United States Patent

Locke

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[54] ASYNCHRONOUS PRINTER

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[73] Assignee: **Sperry Rand Corporation**, New York, N.Y.

[22] Filed: **Jan. 22, 1971**

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Related U.S. Application Data

[63] Continuation of Ser. No. 782,319, Dec. 9, 1968, abandoned.

[52] **U.S. Cl.** ..... **197/49**, 101/93 C

[51] **Int. Cl.** **B41j 1/22**

[58] **Field of Search** 197/49, 55; 101/93

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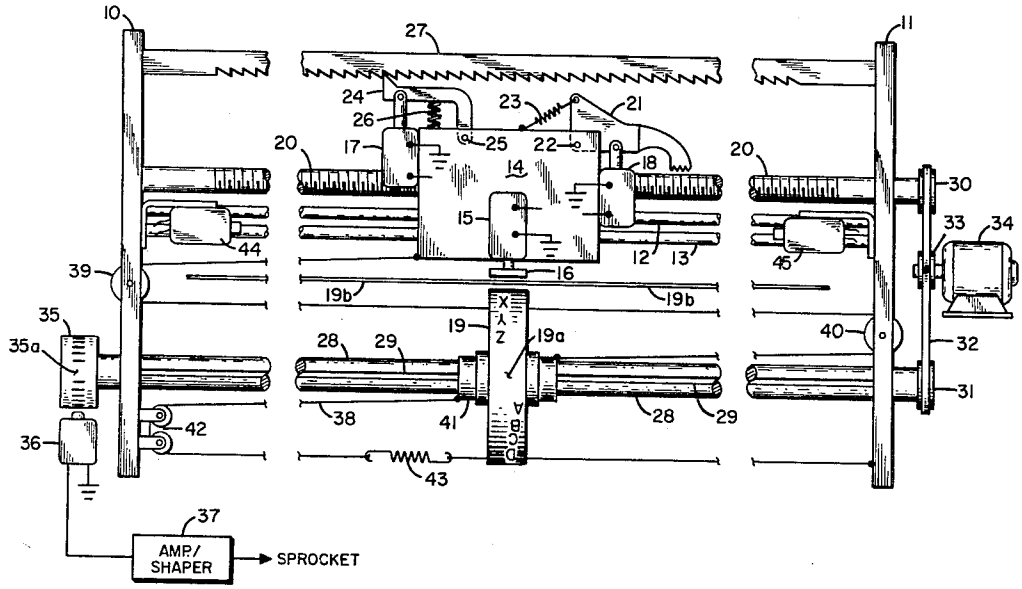
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[57] **ABSTRACT**

An asynchronous printer mechanism is described. The printer mechanism includes a rotating type wheel which has its characters arranged to lie along a helical path. The wheel is rotated continuously about the axis of the helical path. A drive mechanism which is coupled to the wheel is operable upon receipt of a data character to be printed to step the wheel along a print line one column at a time. A rack and pawl mechanism is added to hold the print wheel at its last columnar printing position until the next character to be printed is received.

