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Fulton et al.

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[45] **July 8, 1975**

[54] **SPECIAL SYMBOL GENERATOR FOR HIGH SPEED PRINTER**

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[73] Assignee: **Extel Corporation**, Northbrook, Ill.

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[52] **U.S. Cl.** ..... **197/1 R**; 101/93.05

[51] **Int. Cl.** **B41j 3/04**

[58] **Field of Search** ..... 197/1 R; 101/93.05; 340/172.5; 178/30

[56] **References Cited**

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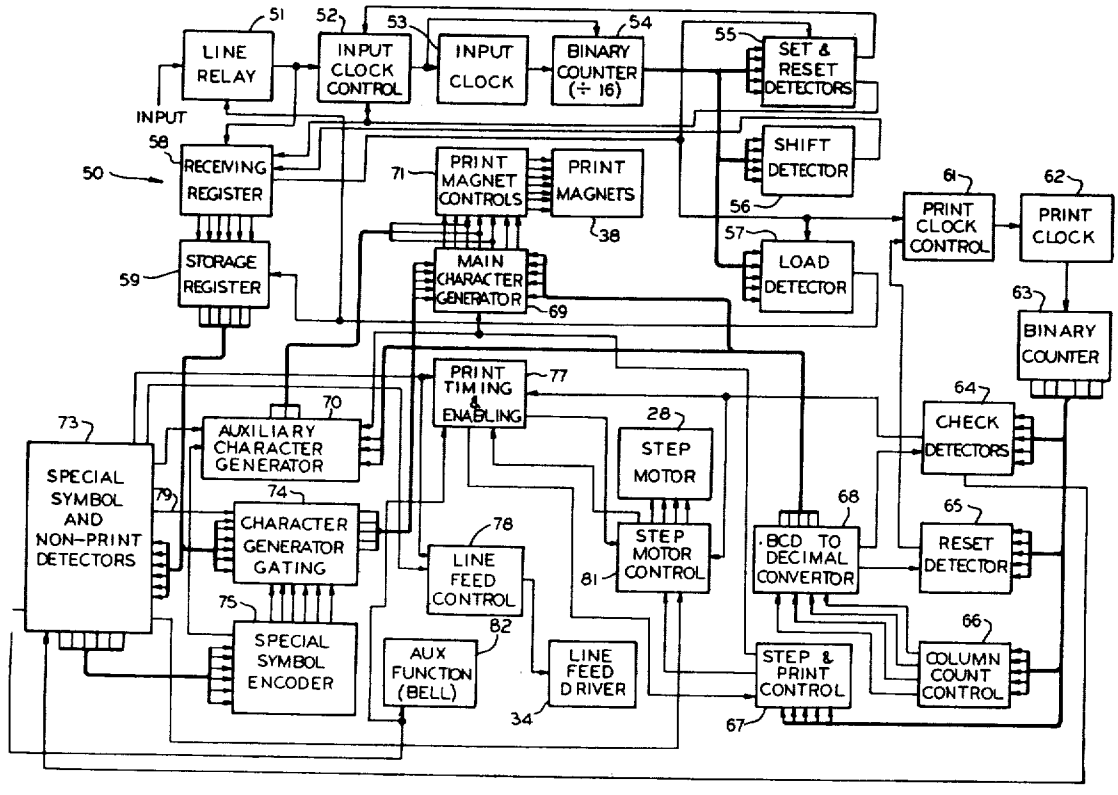
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Primary Examiner—Edgar S. Burr
Assistant Examiner—R. T. Rader
Attorney, Agent, or Firm—Kinzer, Plyer, Dorn & McEachran

[57] **ABSTRACT**

An all electronic control system for a high-speed dot-matrix printer, which enables the printer to print special symbols unsuited to the usual character format constituting a group of dot-position columns separated from the next character by a number of blank columns, using an input signal comprising a series of intermixed code words individually representative of standard data characters and special symbols. The control system comprises an input data store, a main character signal generator for actuating the printer elements to print standard characters, and a special symbol encoder which generates a series of special code words representative of special symbol components that are reproducible in the basic format; these special symbol code words actuate the main character signal generator to reproduce those components. An auxiliary character signal generator actuates the dot printer elements directly to print dots in the normally blank columns adjacent the basic format columns to complete printing of the special symbols; a special symbol detector identifies received code words representative of special symbols to control special symbol printing.

8 Claims, 8 Drawing Figures



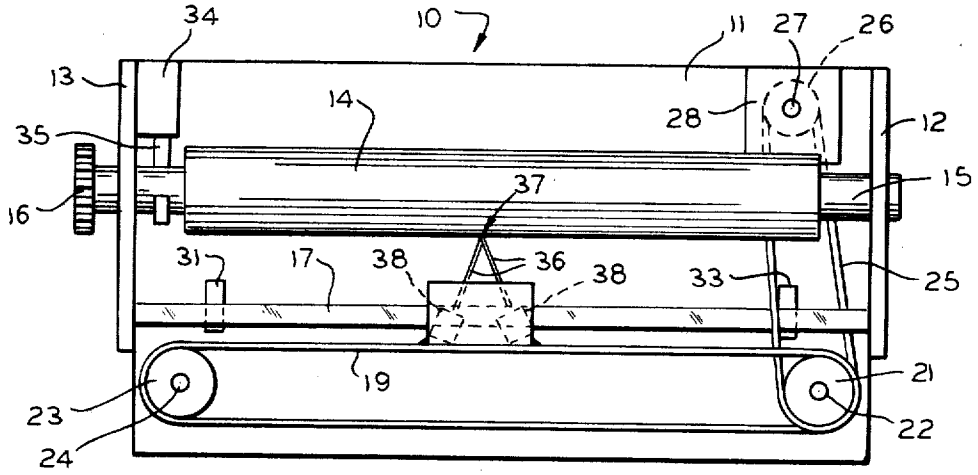


FIG.1

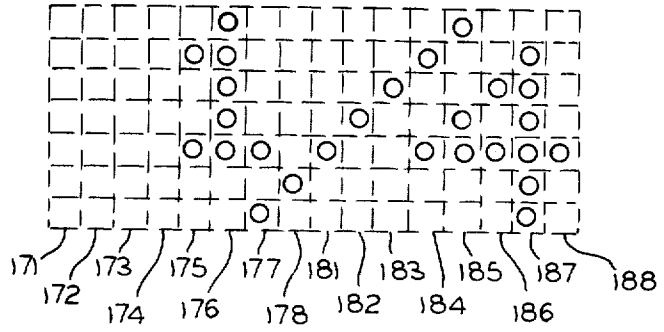


FIG. 4

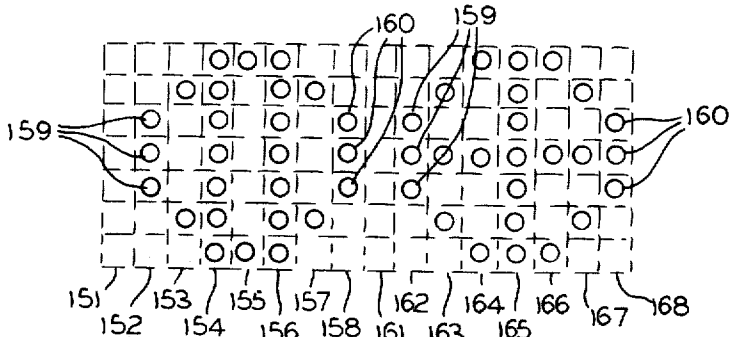


FIG.3

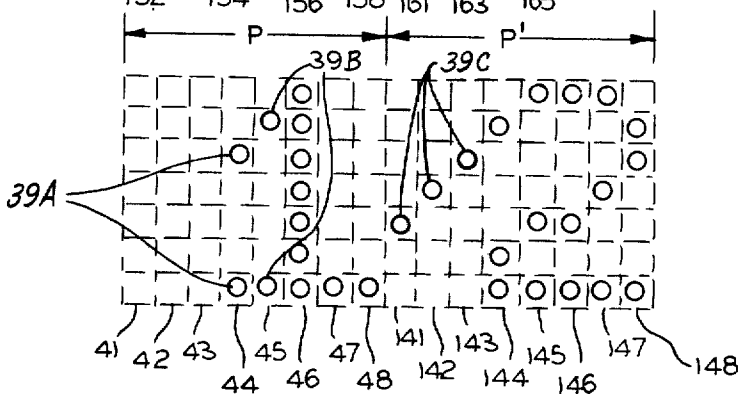
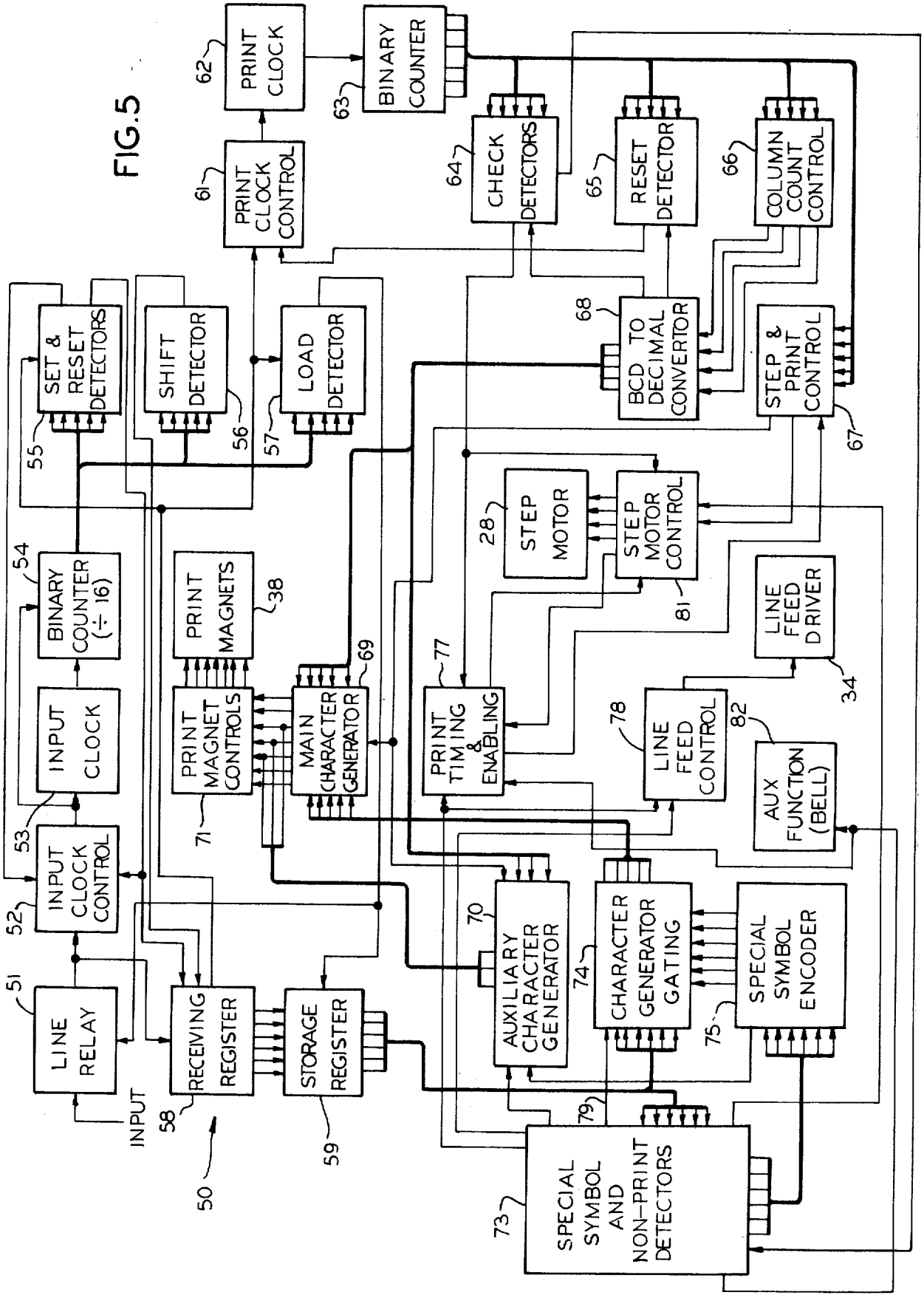


