual output [manifestations] *images* on a web, comprising:

head means having a *non-linear* plurality of print elements engaging said web, each element being located at the intersection of first and second [coordinate positions] *coordinates of position* in the head, with no [element occupying] *two elements having* the same first coordinate [position] and no [element occupying] *two elements having* the same second coordinate [position];

drive means coupled to at least one of the web and the head means for providing relative motion [of] *between* the head means [with respect to] *and* the web along *at least one of the* two orthogonal coordinates *of the web*; and

logic means disposed to receive data and coupled to the drive means and to the *print elements of the* head means for forming visual output [manifestations] *images* on the web in one of four directions along the two orthogonal coordinates *of the web* by causing the drive means to move at least one of the web and head means to a selected position *in selected steps* and energizing selected *print* elements of the head means to form selected portions of the visual output [manifestations] *images* in response to said data *at each position of the head means relative to the web.*

2. The system as in claim 1 wherein each first coordinate of the print elements is a row coordinate and each second coordinate is a column coordinate, the print elements being symmetrically located about at least one of two substantially 45° diagonals.

3. The system as in claim 1 wherein the logic means includes a stored routine for producing alphanumeric characters, the web is thermally sensitive paper, and the print elements comprise at least nine thermal resistive elements.

4. The system as in claim 1 wherein the head means includes a plot element for plotting lines on the web.

5. The system as in claim 2 wherein the print elements are aligned in overlapping contiguity along the coordinates, this arrangement being effective for producing contiguous partly-overlapping marks on the web.

6. The system as in claim 5 wherein the drive means includes a web drive means and a head drive means, and the logic means controls [the head means,] the head drive means, the web drive means and [controls] the energizing of selected numbers of those *print* elements contiguously aligned along a selected coordinate, to produce line segments in the direction of the selected coordinate having thickness related to the number of elements energized.

7. A method of forming output [manifestations] *images having one or more rows and columns* on a web using a movable head with a *non linear* plurality of print elements *thereon* to form portions of each output [manifestation] *image* in one of four orthogonal directions, the method comprising the steps of:

selecting a number of *print* elements to be energized;

positioning one of the head and web with the selected *print* elements located over selected portions of the output [manifestation] *image* to be formed in such a manner that at each positioning no more than one *print* element is located over a column of the output [manifestation] *image* to be printed, and no more than one *print* element is located over a row of the output [manifestation] *image* to be printed; and

energizing the selected *print* elements to form portions of the output [manifestation] *image* in one or four orthogonal directions.

8. The method of claim 7 where the step of positioning includes the steps of moving the head in a first direction to produce output [manifestations] *images* oriented in said first direction, and moving the head in a second direction to produce output [manifestations] *images* oriented in said second direction.

9. The method of claim 7 where the step of positioning further includes the steps of moving the web in a third direction to produce output [manifestations] *images* oriented in a fourth direction opposite to said third direction, and moving the web in a fourth direction to produce output [manifestations] *images* oriented in the third direction.

10. The method of claim 7 where the movable head includes a plot element for forming lines on the web in any selected direction and the method includes the steps of:

selecting the plot element to be energized;

positioning one of the head and web such that the plot element is located over a segment of the line to be formed; and

energizing the plot element to form the line segment in the selected direction.

[11. A print head comprising a cluster of a selected number of print elements disposed on and about at least two diagonals for forming output manifestations on a web in any of four orthogonal directions, such elements being located at the intersection of first and second coordinate positions, with no element occupying the same first coordinate position and no element occupying the same second coordinate position.]

[12. The print head as in claim 11 wherein each first coordinate of the print element is a row coordinate and each second coordinate is a column coordinate.]

[13. The print head as in claim 11 wherein the print elements are aligned in overlapping contiguity along the coordinates for producing partly-overlapping contiguous output manifestations on the web.]

[14. The print head as in claim 11 wherein the print elements are disposed having independent conductor leads and a common ground lead.]

[15. The print head as in claim 11 wherein a first group of the selected number of print elements are used for printing output manifestations in the form of upper case characters, a second group of said elements are used for printing lower case characters, and a third group of said elements are used to print punctuation characters.]

[16. The print head as in claim 11 including a plot element disposed externally to the cluster of print elements for plotting lines.]

17. A system for forming visual output [manifestations] *images* on a web, comprising:

head means having a *non-linear* plurality of print elements and a plot element engaging said web, each element being located at the intersection of first and second [coordinate positions] *cartesian coordinates of position* in the head, with no [element occupying] *two elements having* the same first coordinate [position] and no [element occupying] *having* the same second coordinate [position];

drive means coupled to at least one of the web and the head means for providing relative motion [of] *between* the head means [with respect to] *and* the

web along *at least one of the* two orthogonal coordinates *of the web*; and

logic means disposed to receive data and coupled to the drive means and to the head means for substantially simultaneously printing and plotting visual output [manifestations] *images* on the web in one of four directions along the two orthogonal coordinates *of the web* by causing the drive means to move at least one of the web and head means to a selected position *in selected steps* and energizing selected *print* elements of the head means to form selected portions of the visual output [manifestations] *images* in response to said data *at each position of the head means relative to the web.*

18. A method of substantially simultaneously printing and plotting visual output [manifestations] *images having one or more rows and columns* on a web using a movable head with a *non-linear* plurality of print elements and a plot element *thereon* to form portions of each output [manifestation] *image* in one of four orthogonal directions, the method comprising the steps of:

selecting a number of *print* elements to be energized;

positioning one of the head and web with the selected *print* elements located over selected portions of the output [manifestation] *image* to be formed in such a manner that at each positioning no more than one *print* element is located over a column of the output [manifestation] *image* to be printed, and no more than one *print* element is located over a row of the output [manifestation] *image* to be printed; and

energizing the selected *print* elements to form portions of the output [manifestation] *image* in one of four orthogonal directions.

[**19**. A print head comprising a plot element and a cluster of a selected number of print elements disposed on and about at least two diagonals for printing and plotting substantially simultaneously and forming output manifestations on a web in any of four orthogonal directions, such elements being located at the intersection of first and second coordinate of positions, with no element occupying the same first coordinate position and no element occupying the same second coordinate position.]

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : Re. 30,743

DATED : September 15, 1981

INVENTOR(S) : David J. Shelley et al.

It is certified that error appears in the above—identified patent and that said Letters Patent is hereby corrected as shown below:

Column 13, line 5, after "second" insert -- cartesian --.

Column 14, line 63, after "no" insert -- two elements --.

Signed and Sealed this

Fifth Day of *January 1982*

[SEAL]

Attest:

Attesting Officer

GERALD J. MOSSINGHOFF

Commissioner of Patents and Trademarks