3 Claims, 4 Drawing Figures



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SHEET 1 OF 3

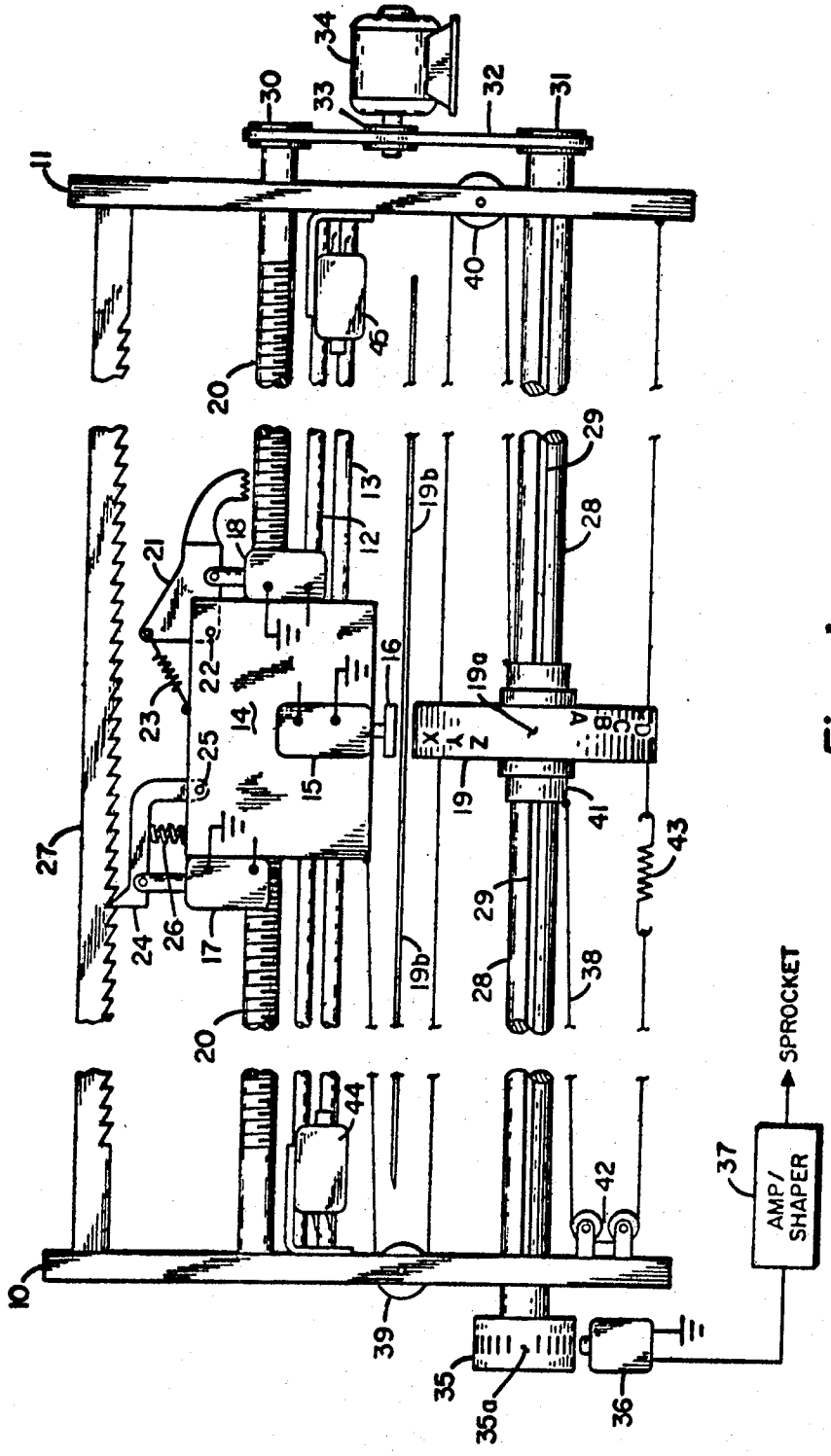


Fig. 1

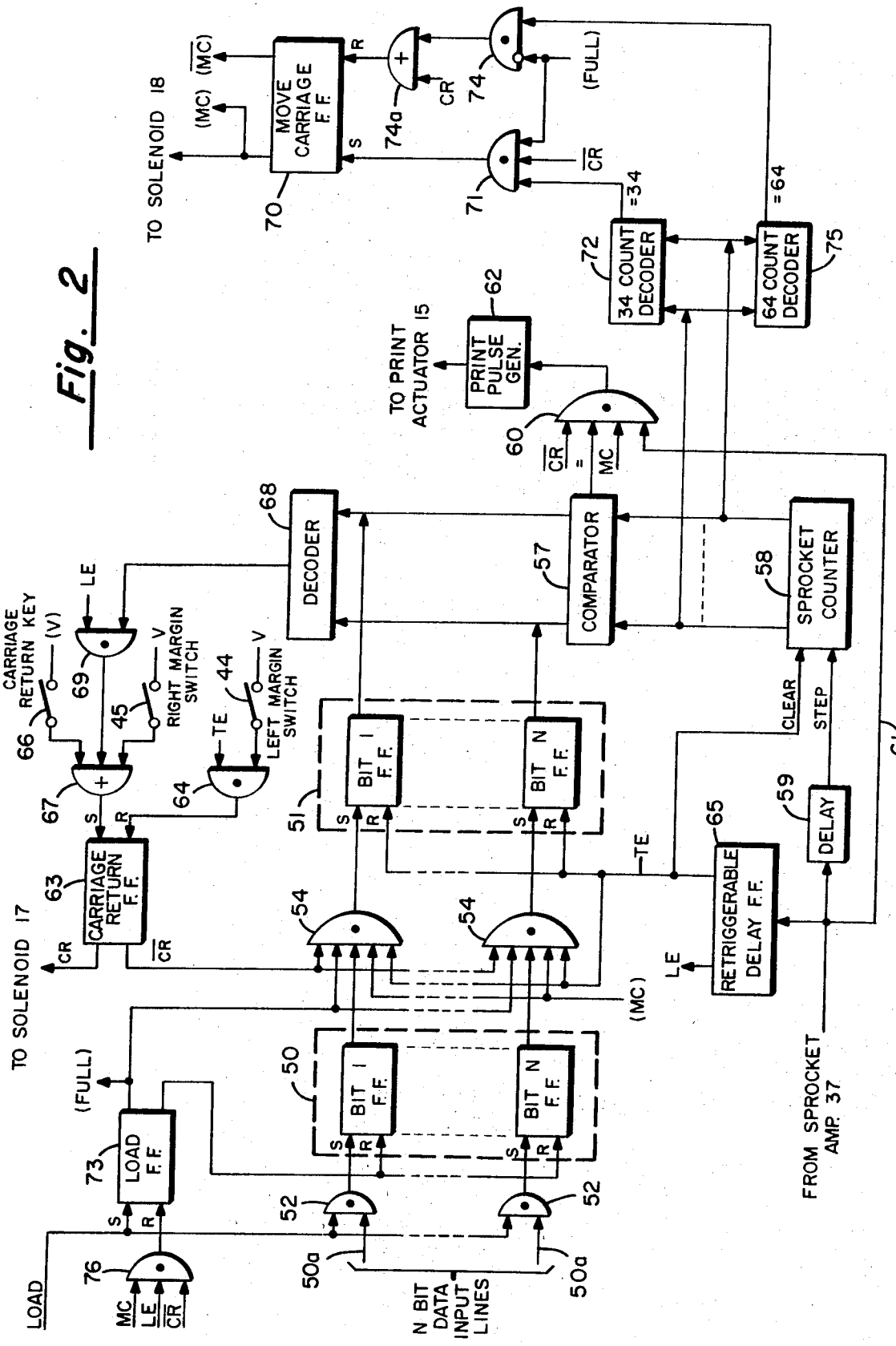

TO SOLENOID 18
(MC)
(MC)
MOVE CARRIAGE F.F.
R
S
70
74a
CR
74
(FULL)
71
CR
=34
=64
72
34 COUNT DECODER
64 COUNT DECODER
75
TO PRINT ACTUATOR 15
62
PRINT PULSE GEN.
60
CR
=
MC
68
DECODER
57
COMPARATOR
58
SPROCKET COUNTER
CARRIAGE RETURN KEY
(V)
66
LE
69
V
RIGHT MARGIN SWITCH
45
V
LEFT MARGIN SWITCH
44
TE
64
67
51
BIT 1 F.F.
BIT N F.F.
CLEAR
STEP
61
59
DELAY
TE
65
RETRIGGERABLE DELAY F.F.
63
CARRIAGE RETURN F.F.
CR
CR
54
54
TO SOLENOID 17
(MC)
LE
(FULL)
50
BIT 1 F.F.
BIT N F.F.
FROM SPROCKET AMP. 37
73
LOAD F.F.
52
52
LOAD
76
MC
LE
CR
50a
50a
N BIT DATA INPUT LINES