FIG.2

FIG.5


PRINT CLOCK
BINARY COUNTER
PRINT CLOCK CONTROL
CHECK DETECTORS
RESET DETECTOR
COLUMN COUNT CONTROL
SET & RESET DETECTORS
SHIFT DETECTOR
LOAD DETECTOR
BCD TO DECIMAL CONVERTOR
STEP & PRINT CONTROL
STEP MOTOR
STEP MOTOR CONTROL
BINARY COUNTER (÷ 16)
PRINT MAGNETS
LINE FEED DRIVER
INPUT CLOCK
PRINT MAGNET CONTROLS
MAIN CHARACTER GENERATOR
PRINT TIMING & ENABLING
LINE FEED CONTROL
AUX FUNCTION (BELL)
INPUT CLOCK CONTROL
AUXILIARY CHARACTER GENERATOR
CHARACTER GENERATOR GATING
SPECIAL SYMBOL ENCODER
LINE RELAY
RECEIVING REGISTER
STORAGE REGISTER
SPECIAL SYMBOL AND NON-PRINT DETECTORS
INPUT
50
51
52
53
54
55
56
57
58
59
61
62
63
64
65
66
67
68
69
70
71
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74
75
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78
79
81
82
28
34
38

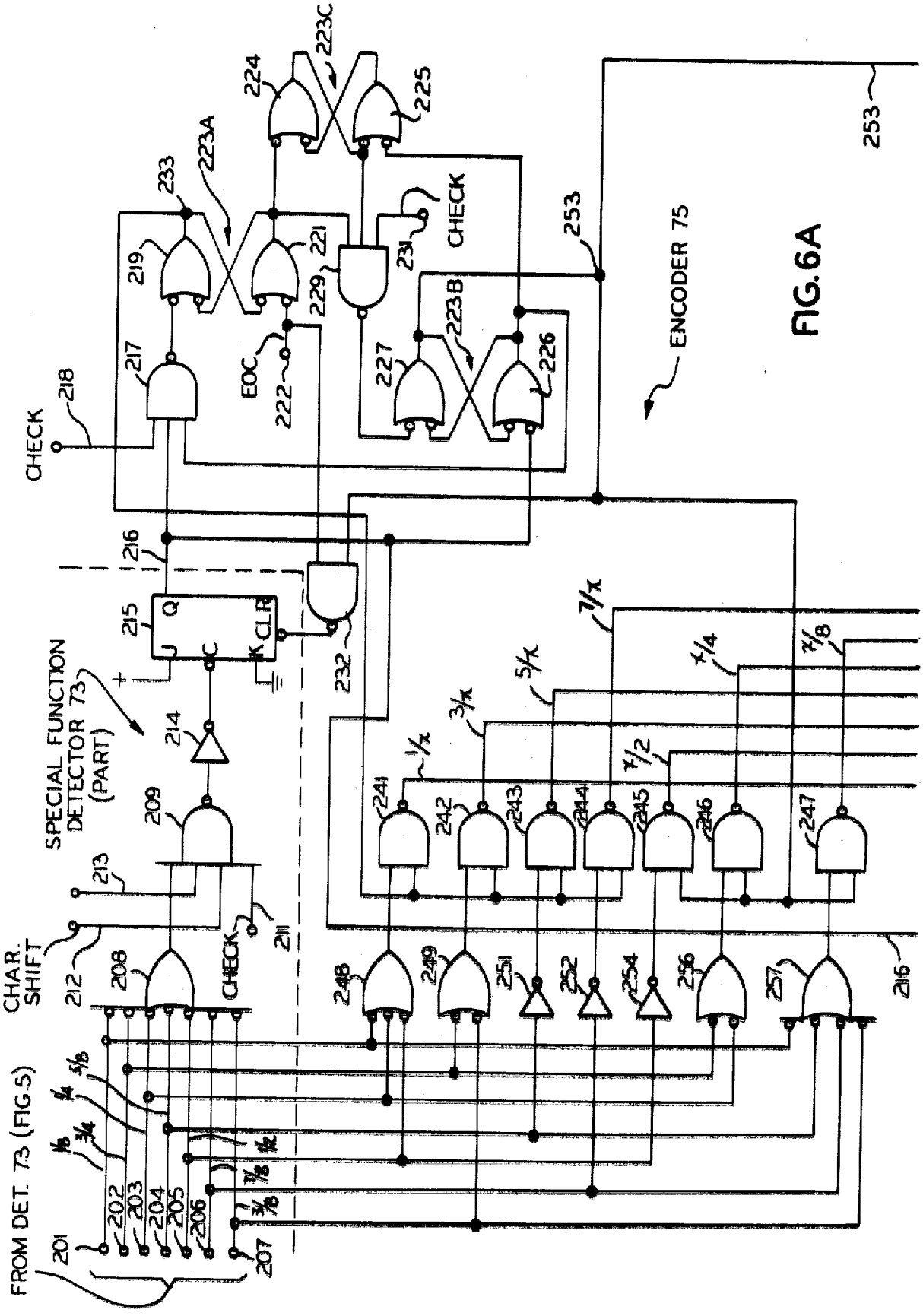

FROM DET. 73 (FIG.5)
CHAR. SHIFT
SPECIAL FUNCTION DETECTOR 73 (PART)
CHECK
EOC
ENCODER 75
Q
CLR
J
C
K
1/16
1/8
3/16
1/4
5/16
3/8
7/16
1/2
9/16
5/8
11/16
3/4
13/16
7/8
15/16
1/1
201
202
203
204
205
206
207
208
209
211
212
213
214
215
216
217
218
219
221
222
223A
223B
223C
224
225
226
227
229
231
232
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246
247
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252
254
256
257
253