Fig. 2

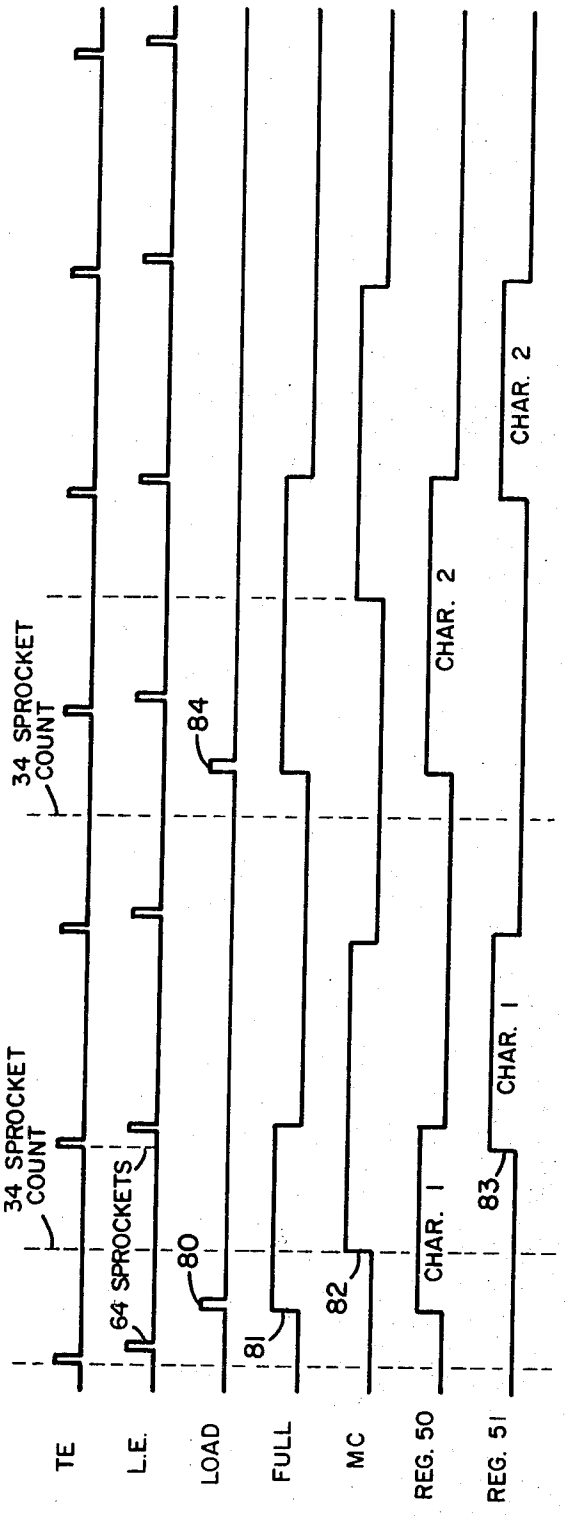

TE
L.E.
LOAD
FULL
MC
REG. 50
REG. 51
34 SPROCKET COUNT
64 SPROCKETS
80
81
82
83
84
CHAR. 1
CHAR. 2

Fig. 3a

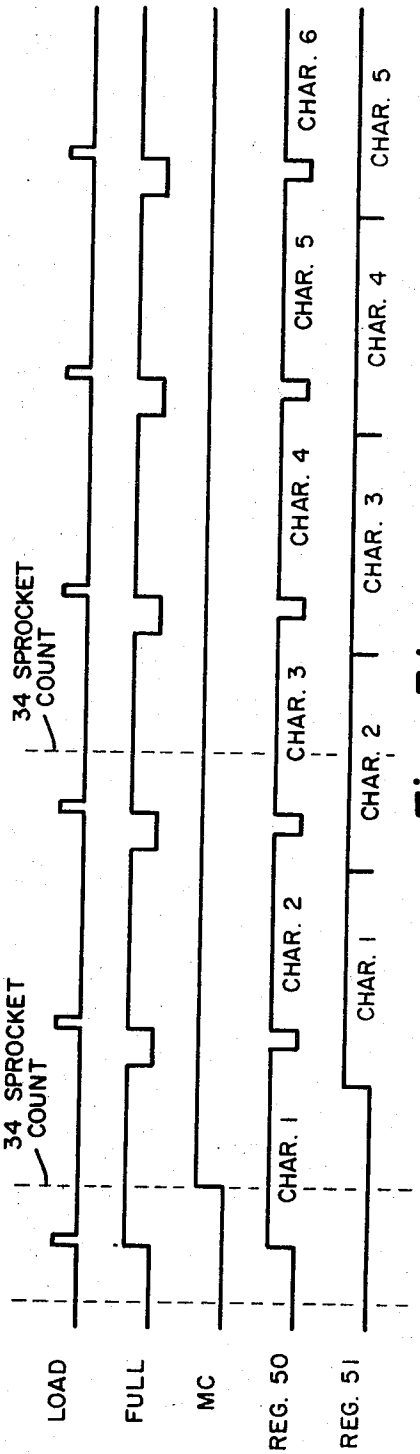

LOAD
FULL
MC
REG. 50
REG. 51
34 SPROCKET COUNT
CHAR. 1
CHAR. 2
CHAR. 3
CHAR. 4
CHAR. 5
CHAR. 6

Fig. 3b

ASYNCHRONOUS PRINTER

This application is a continuation of Ser. No. 782,319, filed Dec. 9, 1968, and now abandoned.

This invention relates to a printer mechanism and in more particular to an improvement over U.S. Pat. No. 2,843,243.

The printer mechanism shown in the above patent comprises a rotating print member which in the preferred embodiment is a print wheel. The print wheel has a series of type characters arranged to lie in a helical path about the periphery of the wheel. The axis of rotation of the wheel parallels a print line and the wheel is continuously rotated about its axis and at the same time moved along its axis. The pitch of the helical path defined by the type characters is set to so compensate for the movement of the wheel along its axis that all the characters will scan past a first columnar print position during one revolution of the wheel and then scan past the second columnar print position during the second revolution and so on.

The printer described in the above-identified patent has numerous advantages. For example, it is simple in design and it is relative high speed in action in that the printing takes place while the wheel is moving from column to column.

The advantages and flexibility of such a printer can be extended by making the printer asynchronous in operation. In asynchronous operation, the wheel is selectively moved along its axis only after a character has been received from the data source and is ready to be printed. With this type of operation a printer which has a certain maximum printing rate can be made to print at any slower rate without the need for elaborate synchronizing circuits. Thus such a printer mechanism can be operated directly from a data line terminal, a keyboard or any of a number of other data sources with a minimum amount of interfacing problems. It is therefore an object of this invention to provide a simple yet reliable asynchronous printer mechanism.

BRIEF SUMMARY OF INVENTION

In accordance with the teachings of this invention, a printer mechanism is provided which utilizes a rotatable type wheel on which the type characters are arranged to lie along a helical path. The type wheel is continuously rotated about the axis of the helical path and means are provided to step the type wheel along a print line. Movement of the type wheel along the print line is selective and only occurs when a character to be printed has been received from a suitable data source. Means are provided to hold the print wheel in the last column to be printed so that the action of the printer is incremental. That is, when a character to be printed is received from the data source, it causes the print wheel to be moved along the print line and the character to be printed while the wheel is moving. The motion of the print wheel along the print line is then stopped and awaits the arrival of the next character to be printed. If the recurrence rate of the characters from the data source equals the rotational rate of the print wheel, the action of the printer becomes synchronous in that the motion of the print wheel becomes continuous and does not stop as the print wheel advances from one print position to the next.

In the drawings,

FIG. 1 is a diagrammatic showing of the printer mechanism of this invention when viewed from above;

FIG. 2 is a block diagram showing the control logic for the printer mechanism;

FIG. 3*a* is a set of timing diagrams useful in illustrating the operation of the printer mechanism in an asynchronous mode; and

FIG. 3*b* is a set of timing diagrams useful in illustrating the operation of the printer mechanism in a synchronous mode.

Reference is now made to FIG. 1 where there is shown at **10** and **11** a pair of end plates, cast metal for example, or support members for supporting the printing mechanism comprising this invention. Disposed between the end plates **10** and **11** are a pair of guide rods **12** and **13** on which a carriage **14** is mounted for translation between the end plate **10** and **11**. The

carriage **14** carries a print actuator solenoid **15** and print hammer **16**. To effect the translation of the carriage **14**, a lead screw **20** extends between the end plates **10** and **11** and is journaled for rotation in each of the end plates as indicated. The right-hand end of the lead screw **20** terminates externally of the end plate **11** in a suitable pulley member **30**. A pawl **21** is pivotally mounted as shown at **22** on the carriage **14** and is adapted to engage the lead screw **20** in order to impart motion to the carriage **14**. The pawl **21** is normally biased out of engagement with the lead screw as by spring **23** and a solenoid **18** is linked to the pawl **21** so upon energization of the solenoid **18** the pawl **21** is pulled into engagement with the lead screw **20**. The lead screw **20**, which is continuously rotated operates, with pawl **21** engaged, to move the carriage **14** in a left to right direction. Also extending between end plates **10** and **11** is a rotatable shaft **28** which has a longitudinal key way cut therein as shown at **29**. Shaft **28** is journaled at each end in end plates **10** and **11** as shown and the right-hand end of shaft **28** terminates in a pulley **31** which has a belt **32** linking it and the pulley **30**. A drive pulley **33** attached to the motor **34** operates via the belt **32** and pulleys **30** and **31** to synchronously drive the lead screw **20** and the shaft **28**. Mounted on shaft **28** and rotated therewith is a helical type wheel **19**. Type wheel **19** is keyed to shaft **28** so as to rotate therewith while at the same time it is free to be translated along shaft **28**. The type wheel **19** contains, as indicated in the aforementioned patent, a set of type characters which are helically placed about the perimeter of the wheel and arranged so that the pitch of the helix defining the character path corresponds to the pitch of the lead screw **20**.

The left-hand end of shaft **28** terminates in a sprocket wheel **35** which in this illustration is a magnetic sprocket wheel. The sprocket wheel **35** contains a separate magnetic spot recorded thereon for each character on the type wheel **19**. In a typical case, 64 characters and 64 sprocket pulses may be used. Also as shown in the Figure, a gap **19***a* of say 10° may be inserted between the first and last characters arranged on the type wheel **19** and a corresponding gap **35***a* is formed in the sprocket track on wheel **35**. The gaps **19***a* & **35***a* give the printer electronics time to recover whenever the last character on the wheel is printed in one column and the first character on the wheel is printed in the next column.

Located next to the sprocket wheel **35** is a magnetic pick up head **36** which senses the sprocket pulses on the sprocket wheel **35** and applies them to an amplifier shaper circuit **37** where the sprocket pulses are amplified and shaped and used to control the electronic circuits in the printer.

To correlate the translation of the wheel **19** between the end plates **10** and **11** with the movement of the carriage **14**, a cable and pulley arrangement **38**, **39**, and **40** is utilized. Specifically, the cable **38** is anchored at one end to the carriage **14**, loops around pulleys **39** and **40** and is fastened to a collar **41** which is journaled to print wheel **19** and adapted to slide along shaft **28**. In this way movement of the carriage **14** affected by the lead screw **20** transmits the motion of the carriage **14** to the print wheel **19** thereby causing the print wheel **19** to follow the motion of the carriage **14**.

The carriage **14** and print wheel **19** are normally biased to a left margin position by another cable, pulley and spring arrangement comprising cable **38***a*, pulley **42** and spring **43**. In particular, cable **38***a* is anchored at one end to the collar **41** of the print wheel **19**, loops over pulley **42** and is then connected via spring **43** to end plate **11**. With this arrangement the spring **43** tends to pull the print wheel **19** and therefore the carriage **14**, operating through cable **38**, to its left margin position adjacent plate **10**.

Also extended between the end plates **10** and **11** and anchored at each end thereto is a rack member **27** which has a saw tooth milled therein for each print column so that the spacing of the teeth corresponds to the columnar spacing of the print line. Engaging the rack **27** is a pawl **24** which is pivotably mounted as at **25** to the carriage **14**. Pawl **24** is normally urged to engage the rack **27** by means of a compression

spring 26. Also linking the pawl 24 is a solenoid 17 which upon energization causes the pawl 24 to disengage from the rack 27 and to permit the tension of spring 43 to move the carriage 14 and the print wheel 19 to a left margin position. The rack 27 and pawl 24 operates when solenoid 17 is deenergized to hold the print wheel 19 and carriage 14 at its last printed columnar position.