FIG.6A

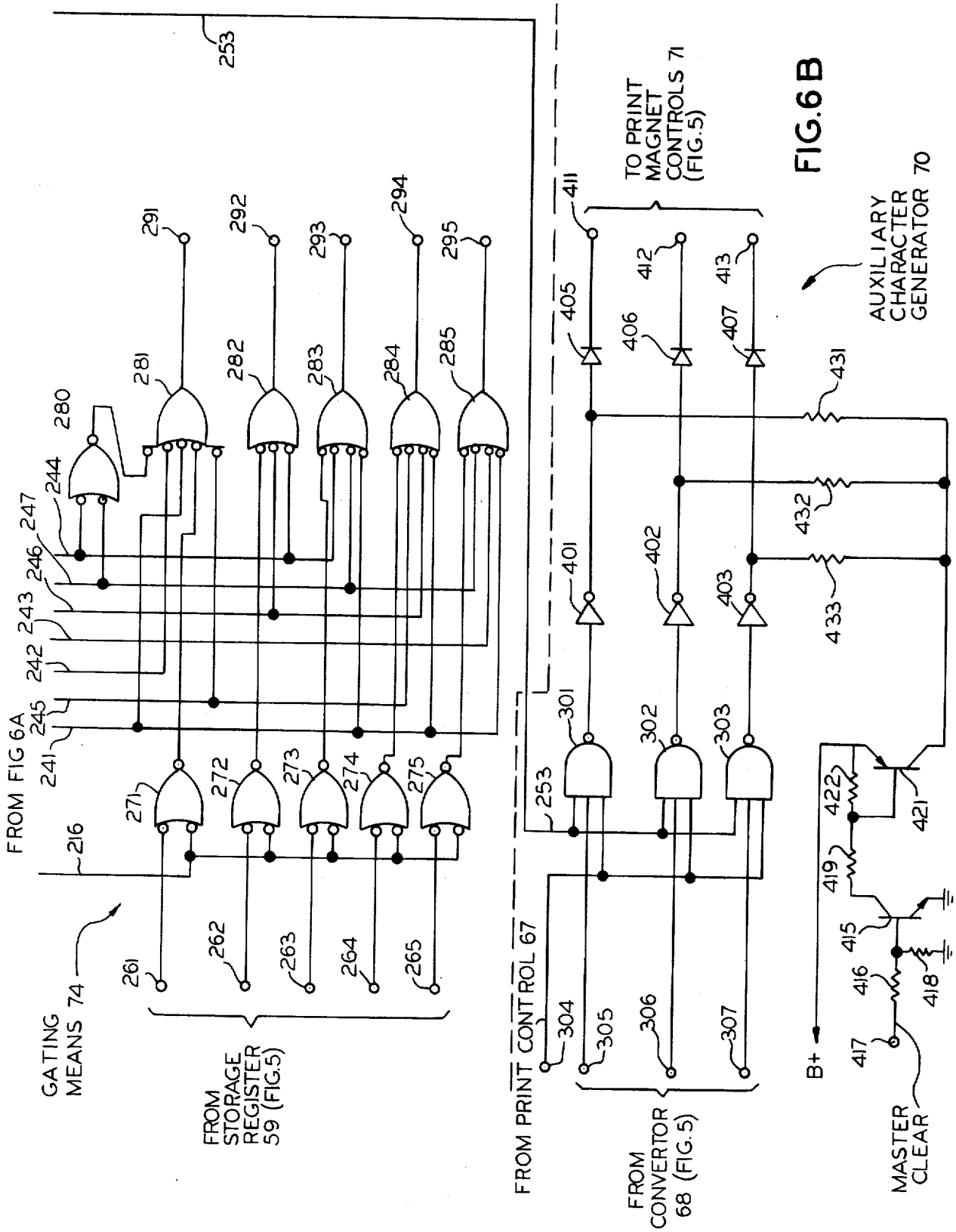

FROM FIG 6A
GATING MEANS 74
FROM STORAGE REGISTER 59 (FIG.5)
FROM PRINT CONTROL 67
FROM CONVERTOR 68 (FIG.5)
TO PRINT MAGNET CONTROLS 71 (FIG.5)
AUXILIARY CHARACTER GENERATOR 70
MASTER CLEAR
B+
253
216
241
242
243
244
245
246
247
261
262
263
264
265
271
272
273
274
275
280
281
282
283
284
285
291
292
293
294
295
301
302
303
304
305
306
307
401
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431
432
433

FIG.6B

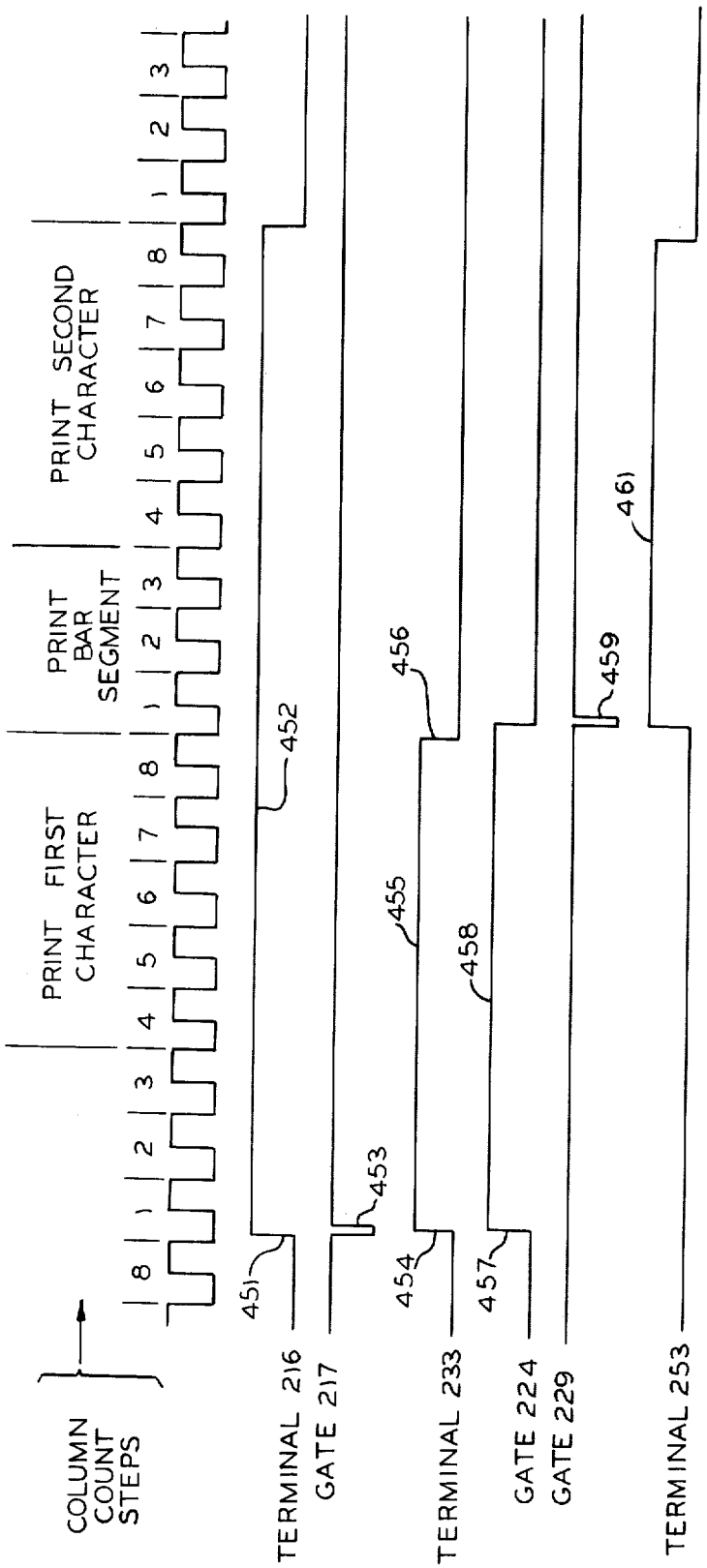

COLUMN COUNT STEPS
PRINT FIRST CHARACTER
PRINT BAR SEGMENT
PRINT SECOND CHARACTER
1 2 3 4 5 6 7 8 1 2 3 4 5 6 7 8 1 2 3
451
452
453
454
455
456
457
458
459
461
TERMINAL 216
GATE 217
TERMINAL 233
GATE 224
GATE 229
TERMINAL 253

FIG. 7

SPECIAL SYMBOL GENERATOR FOR HIGH SPEED PRINTER

BACKGROUND OF THE INVENTION

High-speed printers are often controlled by permutation-coded input signals, such as the conventional Baudot code. In some of these printers, each character is reproduced in a series of sequentially imprinted individual columns of dots. Each code word, as received, is translated into a form usable in control of the printer, and the translated information is presented to the printer mechanism with precise timing and at a speed sufficient to permit multiple functions of the printer mechanism before a new code word is received. In conventional control systems, the received code words are applied to a character generator that performs the required translation, directly from an operational data store. When special symbols unsuited to the basic format of the control system are introduced, a problem arises as to accommodation and reproduction of the special symbols.

Accommodation of the special symbols by changes in the character generator would require a complete reprogramming of the basic character generator, usually a read-only memory, and basic changes in the system format. This would be necessary to afford a usable dot-matrix array for special symbols such as weather symbols, fractions, and other unusual symbols. Incorporation of the special symbols into the character generator programming would require a larger number of dot columns employed to print the characters. An expanded array approach would complicate the character generator design or would limit the number of code words possible in a given system. Further, such an expanded array is inefficient, since the majority of characters do not require an expanded array; only special symbols require extra dot columns. Conforming the special symbols to the conventional dot array pattern is also unacceptable, because distorted characters and erroneous interpretations and errors can easily result.

SUMMARY OF THE INVENTION

It is a principal object of the invention, therefore, to provide a control system for a high speed dot matrix printer that enables the printer to print special symbols unsuited to the basic character format, utilizing an input signal comprising a series of intermixed code words individually representative of standard data characters, non-print functions, and special symbols.

A specific object of the invention is to provide a control system that actuates the dot printer elements to print dots in a predetermined pattern in one or more columns adjacent the columns of the basic format to reproduce special symbols, without materially altering the reproduction of standard characters.

Another object of the invention is to provide a control system with encoding means for generating a series of modified code words, each representative of a part of a special symbol that is reproducible in a basic format, and that includes an auxiliary character signal generator that actuates the dot printer elements to complete the reproduction of the special symbols by printing dots in one or more columns adjacent the columns of the basic format.

Accordingly, the invention relates to a control system for controlling a high speed dot matrix printer of the kind comprising a plurality of individual signal-actuated dot printer elements that print standard data characters in a basic format constituting a group of dotposition columns each including a given number of dot positions, with each such group of columns normally separated from the next adjacent group by a predetermined number of blank columns. The control system enables the printer to print special symbols unsuited to the basic format, utilizing an input signal comprising a series of intermixed code words individually representative of standard data characters and special symbols. The control system comprises a plural-level data store capable of storing a plurality of received code words, for receiving the input signal, each code word being initially recorded in an input level and then advanced to an output level. A main character signal generator is coupled to the dot printer elements and actuates the dot printer elements to print characters in the basic format. The system includes encoding means for generating a series of modified code words, each of which is representative of a part of a special symbol that is reproducible in the basic format. An auxiliary character signal generator is coupled to the dot printer elements for actuating the elements to print dots in a predetermined pattern in one or more columns adjacent the columns of the basic format, completing the reproduction of special symbols. Gating means are provided, coupling an output level of the data store and the encoding means to the main character signal generator. Special symbol detector means are provided and are coupled to the data store, the gating means, and the encoding means for identifying received code words representative of special symbols. The special symbol detector means actuates the gating means and encoding means to apply modified code words to the character generator. The auxiliary character signal generator is actuated, when a special symbol is received, by means of the special symbol detector means and the encoding means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a simplified plan view of a high speed dot matrix printer of the general kind to which the control system of the present invention may be applied;

FIG. 2 illustrates one of the special symbols that may be printed by the printer of FIG. 1;

FIG. 3 illustrates special weather symbols which may be printed by the printer of FIG. 1;

FIG. 4 illustrates an alternate form of a special symbol that may be utilized;

FIG. 5 is a block diagram of a high speed printer control system constructed in accordance with the present invention;

FIGS. 6A and 6B together constitute a detailed schematic and logic diagram for a preferred form of a portion of the control system illustrated in FIG. 5; and

FIG. 7 is a timing chart illustrating the sequence of operations when a special symbol is received, in the control system of FIGS. 5, 6A and 6B.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates, in a simplified form, a high speed dot matrix printer 10 in which the control system of the present invention may be employed; printer 10 produces standard characters and special symbols in dot matrix form as shown in FIGS. 2, 3 and 4. Printer 10 comprises a base 11 with two vertical frame members

12 and 13 affixed to the opposite sides of the base. A platen 14 mounted on a shaft 15 is incorporated in printer 10; shaft 15 is journalled in suitable bearings in the two side frame members 12 and 13. A knob 16 may be mounted on one end of shaft 15 for manual rotation of the platen 14.

A carriage guide rail 17 is mounted near the front of printer 10, extending transversely of the printer between frame members 12 and 13 and parallel to platen 14. A carriage 18 is slidably mounted upon guide rail 17 and is connected to a carriage positioning belt 19. Preferably, belt 19 is a toothed belt of the kind sometimes referred to as a timing belt or gear belt. The right-hand end of carriage positioning belt 19 extends around a drive pulley or sprocket 21 mounted upon a shaft 22 that projects vertically upwardly from base 11. The opposite end of belt 19 engages an idler pulley 23 mounted upon a vertical shaft 24 that projects upwardly from base 11 at the left-hand side of the printer.

Shaft 22 is connected to another pulley, not shown, that is engaged by a drive belt 25. Drive belt 25 extends around a drive sprocket 26 mounted upon the shaft 27 of a motor 28. Motor 28 is a reversible stepping motor that rotates through a discrete angle of rotation each time an electrical signal pulse is applied to the windings of the motor.

There are two control switches 31 and 33 mounted on base 11 in position to be actuated by engagement with carriage 18. Switch 31 is located at the left-hand side of printer 10 and constitutes a left-hand margin control switch. Switch 33 is a right-hand margin control switch. Printer 10 also includes a line feed driver 34 mounted in the rear left-hand corner of base 11. Driver 34 is connected to a line feed linkage 35, shown as a simple line feed lever, for rotating platen 14 through a discrete angular distance to achieve a line feed operation.

In operation, a sheet or web of paper extends around platen 14 and is imprinted by impact from a plurality of printing rods or needles 36 that extend from carriage 18 toward platen 14. In a typical printer, there are seven rods 36 arranged in vertical alignment with each other at the printing station 37 adjacent the surface of platen 14, each rod 36 being provided with an individual drive magnet 38.

Printer 10 is, essentially, a simplified illustration of the high speed printer described and claimed in U.S. Pat. No. 3,670,861 of Walter J. Zenner, to which reference may be made for a more complete and comprehensive description of the mechanical construction and operation of the printer. Details of some of the mechanical linkages in printer 10, such as a return spring for return of carriage 18 to the left-hand margin and a clutch to release the carriage drive for return movement, have been omitted as unnecessary to an understanding of the present invention. The preferred construction for the print head incorporated in carriage 18, including print rods 36 and the print rod magnets, is described and illustrated in detail in U.S. Pat. No. 3,729,079. Only a brief description of the mechanical operation of printer 10 is necessary in this specification.

In the operation of printer 10, as noted above, a sheet or web of impact-sensitive paper is extended around platen 14, between the platen and the print rods 36 of the printer. If preferred, ordinary paper can be employed in conjunction with a carbon ribbon, inked ribbon, or carbon sheet. The starting position for carriage 18 is at the left-hand end of its travel on guide 17, in alignment with the left-hand margin switch 31.

To print a first character, such as the character 1 illustrated in FIG. 2, carriage 18 advances P discrete column steps from left to right, the carriage being driven by its positioning belt 19 through the drive afforded by stepping motor 28, drive belt 25, and pulley 21; in the illustrated embodiment, $p = 8$. During the first three steps of carriage 18, traversing columns 41, 42 and 43, no impression is made on the paper in printing a standard data character. In the next five steps of the carriage, the group comprising columns 44 through 48, the complete character is imprinted by selective actuation of rods 36 into driving impact with the surface of the paper on platen 14 (FIG. 1).

As shown in FIG. 2, the initial advancing movement of carriage 18 leaves three blank columns 41, 42 and 43 preceding the first character. In the first character column 44, two of the print rods 36 are driven into impact with the paper, at the third and seventh levels from the top of the array, producing two vertically displaced dots 39A. On the next incremental column step 45 in the advancing movement of carriage 18, two dot impressions 39B are formed, at the second and seventh levels. In the sixth column 46, all seven of the print rods 36 are driven into impact, producing seven dot impressions. On the next two incremental steps, columns 47 and 48, only the seventh level print rod is actuated. Column 48 is the eighth or final stage of movement for the character format illustrated in FIG. 2. This results in printing the numeral 1 as illustrated in FIG. 2. In this same manner, a complete line of standard characters can be imprinted across the paper on platen 14, with carriage 18 moving from left to right a total of eight column steps for each individual character.

As carriage 18 moves toward the right-hand end of platen 14, it approaches switch 33. Carriage 18 may continue its movement until it engages switch 33, following which the carriage return and line feed mechanisms of printer 10 are mandatorily actuated to return the carriage to the initial left-hand margin position. Before a new line of print is initiated, driver 34 is actuated to rotate platen 14 through one or more line feed increments, placing a fresh line segment of the paper web or sheet in alignment with carriage 18 ready for printing a subsequent line of characters on the paper.

A carriage return operation may also be initiated by a carriage return function code incorporated in a telegraph signal that controls printer 10. A separate line feed code may be utilized to actuate the line feed mechanism comprising driver 34 and linkage 35. Other non-print function codes and special symbol codes may be included in the received signal for control of printer 10.

Fractions, as shown in FIGS. 2 and 4, and weather symbols, as shown in FIG. 3, are some of the special symbols that can be imprinted by the printer 10 when equipped with the control system of the present invention, even though these symbols do not fit the basic format described above for the character 1 in FIG. 2. Moreover, this is accomplished with a received signal that includes code words for both standard characters and special symbols, intermixed with each other. The special symbol code to print a fraction, such as the fraction one-half (FIG. 2) controls the printer 10 to print a first fraction character a second fraction character,

and a pattern of dots in the normally blank columns between the two characters to complete the special symbol. FIG. 2 illustrates one fraction array that may be utilized, while an alternate fraction array is shown in FIG. 4. A weather symbol array is shown in FIG. 3.

FIG. 5 illustrates, in block diagram form, a printer control system 50 that incorporates one embodiment of the present invention. The basic control is similar to that described in U.S. Pat. No. 3,719,781.

The input stage of control system 50 is shown as a line relay circuit 51 to which a conventionally coded telegraph signal is supplied. In the following description, it is assumed that the incoming signal is encoded in accordance with the standard seven and one-half unit Baudot code, but other similar permutation codes can be employed with appropriate modifications in the control system to interpret the input code.

The output of line relay 51 is connected to an input clock control circuit 52, in turn coupled to an input clock 53. Clock 53 may comprise a start-stop multivibrator or other oscillator of constant frequency. The input clock frequency is taken as n times the pulse rate of the input signal; for the control described herein, n - 16. For the Baudot permutation code, which is a 7 ½ unit code comprising one start pulse, five data pulses, and one and one-half stop pulses, the frequency for clock 53 is 1,200 hz, assuming an input rate of 100 words per minute and a pulse rate of 75 pulses per second.

The output of clock 53 is applied to a binary counter 54, which also has an input derived from clock control 52. Counter 54 is a sixteen stage counter and thus cycles once for every pulse in the input signal. The outputs from individual stages in the binary counter are connected to a set and reset detector circuit 55, to a shift detector circuit 56, and to a load detector circuit 57. Control circuit 52, clock 53 and counter 54 comprise an input clock means for control system 50.

The output of circuit 51 is also connected to a receiving data storage register 58 serving as a buffer storage unit for the control system. Register 58, comprising an all-electronic shift register, also receives control signals from detector units 55 and 56. Another output from detector 55 is connected back to the input of clock control circuit 52.

The individual stages of receiving register 58 are connected in parallel to individual stages in the input level of an operational storage means comprising a storage register or data store 59. A control input to data store 59 is supplied from load detector 57. The output of load detector 57 is also connected to line relay 51.

The output of a print clock control circuit 61 is connected to a print clock 62 in turn connected to a binary counter 63. The clock control, clock, and counter circuits 61–63 constitute a print clock means essentially similar to circuits 52–54; however, print clock 62 usually operates at a different frequency from input clock 53. The operating frequency for print clock 62 is determined by the printing pulse rate for printer 10 and is made equal to at least n times the printing pulse rate. The print clock frequency may be lower or higher than the input clock frequency, depending upon the relationship between the printing code and the input code; the print clock must be fast enough to assure completion of a printing operation during the time interval required for reception of an input code word. In a typical installation the print clock frequency is 1330 hz. The print clock rate may also be variable, as described in the co-pending application of John R. Fulton, Ser. No. 349,438, filed Apr. 9, 1973.

The outputs from the various levels of binary counter 63 are connected to a check signal detector means 64, a reset detector 65, a column count control circuit 66, and a step and print control circuit 67. Detector 64 produces check (timing) signals that are applied to a number of circuits in control system 50 as described more fully hereinafter. The output of reset detector 65 is an end-of-character (EOC) signal that is applied to the print clock control circuit 61 to reset that circuit at the end of each character code or other code word. The column count control circuit 66 has a plurality of output circuits individually connected to the several stages of a code converter 68 that converts the column count signals from binary coded decimal (BCD) form to decimal form. Converter 68 has a plurality of output circuits individually connected to a main character generator 69, to an auxiliary character generator 70, to check detectors 64, and to reset detector 65.