Mounted adjacent to each of the end plates 10 and 11 is a pair of switches 44 and 45. These switches which may be movable toward and away from the corresponding end plates 10 and 11 comprise the left and right margin switches for the printer. In operation these switches are positioned so that when the carriage is moved to its left margin position as represented by the position of switch 44, switch 44 will be actuated on contact by the carriage 14. Similarly, when the carriage 14 has moved to its right margin position a represented by the position of switch 45, switch 45 will be actuated on contact by the carriage 14.

Before leaving the description of FIG. 1 it should be noted that the print receiving medium is shown diagrammatically at 19*b*, while the inking mechanism for wheel 19 has been omitted for purposes of simplification.

Reference is now made to FIG. 2. As indicated in this figure, the control logic for the printer includes a pair of data registers 50 and 51. These registers, which are conventional in design, are each capable of holding one character of data. Each register, for example may comprise, if the data is in the form of N binary bits, N flip-flop stages connected in parallel. In a typical embodiment N may comprise seven or more bits. The input data which may be derived from, as previously indicated, a typewriter, a data terminal, a perforated tape or a card system, arrives as N parallel binary bits on the N input lines 50*a*. These input lines 50*a* are in turn connected through N "AND" gates 52 to the set input terminals of the N flip-flops comprising the data register 50. Connected in parallel to all the "AND" gates 52 is a strobe line labeled "LOAD". This line is energized by a "load" pulse obtained from the data source itself whenever a data character arrives on the lines 50*a* from the source. With this connection, data appearing on lines 50*a* is gated into the data register 50 where it is temporarily held. The register 50 represents the input register for the system and data stored therein is subsequently transferred at a predetermined time in the rotation of sprocket print wheel 19 to a correspondingly configured output data register 51 again via N "AND" gates designated here by the reference character 54. After a data character has been transferred to register 51 it is held in this register for one revolution of the print wheel 19 and printed. To effect printing, the N binary outputs from the data register 51 are applied to a binary comparator 57 which is of conventional design. The other input to the comparator 57 is obtained from an N stage sprocket counter 58 which is driven from the output of the sprocket amplifier 37 shown in FIG. 1 via a delay 59. As will be later described the sprocket counter 58 is advanced one count for each sprocket pulse on wheel 35 and therefore for each character on type wheel 19. The binary counter 58 is thus made to generate a binary coded output which corresponds to the character on the type wheel 19 which is coming into printing position. Then when the data character stored in the data register 51 corresponds to the type character coming into printing position as represented by the sprocket counter 58 count, the comparator 57 operates to generate an output signal which is then applied to and conditions an "AND" gate 60. If the "AND" gate 60 is fully conditioned by the MC and $\overline{CR}$ signals applied thereto as well as the equality signal from the comparator 57, the sprocket pulse applied thereto via line 61 will pass through gate 60 to actuate the print pulse generator 62. The output of the print pulse generator 62 is applied to the actuator 15 to cause the hammer 16 to impact the print receiving paper 19*b* against the print wheel 19 to thus cause a character to be printed on the paper 19*b*.

The $\overline{CR}$ signal applied to gate 60 is obtained from the reset output of the carriage return flip-flop 63. This signal which is normally present indicates that the carriage 14 and type wheel 19 are not undergoing a carriage return action. The output of an "AND" gate 64 is used to reset the carriage return flip-flop 63 and thus produce the $\overline{CR}$ signal. The input to the "AND" gate 64 is obtained from the left margin switch 44 and from the left margin switch 44 and from the TE output of a retriggerable delay flop 65. The retriggerable delay flop 65 is a conventional circuit which is driven from the output of the sprocket amplifier 37 as shown. In operation retriggerable delay flop 65 will be set to produce an output pulse on its LE terminal in response to the first sprocket pulse following the gap 35*a* in the sprocket wheel 35. After the circuit 65 has been so set it will remain in its set position until after the last sprocket pulse before the gap 35*a* has been received from the sprocket wheel 35. Then shortly after the last sprocket pulse is received, the retriggerable delay flop 65 will reset and produce an output pulse on its TE terminal. The TE and LE pulses are thus cyclic and occur once each revolution of the print wheel 19.

The set or CR output of the carriage return flip-flop 63 is used to energize solenoid 17 and therefore to return the carriage 14 and print wheel 19 to their left margin position. The carriage return flip-flop 63 may be triggered to its set condition through any one of at least three different paths. First it may be keyboard controlled by key 66 through buffer or "OR" gate 67. Secondly, it may be set by the action of the right margin switch 45 so that when the carriage 14 and print wheel 19 reach the right margin position switch 45 will be actuated and the carriage 14 and print wheel 19 automatically returned to their left margin position. Finally, the flip-flop 63 may be set by a "Carriage Return" data character arriving from the data source itself. In this case, the "Carriage Return" character stored in data register 51 is decoded in decoder 68. The output of the decoder 68 conditions an "AND" gate 69 which also receives an LE pulse from the retriggerable delay flop 65. Thus when a "Carriage Return" character has been received from the data source, gate 69 is conditioned and the LE pulse obtained from retriggerable delay flop 65 passes through gate 69 and buffer 67 to set the carriage return flip-flop 63. Once flip-flop 63 has been set, the carriage 14 and type wheel 19 are returned to their left margin position where actuation of the left margin switch 44 will reset the flip-flop 63 with the next TE pulse.