Each of the character generators 69 and 70 has an input circuit connected to an output of the step and print control circuit 67. The main character generator 69 also has a plurality of inputs connected to outputs of a character generator gating means 74. The main character generator 69 is a commercially available signal translation matrix of integrated circuit construction, or a combination of such integrated circuits.

Character generator 69 affords seven output circuits, one for each print rod 36 of printer 10 (FIG. 1). Each output of character generator 69 (FIG. 5) is individually connected to one of seven print magnet control circuits 71. Each print magnet control is in turn connected to one of the print magnets 38 for actuating one of the print rods 36. The auxiliary character generator 70 has a plurality of outputs connected to the print magnet controls 71. Generator 70 has a timing control input connected to a special symbol encoding means 75.

The character generator gating means 74 has a plurality of input circuits that are connected to the individual stages of the operational storage register 59. A second plurality of inputs to the gating means 74 is also provided from the special symbol encoder means 75.

The input signal to system 50 includes code words indicative of non-part functions (carriage return, line feed, etc.) as well as characters to be printed. Moreover, the character code words include those characters that are reproducible in the standard 5 × 7 format and other special symbols that cannot be printed in that format. Occurrence of any of these non-print function codes and special symbol codes is detected in a special symbol and non-print function detector unit 73 coupled to the output level of data store 59. The detectors in unit 73 not only identify the occurrence of a non-print function code or a special symbol code, they also identify the particular function or symbol entailed.

One output from detector unit 73 is connected to a print timing and enabling circuit 77 and to a line feed control circuit 78. Circuit 78 has a second input derived from the output of a line feed detector in detector 73. The output of the line feed control circuit 78 is connected to the line feed driver 34. Another output from detector unit 73 is connected to gating unit 74. Detector 73 also has a plurality of outputs connected to encoder 75. Encoder 75 has a plurality of outputs coupled

to gating means **74** and also has a control output connected to auxiliary character generator **70.**

The operation of the control system **50** is similar to that described in U.S. Pat. No. 3,719,781, with the exception of the detector unit **73,** encoder **75,** gating means **74,** and the auxiliary character generator **70.** When a code word for a standard data character is received, and reaches the output level of storage register **59,** the detector **73** actuates gating means **74** to couple the data outputs of data store **59** to the inputs of the main character generator **69.** Encoder **75** and the auxiliary character generator **70** are essentially nonfunctioning when a standard data character code word is received. Imprinting of the character takes place in a standard format, such as three blank columns and five character columns, as described previously and shown by the numeral 1 in FIG. **2.**

When a special symbol code word is received and is identified by detector means **73,** a signal on the logic control lead **79** from detector unit **73** to gating means **74** causes the gating means to couple the outputs of the special symbol encoder **75** to the main character generator **69** in place of the data outputs from store **59.** The special symbol encoder **75** is driven by the special symbol outputs of detector unit **73.**

The special symbol may be any symbol that is unsuited to the basic format of the dot array. Such symbols may include fractions, as shown in FIGS. **2** and **4,** weather symbols as shown in FIG. **3,** or any other symbol representing a data character not fully adaptable to the standard format. Special symbols may be utilized in machines with various standard formats. Two particular standard formats of interest are characters formed by three blank columns followed by five dot-position columns, as described above, or two blank columns followed by five dot-position columns and one blank column. It should be noted that any other combination of blank and dot-position columns might also be suitable.

When a special symbol is to be printed, encoder **75** generates one or more modified code words, each representative of one part of a special symbol that is reproducible in the basic format. The auxiliary character generator **70** on the other hand, actuates the dot printer elements **36** to print dots in a predetermined pattern in one or more of the normally blank columns adjacent the columns of the basic format and thus complete the printing of the special symbol.

An auxiliary function output from detector unit **73,** FIG. **5,** is connected to an auxiliary function circuit **82,** which may comprise a buzzer, a bell, or other auxiliary device. This output of detector **73** is also connected to the print timing and enabling circuit **77.** Circuit **77** has one output that is connected to the step and print control **67** and another connected to a step motor control circuit **81.** The step motor control circuit **81** also has inputs derived from a carriage return output of detector means **73** and check detector circuit **64.** Check signals from detector **64** are also supplied to the print timing and enabling circuit **77** and to detector unit **73.**

The step motor control circuit **81** has four outputs individually connected to the motor windings of step motor **28.** Control **81** that determines the direction of rotation of step motor **28** and also controls the number of steps through which the motor is driven in any given operational sequence.

In considering operation of control system **50,** it should be remembered that the initial pulse in each code word, in the telegraph signal supplied to line relay **51,** is a start pulse of given polarity, sometimes referred to as a "space" pulse. The next five pulses in each code word (assuming Baudot code) are data pulses identifying a standard character, a special symbol, or a nonprint function; each of these five data pulses may be a space pulse or a "mark" pulse of opposite polarity. The final 1½ pulses in the code word are stop pulses; both are mark pulses. In the following description, it is assumed that the space pulses in the incoming signal are negative-going signals and that the mark pulses are positive-going signals.

Operation in Response to a Standard Data Character Code

When a signal transmission to control system **50** begins, the initial space code pulse or baud in the input signal actuates line relay **51,** producing an output signal that triggers control circuit **52** to start input clock means **52–54** in operation. As noted above, clock **53** produces a clock signal at a frequency of sixteen times the pulse rate of the input signal; this clock signal is supplied to binary counter **54.** From the frequency relations given above, and as described in more detail in U.S. Pat. No. 3,719,781, it can be seen that binary counter **54** produces sixteen output signal pulses during the time interval prior to occurrence of the next pulse in the incoming signal, which may be either a space or a mark pulse, depending upon the character or function code being transmitted.

When counter **54** reaches a given count, typically a count of six, detector unit **55** is actuated to produce a "set" signal that is supplied back to the input clock control **52** (FIG. **5**) to maintain input clock **53** in operation for the full period of time required for receipt of a complete code word. That is, the set signal from circuit **55** maintains the input clock means **52–54** in operation until reset upon receipt of all of the data pulses in a complete code word.

When counter **54** reaches a higher count (e.g., seven), detector **56** applies a shift pulse to receiving register **58** (FIG. **5**). Register **58** then records the space signal appearing at the output of line relay **51** in its input stage. The input clock **53** continues to run.

At the beginning of the second cycle of operation of input clock means **52–54,** a second input signal pulse is received in line relay **51.** This is the first data pulse; it may be a mark signal or it may be a space signal. At count seven of counter **54,** during this first data signal pulse, a shift signal is again supplied to receiving register **58** from detector **56.** This shifts the initially recorded space pulse to the second stage of the receiving register and records the present output of line relay **51** in the first stage of receiving register **58.** This process continues, with the shift detector **56** producing a shift pulse in each cycle and recording the incoming data from circuit **51** sequentially in the individual stages of receiving register **58.**

When the initial space pulse that started the transmission reaches the final stage of receiving register **58,** the receiving register produces a signal indicating reception of a complete code word that is applied to detectors **55** and **57.** This is an enabling signal that conditions the system for subsequent operations.

In the same cycle of the input clock means **52–54,** on a given count (e.g. nine) in counter **54,** a "load" signal is developed by load detector **57.** This load signal is supplied to data store **59** to transfer the information re-

corded in receiving register **58** into the input level of the operational storage register. The transfer of data between registers **58** and **59** is accomplished in a single input clock pulse, on a parallel basis.

On the count of six in counter **54**, after a complete set of data pulses for a code word has been stored in receiving register **58** and transferred to storage register **59**, detector unit **55** develops a reset signal. This reset signal is supplied to control **52** to interrupt operation of input clock means **52–54** until a further code signal is received in line relay **51**. The reset signal is also supplied to receiving register **58** to clear the shift register in preparation for recording a new character or function code word therein.

An actuating signal is supplied to print clock control circuit **61** to initiate operation of print clock means **61–63** when a complete character or function code has been stored in register **59**, affording a clock signal for timing the operational control circuits **59–82**. The output pulses from print clock **62** are counted in binary counter **63** which, like counter **54**, counts in groups of sixteen. On each count of one in counter **63**, control **66** is actuated to produce a column count signal that is supplied to converter **68** for conversion from binary coded decimal to decimal notation. For each complete character (or function) code, there are eight pulses in the column count signal.

On selected counts in the output of counter **63** (e.g., two, three, and four), "check" signals are produced by detector unit **64**. These check signals from detector means **64** are supplied to the non-print function detector **73**, to the print timing and enabling circuit **77**, to the step motor control circuit **81**, and to other circuits (not shown) to control timing of the printing operation or other functions of printer **10**.

As described above, printer **10** provides a total of eight columns for printing each character, but in one standard format the first three columns are normally utilized for spacing between characters and only the last five columns are actually employed for printing. A system having the first two columns for spacing, the next five columns for printing and the eighth column for spacing may be utilized similarly. Five output signal connections are provided from converter **68** to the main character generator **69**; the signals from the converter are employed in the character generator as column strobe signals. The first column signal output from converter **68** is supplied to check detector **64** for check pulse gating. Additional outputs from converter **68** are available for use in printing special symbols. When a code word for a standard data character is identified as being stored in an output level of data store **59** by detector unit **73**, the detector unit actuates gating means **74** to couple the output level of store **59** to the main character generator **69**. The information from the output level of store **59** is continuously available to the main character generator until new code data is shifted into the data store by another load pulse from detector **57**. The main character generator **69** develops a series of output signals, in response to the column strobe signals from converter **68**, that are utilized to actuate the individual print magnets **38** for the print rods **36** of printer **10** (FIGS. **1** and **5**).

When counter **63** (FIG. **5**) reaches a given count (e.g., seven) near the mid-point of the counter cycle, the step and print control circuit **67** is actuated to develop a "step" signal that is supplied to step motor control **81**. This step signal is utilized, in control **81**, to develop appropriate drive signals to advance step motor **28** one column step. This action occurs once for each of the eight columns entailed in reproduction of a standard character. The step and print control **67** also receives a timing signal from the print timing and enabling circuit **77** and develops a "print" pulse timing signal that occurs shortly after the step signal. The print pulse timing signal is supplied to character generator **69** to control timing of energization of the print magnets **38**, so that the print magnets are energized immediately after step motor **28** has advanced one column step.

As noted above, character generator **69** is a commercially available integrated circuit matrix suitable for generating actuating signals in response to the code data signals from character generator gating means **74**, the column count signals from converter **68**, and the print signals from control **67**. In the reproduction of a standard data character only the column count signals for columns four through eight (or three through seven) are supplied to character generator **69**. Upon the receipt of one column count signal pulse, character generator **69** (FIG. **5**) develops from zero to seven actuating signals, depending upon the particular print magnets that are to be energized for each given column of the character being reproduced. These signals are supplied to the individual print magnets **38**, through appropriate drive circuits in the print magnet control **71**, reproducing the desired character as described above in connection with FIG. **2**.

After completion of printing of the character, on the occurrence of a count of sixteen in the output of binary counter **63** and with a column eight signal available from converter **68**, reset detector **65** is actuated to produce an "end-of-character" reset signal (EOC) that is supplied to print clock control **61** and to other circuits in system **50**. This stops print clock **62**, readying control system **50** for printing of another standard character, printing of a special symbol, or for any other function dictated by the next code word received by line relay **51**.

Operation in Response to a Function Code

The initial operation of control system **50** in response to a non-print function code word is basically similar to that for a standard data character code word. Thus, the initial space pulse at the beginning of the function code word initiates operation of input clock means **52–54**. The code word is stored in receiving register **58**, pulse by pulse, in the manner described above, under control of shift signals from detector **56**. When all data pulses from the complete code word are stored in receiving register **58**, the load signal from detector **57** initiates transfer of the data from register **58** to data store **59**. As before, a signal generated by detector unit **55** re-sets the input circuits for receipt of a new code word.

Print clock means **61–63** is again actuated and column count control **66** again develops a column count signal. Moreover, check detector **64** again develops check pulse signals for timing operation of motor control **81** and the print timing and enabling circuit **77**. The check signals are also applied to the special symbol and non-print function detector means **73**, which identifies the code data now stored in the output level of register **59** as pertaining to a non-print function rather than a standard character or a special symbol. Detector means **73** develops a general non-print function signal

that is supplied to the print timing and enabling circuit **77**, the line feed control **78**, and each of several specific function detectors in detector means **73**.

If the data in the output level of register **59** is the code for a carriage return operation, the carriage return detector of detector means **73** develops a carriage return signal that is supplied to motor control **81**. Control **81** initiates a reverse stepping movement of motor **28**, where reverse movement of the motor constitutes the mechanical action necessary to begin a carriage return operation in printer **10**. In one form of control system **50**, motor **28** is stepped four steps in the reverse direction to release carriage **18** (FIG. **1**) and allow it to return to the initial line position at the left-hand side of printer **10**. In this arrangement, the left-hand margin switch **31** is connected to step motor control **81** to step the motor **28** forward four steps and restore the normal driving conditions for carriage **18** once the carriage has reached its initial position at the left-hand side of the printer.

The use of four reverse steps of motor **28** required to initiate a carriage return movement is subject to substantial variation. Three, five, or even eight steps could be utilized if desired. It will be recognized, of course, that with a different mechanism for carriage return, the output of the carriage return detector in unit **73** could be applied to a separate carriage return device.

If the data in the output level of storage register **59** is a line feed code, the line feed detector of means **73** applies a line feed signal to the line feed control **78** together with the non-print function signal from detector means **73**. Control **78** supplies an actuating signal to the line feed driver **34** to initiate a line feed operation. During the line feed operation, operation of step motor **28** is inhibited.

If the data stored in register **59** is a separate auxiliary code for a non-print function, it is detected in an auxiliary detector circuit in means **73**. Detector means **73** thus produces an output signal that is supplied to the print timing and enabling circuit **77** to preclude actuation of step motor **28** through control **81**. An output signal from detector means **73** is also supplied to auxiliary function circuit **82** to ring a bell, sound a buzzer, or perform such other auxiliary function as may be required.

For each non-print function code, just as for each standard character code, column count control **66** is operated and supplies the column count signal to converter **68**. When the column stage of converter **68** is actuated, it produces an output signal that is supplied to reset detector **65**. Detector **65** then produces a reset signal that interrupts operation of print clock means **61–63** and thus conditions system **50** for the next received code word.

Operation in Response to a Special Symbol Code

The operation of system **50** is response to a special symbol code is also similar to the operation in response to a standard character code. However, the operation differs in the control of the main character generator **69** and the print magnet controls **71**, carried out by the auxiliary character generator **70**, gating means **74**, encoder **75** and the special symbol detector circuits included in detector means **73**.

Examples of various special symbols that may be imprinted by controlled operations of the printer **10** are shown in FIGS. **2**, **3**, and **4**, In FIG. **2** one special symbol, the fraction one-half, is shown as imprinted by a machine utilizing a standard dot-position column array having the first three columns **41–43** as the standard character printing columns.

The particular array for the fraction shown in FIG. **2** is accomplished by printing a portion of the symbol (in this instance a complete numeric character) in the normal dot-position **44–48** of the first character group P, by printing dots in a predetermined pattern in one or more of the normally blank columns **141–143** of the next succeeding character format group P', and by printing the terminal portion of the symbol (another numeric character) in the succeeding five volumns **144–148**.

When a special symbol code word is received, detector means **73** produces an output, identifying the special symbol, which is applied to encoder **75** to produce code word signals for the first and second characters. For this particular fraction format, the code words may be the same as the standard code words for corresponding numeric characters. These are supplied to the character generator gating means **74**. Detector means **73** also actuates gating means **74** to couple the outputs of encoder **75** to the main character generator **69**, as opposed to coupling the outputs of data store **59** to the main character generator **69** as in response to a standard character code.

Encoder **75** also actuates the auxiliary character generator **70** to imprint the desired dot pattern (e.g., dots **39C**) in columns **141–143** of FIG. **2** by direct control of the print magnet control **71**.

Other special symbols, such as the weather symbols shown in FIG. **3**, may also be printed by means of the control system of the invention. In the case of weather symbols the most desirable format utilizes dot reproduction in a total of seven columns to display the full weather symbol and prevent distortion or confusion. For weather symbols, the most efficient manner of programming control system **50** utilizes one extra column on each side of the five dot-position columns of the standard character format. When the standard character format constitutes three blank columns followed by five dot-position columns, the extra column desired for a weather symbol, after the five standard dot-position columns, falls in a blank column of the next character. This presents some difficulty, since the most efficient means to produce a special symbol only seven columns wide is to confine the programming for that symbol to the eight columns normally assigned to one character. Accordingly, it is desirable to alter the standard character format to afford two blank columns preceeding and one succeeding the five normal dot-position columns, resulting in an equivalent eight total columns allotted per character.

In FIG. **3** columns **151** and **152** are normally blank columns and columns **153–157** are the dot-position columns for a standard data character, while column **158** is a normally blank column succeeding the five character columns. Printing of the three dots **159** in the third, fourth and fifth levels of column **152** and the three dots **160** in the third, fourth and fifth levels of column **158** are controlled by the auxiliary character generator **70**, directly actuating the print magnet control **71**. The detector means **73**, the special symbol encoder **75**, the gating means **74** operate, as described above in the generation of a fraction symbol, to produce the five-column portion of the special symbol allotted to the columns used for standard data characters.

Column 161, immediately succeeding the last column 158 of the first symbol shown in FIG. 3, is the first blank column of the succeeding character, which in this case is also a special weather symbol. Here again, the three dots 159 are printed in the third, fourth and fifth levels of the second column 162, which would be blank for a standard character. Another set of three dots 160 is imprinted in the third, fourth and fifth levels of the normally blank column 168 following the five standard dot-position columns 163–167. As in the case of fractions, the main character generator 69 is actuated by encoder 75 and gating means 74 to produce that portion of the symbol contained in the standard dot-position columns 163–167 and the remaining portions, dots 159 and 160, are imprinted under the control of the auxiliary character generator 70.

FIG. 4 illustrates a different fraction display using two eight column groups 171–178 and 181–188. This display utilizes non-standard characters for the two numerals of the fraction, such as the one and the four for the fraction one-fourth. The first numeral of the special symbol is imprinted in the standard dot-position columns 174–178 of the first group (actually, column 174 remains blank for the illustrated numeral "one"). The second numeral is printed in the standard dot-position columns 184–188 of the second group. In addition, however, one dot is printed in each of the normally blank columns 181–183 of the second group and the fraction bar is completed by the extra dots in each of columns 177, 17, 184 and 185. Thus, the complete fraction constitutes a first "character" in columns 174–178, a second character in columns 184–188, and an intervening portion in columns 181–183, just as in FIG. 2, but with different coding. This format requires a special encoding of the code words for the numeric characters in encoder 75, allowing a size reduction from standard numeric characters. However, the display of FIG. 4 may be more desirable than that of FIG. 2 since the bar for the fraction of FIG. 2 must be printed in the limited space afforded by the three columns 141–143 and there is a tendency for the characters to "run together."

From the foregoing description, it can be seen that each received character, special symbol, or non-print function code is first stored in the register 58 by the distributor circuits comprising line relay 51, input clock means 52–54, and detectors 55, 56 and 57. Once all of the data pulses of a complete code word are stored in register 58, the data is transferred from the receiving register to the storage register 59. The load signal from detector 57 initiates the transfer of data between registers 58 and 59. Printing, of a standard character or a special symbol, or another machine function, is indicated when each code word reaches the output level of data store 59. During the time that a character is printed or some other machine function is effected, a code word can be received and stored in the buffer store comprising receiving register 58. The overall operating cycle for the printing and function circuits of system 50, controlled by the print clock means 61–63, is kept shorter than the data input cycle controlled by the input clock means 52–54. Accordingly, printing of a character or completion of a non-print function dictated by data in storage register 59 is usually accomplished before it is necessary to transfer new data into register 59 from receiving register 58. If a special symbol requiring two groups of print columns (FIGS. 2 or 4) is printed, the next code word may be delayed in store 59, necessitating use of a plural-level data store. To accommodate transmissions including frequent fractions or other like symbols, an accelerated print rate may be provided, as in the aforementioned application of J. Fulton, Ser. No. 349,438.