The MC signal applied to gate 60 is obtained from the set output of the move carriage flip-flop 70, and it obtains whenever data has been loaded into the register 50. The MC signal, as indicated, also operates the solenoid 18 to thus pull in the pawl 21 and cause carriage 14 and type wheel 19 to translate from left to right. The move carriage flip-flop 70 is set from the output of an "AND" gate 71 which receives as inputs, the $\overline{CR}$ output of the carriage return flip-flop 63, the set output of the load flip-flop 73 (labeled Full) and the decoded 34th sprocket count from sprocket counter 58 as decoded by decoder 72. In operation, when a "Load" pulse has been received and a data character loaded into register 50, the load flip-flop 73 is set to produce the "Full" signal. This signal together with the normally present $\overline{CR}$ signal conditions gate 71 so that when the sprocket counter 58 reaches a count of 34 gate 71 passes a signal to the set input terminal of the move carriage flip-flop 70 to set flip-flop 70 and thus actuate pawl 21. As will subsequently be seen, the solenoid 18 is energized during one revolution of the type wheel and printing actually occurs during the next revolution of the type wheel. The reason for this is that there is a certain amount of delay between the start of the generation of the MC signal and the time that the pawl 21 actually pulls in to start the translation of the print wheel 19. In a constructed embodiment where a 25 character per second or 40 millisecond rotation rate for print wheel 19 was used, a sprocket count of 34 was found to provide a satisfactory delay compensation.

The move carriage flip-flop 70 can be reset by either the CR signal from the carriage return flip-flop 63 passing through buffer 74*a* or from the output of an "AND" gate 74 a shown.

An output is produced from gate **74** when the output of the sprocket counter **58** reaches a count of 64 as detected by decoder **75** and, then only if the load flip-flop **73** has been reset. The load flip-flop **73** is reset from the output of an "AND" gate **76** which receives as its inputs, the MC signal of the move carriage flip-flop **70** itself, the LE signal from the retriggerable flip-flop **65** and the $\overline{CR}$ signal from the carriage return flip-flop **63**. From the signal line up on gate **76** it will be understood that the load flip-flop **73** will not be reset until the first LE time following the setting of the move carriage flip-flop **70**. When the load flip-flop **73** has been reset the inhibition on gate **74** is removed and the 64th sprocket pulse will pass through gate **74** to reset the move carriage flip-flop **70** and thus arrest further movement of the print wheel **19** and carriage **14**.

To illustrate the operation of the circuit of FIG. **2** and the control thereof over the structure shown in FIG. **1**, reference is now made to FIG. *3a* which shows a typical asynchronous operation for the printer. As shown in the first and second lines of FIG. *3a* the pulses labeled "TE" and "LE" are periodically generated by the retriggerable delay flop **65** once each revolution of the type wheel **19** as above described.

Starting coincidentally with the LE pulse there will be generated at the output of amplifier **37**, 64 time spaced sprocket pulses for a 64 character print wheel **19**. These 64 sprocket pulses which occur between each LE pulse and the next successive TE pulse are applied through delay element **59** to the step input of the counter **58** and also through line **61** to the gate **60**. The delay **59** permits the sprocket pulses to first strobe gate **60** for an output and then later step the counter **58** for the next character comparison.

The third line of FIG. *3a* shows at **80** the occurrence of a load pulse and therefore the arrival of data at the input register **50** at a time which occurs shortly after the leading edge pulse LE and before the sprocket counter **58** has counted to **34**. As shown at **81** on the fourth line, the load pulse sets the load flip-flop **73** upon its arrival. This action partially conditions the transfer gate **54** between the data registers **50** and **51** and also partially conditions gate **71** which connects to the set input of the motion control flip-flop **70**. Also as shown on the sixth line of FIG. *3a* the load pulse acting through input gates **52** loads the incoming data into the register **50**. Upon arrival of the 34th sprocket pulse from amplifier **37** when the sprocket counter **58** has counted to 34, decoder **72** fully conditions gate **71** to set the motion control flip-flop **70** to its MC state as shown at **82** by the fifth line of FIG. *3a*. Setting flip-flop **70** to its MC state fully conditions the transfer gates **54** between the data registers **50** and **51**. Upon the arrival of the next the pulse, shown as the second TE pulse in the first line of FIG. *3a*, the data presently stored in data register **50** is transferred through gates **54** by the TE pulse to data register **51** as shown at **83** in the seventh line of FIG. *3a*. This TE pulse is also applied to the reset inputs of the flip-flops comprising the register **51** so as to clear the register of its previous contents while loading the new contents therein. To this end, the flip-flops comprising register **51** are of the type where set inputs override reset inputs. Shortly after this TE pulse, the second LE pulse appears and passes through gate **76** to reset the load flip-flop **73**. Resetting the load flip-flop **73** by the LE pulse clears the data register **50** and prepares the same to receive the next data character. At the time of generation of the second TE pulse, the data to be printed is loaded in register **51** and is ready to be compared with the output of sprocket counter **58**. This comparison as shown by the last waveform in FIG. *3a* continues over the period of one revolution of the print wheel and extends from the second TE pulse to the third TE pulse. In response to the third TE pulse, the data in register **51** is cleared and register **51** is ready to receive the next character to be printed. Since the time span between the second and third TE pulses equals one complete revolution of the print wheel **19** all the characters contained thereon will have been compared with the data character stored in register **51**. When a comparison which indicates that the character on the print wheel corresponds to the character stored in register **51** occurs an output will be produced from comparator **57**. When this occurs gate **60** is fully conditioned and the sprocket pulse appearing on line **61** passes through gate **60** to trigger the pulse generator **62** to generate a print pulse which energizes the actuator **15** shown in FIG. **1**. Actuation of the actuator **15** causes the type hammer **16** to push the paper **19a** against the type wheel **19** and thus to print the character on the paper **19***a*.

Continuing now with the description of FIG. *3a*, the second data character to be printed arrives between the third and fourth TE pulses and for illustration purposes is assumed to arrive sometime after the sprocket counter has passed the count **34** as shown by the second load pulse **84** in the third line. In this case, while the load pulse sets the load flip-flop **73** as shown in the fourth line and data is loaded in register **50** as shown in the sixth line, the move carriage flip-flop **70** is not set until the sprocket count of **34** has been produced in the internal between the fourth and fifth TE pulses shown in the first line. In this case printing occurs between the fifth and sixth TE pulses. In this way the move carriage flip-flop **70** is always set at a predetermined point of time in the print wheel **19** rotation and this point is selected so that the type wheel **19** and the carriage **14** begin their translation approximately simultaneously with the generation of the next TE pulse. Also at this time the said next TE pulse transfers the data from register **50** to register **51** and printing can then take place during one complete revolution of the print wheel **19**.

Thus from the foregoing description it will be recognized that if a load pulse is received before a sprocket count of **34**, the move carriage flip-flop **70** will be set during the first revolution of the print wheel and printing will occur during the next revolution of the print wheel. On the other hand, if the load pulse is received after a sprocket count of **34** the move carriage flip-flop **70** will be set during the next revolution of the print wheel and printing will occur during the revolution after that.

To further summarize, FIG. *3a* shows the condition where the print wheel **19** is stepped from one print column to the next and then stopped and awaits the receipt of the next data character.

FIG. *3b* which will now be described shows the condition where a data character is received for each revolution of the print wheel **19**. In this figure, the first line shows a load pulse being received before a sprocket count of **34** for each revolution of the print wheel. The second line of FIG. *3b* shows the load flip-flop **73** being set by each load pulse and reset by the next LE pulse following the load pulse. The third line shows the move carriage flip-flop **70** being set at a sprocket count of **34** and then not being reset thereafter. This action occurs, of course, in the assumed example since the load flip-flop **73** is set each rotation of the print wheel **19** and setting the load flip-flop inhibits the resetting of the move carriage flip-flop **70**. In this example, the pawl **21** is initially pulled into engagement with the lead screw **20** upon the arrival of the first data character and then held into engagement with lead screw **20** as long as data characters are being received for each revolution of the print wheel **19**. In this example, the print wheel **19** moves in a continuous non-stop manner, while the received data characters are transferred from register **50** to **51** as shown by the fourth and fifth lines of FIG. *3b*.

Accordingly, from the foregoing description it will be seen that the presently described printer can operate either as an asynchronous or a synchronous printer.

What is claimed is:

1. A printer mechanism for printing symbols along a line on a print receiving medium comprising, a rotatable printing member having a series of type elements arranged about a helical path on said member, a carriage, a print hammer mounted on said carriage, means for continuously rotating said printing member about the axis of said helical path, a drive means comprising a constantly rotating lead screw paralleling the print line, a means including a pawl member opera-

ble when actuated to couple the carriage and printing member to said lead screw and to decouple said carriage and printing member from said lead screw when unactuated and a control means for actuating said pawl member to thereby cause said carriage and said printing member to move in unison along the print line of said print receiving medium; a stop rack paralleling the lead screw, a member carried by said carriage engaging said stop rack to hold the printing member and carriage in any columnar position along the print line during the unactuated condition of said pawl member, a signal generating means for applying a control signal to said control means to actuate said pawl member for the duration of the control signal, said signal generating means being operative in response to the arrival of each character to be printed to produce a control signal having a duration at least equal to the time required for one revolution of said printing member, a print control means for producing a momentary print actuation signal in response to the receipt of each character to be printed, and a print hammer actuating circuit connected to said print control means operable in response to said print actuation signal to actuate said print hammer.

2. The combination of claim 1 wherein there is included a means for disengaging the carriage from the stop rack.

3. The combination of claim 1 wherein there is included a means for normally urging the carriage and printing member to a reference position along the print line.

* * * * *