Specific Control Circuits

One specific group of circuits for special symbol generation that may be used in control system 50 (FIG. 5) is illustrated in detail in FIGS. 6A and 6B, which fit together vertically with FIG. 6A on the top and FIG. 6B on the bottom. The auxiliary character generator 70, the character generator gating means 74, the special symbol encoder means 75 and portions of the detector means 73 are shown in FIGS. 6A and 6B; reference may be made to U.S. Pat. No. 3,719,781 for circuits usable in other portions of the control system. The particular circuits shown in FIGS. 6A and 6B are used in printing fractions in the array shown in FIG. 4, but the circuitry would be similar for other special symbols.

The special symbol input terminals 201 through 207 as shown in FIG. 6A, represent the outputs of individual detector circuits (not shown) used to identify received code words representative of special symbols one-eighth, three-fourths, one-fourth, five-eighths, one-half, seven-eighths and three-eighths respectively. Each of these inputs is actuated to a "low" or "zero" logic level when its particular special symbol (fraction) code word is stored in the output level of store 59 (FIG. 5). Terminals 201–207 (FIG. 6A) are each connected to an input of an OR gate 208 whose output is connected to one input of a NAND gate 209. Gate 209 has another input 211 which is a timing input from the check detector 64 (FIG. 5). A character shift control input 212 is another input to gate 209. One or more additional inputs 213 may be required, depending upon the overall printer control employed.

The output of gate 209 is connected through an inverter 214 to the clock input C of a J-K flip-flop 215. The J input of flip-flop 215 is connected to a high logic level source and the K data input is connected to system ground. The data output at the Q terminal of flip-flop 215 affords a fraction detection or enabling line 216 that is connected to the special symbol encoding means 75 (FIG. 6A) and to the gating means 74 (see FIG. 6B). The Q output of flip-flop 215 is triggered to a high logic level whenever any one of the special symbol detector inputs 201–207 indicates reception of a special code word for a fraction.

The encoding means 75 (FIG. 6A) includes a NAND gate 217 having one input connected to line 216 from the detector means 73 and a second input connected to a check pulse 3 output 218 from check detector 64 (FIG. 5). The output of gate 217 is connected to one input of an OR gate 219 whose output is connected to one input of another OR gate 221. The output of gate 221 is connected to a second input for gate 219. A second input for gate 221 is connected to an end-of-character (EOC) control line 222 from reset detector 65 (FIG. 5). Gates 219 and 221 form a first character enable latch 223A. The output of gate 221 is connected to the set input of an intermediate latch 223C comprising an OR gate 224 whose output is connected to one input of an OR gate 225. The output of gate 225 is connected back to one input of gate 224.

A latch reset input to gate 225 in latch 223C is connected to the output of OR gate 226, which is part of

a second character enable latch **223B**. The output of gate **226** is also connected to one input of gate **217** and to one input of an OR gate **227** which is a part of the second character enable latch **223B**. The output of gate **227** is connected back to an input of gate **226**. A second input of gate **227** is connected to the output of a NAND gate **229**. Gate **229** has one input connected to the output of gate **221** in the first character enable latch **223A**, a second input connected to the output of gate **224** in the intermediate latch **223C**, and a third input **231** connected to a check signal from the check detector **64** (FIG. **5**).

Latch **223A** is employed to control printing of a fraction numerator, in operation of the specific circuits shown in FIGS. **6A** and **6B**, whereas latch **223B** controls printing of the fraction divisor.

The end of character (EOC) input **222** to gate **221** (FIG. **6A**) is also connected to one input of a NAND gate **232**. A second input to gate **232** is connected to the output of gate **227** in the second character enable latch **223B**. The output of gate **232** is connected to the "clear" input of the flip-flop **215** to reset the flip-flop after a special symbol (fraction) print sequence.

The output terminal **233** of gate **219** in the first character enable latch **223A** is connected to one input of each of four encoding gates **241** through **244** in the encoding means **75**. The second input of gate **241** is connected to the output of an OR gate **248**. Gates **248** has three inputs, connected to the one-eighth detector input **201**, the one-fourth detector input **203**, and the one-half detector terminal **205**. The second input of gate **242** is connected to the output of an OR gate **249** whose two inputs are connected to the three-fourths detector input **202** and the three-eighths terminal **207**. The second input of gate **243** is connected to the five-eighths detector line **204** through an inverter **251**. The second input of gate **244** is connected to the seven-eighths detector line **206** by an inverter **252**.

The output terminal **253** of gate **227** in latch **223B** is connected to one input of each of three encoding gates **245–247**. Another input of gate **245** is connected, through an inverter **254**, to the one-half detector input **205**. A second input of encoding gate **246** is connected to the output of an OR gate **256** which has one input connected to the three-fourths detector terminal **202** and a second input connected to the one-fourth detector input **203**. The second input for encoding gate **247** is taken from the output of an OR gate **257** which has inputs connected to the fraction detector terminals **201, 204, 206,** and **207**. The outputs of encoding gates **241–247** are output lines of the encoding means **75** that supply modified code words for special symbols to the gating means **74** (FIG. **6B**).

The gating means **74**, in the form shown in FIG. **6B**, has input terminals **261** through **265** which are connected to the output terminals storage register **59** (FIG. **5**). Terminals **261–265** are each connected to one input of one NAND gate in a series **271–275**, respectively. The other input of each of the gates **271–275** is connected to the outut **216** of flip-flop **215**, which is the fraction or special symbol identification output of detector means **73** (FIG. **6A**). That is, the signal on line **216** affords an enabling-disabling input to gating means **74**.

Gating means **74** further comprises a NOR gate **280** and a group of five OR gates **281** through **285**. The output of gate **271** is connected to one input of gate **281**; similarly, the output of each of the gates **272–275** is connected to one input of a respective one of the gates **282–285**. The remaining inputs for gates **280–285** are all derived from the encoder gates **241–247** in encoding means **75**, FIG. **6A**.

Thus, the two inputs to gate **280** in the character generator gating means **74** (FIG. **6B**) are taken from the outputs of gates **244** and **247** in encoder **75** (FIG. **6B**). The outputs of gate **280** affords one input to gate **281**. The remaining inputs to gate **281** are taken from the outputs of encoding gates **241, 242** and **245**. Two additional inputs are provided for gate **282**, derived from the outputs of encoding gates **244** and **246**. Gate **283** has three additional inputs, derived from the outputs of encoding gates **241–244** and **247**. There are three additional inputs to gate **284**, taken from the outputs of encoding gates **241, 245** and **246**. There are also three additional inputs to gate **285**, taken from the outputs of encoding gates **241, 243** and **247**.

The output terminals **291** through **295** for gates **281** through **285**, respectively, constitute the output terminals of gating means **74** and are connected to character generator **69** (FIG. **5**).

In the form shown in FIG. **6B**, the auxiliary character generator **70** includes three NAND gate **301, 302** and **303**. Each of the gates **301–303** has one input that is connected to an output terminal **253** of gate **227** in the second character enable latch **223B** (FIG. **6A**). Each of the gates **301–303** also has a second input, derived from a terminal **304** of the step and print control **67** (FIG. **5**), which indicates the print mode of operation for printer **10**. Gate **301** has a third input connected to a terminal **305** taken from converter **68** (FIG. **5**) and supplying a strobe signal for printing in the first of the three normally blank columns between dot-position columns in which standard characters are printed. For the format of FIG. **4**, this is column **181**. Similarly, gate **302** has a third input connected to a terminal **306** that receives a signal from converter **68** identifying the column step corresponding to the second normally blank column, column **182** in FIG. **4**. Gate **303** takes its third input from a terminal **307** that receives a signal from converter **68** identifying the third normally blank column **183** (FIG. **4**).

The output of gate **301** (FIG. **6B**) is connected, through an inverter **401** and a diode **405**, to an output terminal **411**. The output of gate **302** is supplied to an output terminal **412** through an inverter **402** and a diode **406**. The output of gate **303** is connected through an inverter **403** and a diode **407** to an output terminal **413**. Output terminals **411–413** are connected to print magnet control **71** (FIG. **5**) to actuate the print magnets and the print rods independently of character generator **69** in printing the dots in columns **181, 182** and **183** of the fraction format illustrated in FIG. **4**.

To prevent undesired energization of the print magnets that are subject to control by signals from the auxiliary character generator output terminals **411–413** (FIG. **6B**) when the printer is first placed in operation, means are provided to inhibit premature operation of the auxiliary character generator **70**. The circuit employed for this purpose, as illustrated in FIG. **6B**, comprises a transistor **415** having its base electrode connected through a resistor **416** to an input terminal **417**. Terminal **417** receives a "master clear" signal when the printer is first turned on.

The base of transistor **415** is connected to system ground through a resistor **418.** The emitter is directly connected to system ground. The collector of transistor **415** is connected through a resistor **419** to the base of a second transistor **421** and is also connected to a B+ supply through the series combination of resistor **419** and a load resistor **422.** The emitter of transistor **421** is connected to the B+ supply. The collector of transistor **421** is connected to the output terminal of each of the three inverters **401–403** by means of three individual resistors **431–433.**

Before reviewing the operation of the circuits shown in FIGS. **6A** and **6B**, a brief discussion of the significance of some of the signals generated therein is in order. Thus, the output on line **216** from flip-flop **215** (FIG. **6A**) signifies the need to print a special symbol (fraction) but does not identify the particular symbol to be printed. The output of the first character enable latch **223A**, in conjunction with encoding logic gates **241–244,** controls printing of a first character, the numeric character and part of a fraction bar printed in columns **174–178** (FIG. **4**). The intermediate latch **223C** (FIG. **6A**) controls actuation of the second character enable latch **223B**. Latch **223B**, in turn, together with encoding logic gates **245–247,** controls reproduction of a part of the fraction bar in columns **181–183** and of the second "character," constituting the remainder of the fraction bar and the second numeric character in columns **184–188** (FIG. **4**).

The outputs of encoder gates **241–244** identify the fraction numerators **1, 3, 5** and **7** respectively, and the outputs of encoder gates **245–247** identify the fraction divisors **2, 4,** and **8** respectively, as marked in FIG. **6A**. The encoder gate outputs are coupled to character generator **69** through gates **280–285** in gating means **74,** replacing the normal inputs to the character generator from data store **59.**

The sequence of operations performed by the circuits illustrated in FIGS. **6A** and **6B**, in printing a special symbol in the format illustrated in FIG. **4,** can best be understood by reference to the timing diagram of FIG. **7.** The timing diagram of FIG. **7** is described in terms of the column count steps controlled by the output signals from converter **68.** The eight column steps assigned to each of two consecutive groups of eight columns are numbered and marked to illustrate the total imprinting of the special symbol, in this instance a fraction.

When a special symbol code word is received, for example, the code word for the fraction one-fourth as shown in FIG. **4**, one of the special symbol detectors in unit **73** produces an output on terminal **203** (FIG. **6A**) corresponding to this particular symbol. OR gate **208** then applies an enabling signal to gate **209,** and an appropriately timed signal is supplied to flip-flop **215.** In this manner, the Q data terminal **216** of flip-flop **215** develops an enabling signal, applied to gates **217** and **226** and to gating means **74** (FIG. **6B**) whenever any of the special symbol detector inputs **201** through **207** are activated. The generation of the special symbol output signal on terminal **216** is shown as the leading edge **451** of the waveform **452** in FIG. **7.** Thus, when a special symbol is received and detected, the output signal at terminal **216** flips from a logical zero to a logical one, and remains at the one level for two full groups of column count steps. When the signal at terminal **216** is high, for a logical one, gates **271–275** in gating means **74** are blocked, and data signals are not translated to character generator **69** from store **59** as in the normal receive mode for standard character code words.

The fraction indication output from terminal **216** is coupled through gate **217,** with appropriate timing determined by the check input **218** (FIG. **6A**), to set the first character enable latch **223A**, gates **219** and **221.** The output of gate **217** is shown in FIG. **7** by the brief pulse **453,** occurring when a check signal is applied to terminal **218** from check detector **64** (see FIG. **6A**). This pulse **453** (FIG. **7**), in setting latch **223A**, produces a change in state at terminal **233** from a zero to a one level, shown as the leading edge **454** of the waveform **455** (FIG. **7**).

The encoding gates **241–244** of the encoding means **75** (FIG. **6A**), relating to the fraction numerator, are now enabled to produce a modified code word representative of the particular special symbol or fraction indicated by the input signal on one of the terminals **201–207.** In the case of the fraction one-fourth, signalled on input terminal **203,** with its connections through gate **248,** gate **241** changes state during the first character enable interval determined by pulse **455** (FIG. **7**) to produce a change in state in gates **281, 283,** 284 and **285,** supplying a modified code word to the character generator **69** through output connections **291, 293, 294** and **295** (FIG. **6B**). With this modified code word coupled to the main character generator **69,** the first character is imprinted in columns **171** through **178** (FIG. **4**) as control system **50** steps through these columns, corresponding to column steps **4** through **8** in FIG. **7.** The numeral one and two fraction bar dots is thus imprinted (FIG. **4**). The first character enable latch **223A** (FIG. **6A**) remains high or enabled until an end-of-character (EOC) signal on input **222** resets the latch as shown as waveform edge **456** in FIG. **7.** The EOC signal is produced by the reset detector **65** (FIG. **5**).

The intermediate latch **223B**, gates **224** and **225,** is also set, producing a "high" output as indicated by the leading edge **457** of the waveform **458** at the output of **224** (FIGs. **6A, 7**) when the first character enable latch **223A** is activated. The intermediate latch **223C** remains activated until the second character enable latch **223B**, gates **226** and **227,** is set. Latch **223B** is set when the inputs to gate **229,** including a check signal on line **231** from check detector **64,** are all at high logic levels. This occurs after the first latch **223A** is reset, waveform edge **456,** FIG. **7.** That is, the second character enable latch **223B** is set by the pulse **459** of the waveform at the output of gate **229.** The enabling of the second latch **223B** is shown by **461** the waveform at terminal **253** (FIGS. **6A, 7**). The second character enable latch **223B** continues at a high logic level throughout a full cycle of eight more column steps.

During the next three (normally blank) column steps, the auxiliary character generator **70** is enabled by the signal on line **253** and by a signal on input **304** (FIG. **6B**). The strobe signals for these three column steps, from converter **68** appearing successively at terminals **305–307,** produce successive outputs at terminals **411–413** (FIG. **6B**) to print dots in columns **181–183** (FIG. **4**). These dots form the central part of the fraction bar.

With the second character enable latch **223B** still set, the signal input on terminal **203,** through gate **256,** actuates encoding gate **246.** The output of gate **246** en-

ables gates **282** and **284** in the gating means **74,** supplying the modified code word for the divisor of the fraction at outputs **292** and **294** of gating means **74** (FIG. **6B**) and hence to the main character generator **69.** The second character, as illustrated in columns **184** through **188** in FIG. **4,** is printed, based on this modified code data, completing the fraction one-fourth.

The second character enable latch **223B** remains set (waveform **461,** FIG. **7**) until the end-of-character (EOC) signal at terminal **222** (FIG. **6A**) resets the flip-flop **215** by means of gate **232.** Resetting of the flip-flop resets the second character enable latch **223B** by means of the signal, on line **216,** applied to gate **226.** The system is now back in the standard mode, ready to receive and utilize a code word for a standard character, another special symbol, or a non-part function.

The special symbol control, including the special symbol detector means **73,** the special symbol encoder **75,** the character generator gating means **74,** and the auxiliary character generator **70,** in cooperation with the overall control system **50,** enables printer **10** to print special symbols that are unsuited to the standard character format, utilizing an input signal that includes a series of intermixed code words individually representative of standard data characters and special symbols. The special symbol code words are identified by the detector means **73,** which provides outputs to the encoder **75** to produce modified code words supplied to the character generator gating means **74.** This technique is employed to reproduce the first and second characters of a fraction or of any other simiar special symbol wide enough to require two standard character formats. The gating means **74** selects between the data store outputs from store **59** and the modified code word outputs from the encoder **75,** under the control of the detector means **73,** and couples either the data store or the encoder to the character generator **69.** The auxiliary character generator **70,** under the timing control of encoder **75,** is directly coupled to the dot printer magnet controls **71** to actuate the printing of dots in a predetermined pattern in one or more columns that would be blank in the basic format to complete printing of the fraction or other special symbol.

The operation is essentially similar for special symbols narrow enough to fit into just one character format, as in the case of the weather symbols shown in FIG. **3,** with the auxiliary character generator **70** controlling the imprinting of dots in normally blank columns on both sides of the standard dot-position columns. The special symbol code word, as received, is modified by encoder **75** to produce a modified code word that controls printing in the standard dot-position columns. The printing of dots in normally blank columns on one or both sides of the standard print columns in directly controlled by the auxiliary character generator **70.**

Virtually any combination of special symbols requiring the imprinting of dots in normally blank columns. involving any reasonable numbers of columns and any number of dots in each column, can be accomplished by circuits similar to those shown in FIGS. **6A** and **6B,** with appropriate revision to fit the basic printer controls.

We claim:

1. In a high-speed dot matrix printer of the kind comprising a plurality of individual signal-actuated dot printer elements that print standard data characters in a basic format constituting a group of dot-position columns each including a given number of dot positions, with each such group of columns normally separated from the next adjacent group by a predetermined number of blank columns, a control system enabling the printer to print special symbols unsuited to the basic format, utilizing an input signal comprising a series of intermixed code words individually respresentative of standard data characters and special symbols, said control system comprising:

a plural-level data store for receiving said input signal and capable of storing a plurality of received code words, each received code word being initially recorded in an input level of said store and then advanced to an output level;

a main character signal generator, coupled to said dot printer elements, for actuating said dot printer elements to print characters in said basic format;

encoding means for generating a series of modified code words each representative of a part of a special symbol, which part is reproducible in said basic format;

an auxiliary character signal generator, coupled to said dot printer elements, for actuating said dot printer elements to print dots in a predetermined pattern in one or more columns adjacent the columns of said basic format to complete the reproduction of said special symbols;

gating means, coupling an output level of said data store and said encoding means to said main character signal generator;

and special symbol detector means, coupled to said data store, said gating means, and said encoding means, for identifying received code words representative of said special symbols, and for actuating said gating means and said encoding means to apply modified code words to said main character generator;

said encoding means also being coupled to said auxiliary character generator to actuate said auxiliary character signal generator.

2. A control system, according to claim **1,** in which said special symbols each comprise two adjacent characters imprinted in said basic format by said main character generator actuating said dot printer elements in response to modified code words for each character.

3. A control system, according to claim **2,** in which said encoding means comprises latch-timing means for generating encoding information and logic means for generating modified code words, said latch-timing means providing the timing information to said logic means for generating a first modified code word representative of the first character and a second modified code word representative of a second character.

4. A control system, according to claim **3** in which said gating means comprises logic coding means for translating said modified code words at the output of said encoding means to a code suitable for driving said main character generator.

5. A control system, according to claim **4,** in which said special symbols are fractions and said auxiliary character signal generator actuates said dot-printer elements to print dots representative of at least a portion of a fraction bar in the normally blank columns interposed between said first character and said second character of the special symbol.

6. A control system, according to claim 5, in which each of said first and second characters, as imprinted under the control of said main character generator, comprises a numeral and a portion of a fraction bar.

7. A control system according to claim 1, in which each special symbol comprises a main character portion formed by dots imprinted in said basic format by said main character generator actuating said dot printer elements in response to a modified code word, and a second portion comprising dots imprinted in at least one column immediately adjacent the dot-position columns of said basic format by said auxiliary character signal generator actuating said dot printer elements.

8. A control system according to claim 7, in which said special symbols are weather symbols and dots are printed in just one column at each side of the dot position columns of said basic format.

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