

FORM 1

APPLICATION ACCEPTED AND AMENDMENTS

600809

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SPRUSON & FERGUSON

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952

APPLICATION FOR A STANDARD PATENT

International Business Machines Corporation, incorporated in New York, of Armonk, New York, New York, 10504, UNITED STATES OF AMERICA, hereby apply for the grant of a standard patent for an invention entitled:

Printer with Enhanced Bidirectional Logic Seeking for Increased Through-Put

which is described in the accompanying complete specification.

Details of basic application(s):-

<u>Basic Applic. No.:</u>	<u>Country:</u>	<u>Application Date:</u>
033449	UNITED STATES OF AMERICA	1 April 1987

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DATED this THIRTIETH day of MARCH 1988

International Business Machines Corporation

By:

[Signature]
Registered Patent Attorney

TO: THE COMMISSIONER OF PATENTS
OUR REF: 53890
S&F CODE: 55785

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COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952-1969

Declaration In Support Of Convention Or
Non-Convention Application For A
Patent Or Patent Of Addition

(This declaration shall be made by the applicant, or, if the applicant is a body corporate, by a person authorized by the body corporate to make the declaration on its behalf).

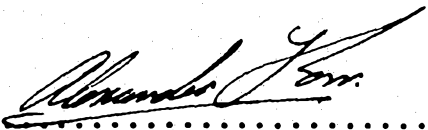
In support of the Application made for a patent for an invention entitled PRINTER WITH ENHANCED BIDIRECTIONAL LOGIC SEEKING FOR INCREASED THROUGH-PUT.

I, Alexander Kerr
c/- IBM Canada Ltd.
3500 Steeles Avenue East
Markham, Ontario
Canada L3R 2Z1

do solemnly and sincerely declare as follows:

1. I am authorized by International Business Machines Corporation, the applicant for the patent to make this declaration on its behalf.
2. (1) Tim Valentine Angst of 6415-F Yateswood Dr., Charlotte, North Carolina, United States of America; and Demetrios Troupes of 8411 Norcroft Dr., Charlotte, North Carolina, United States of America; are the actual inventors of the invention and the facts upon which the applicant is entitled to make the application are as follows: Applicant is entitled to apply by virtue of an Assignment dated April 1, 1987 from Tim Valentine Angst and Demetrios Troupes to International Business Machines Corporation.
3. The basic application as defined by Section 141 of the Act was made in the United States of America on April 1, 1987 by Tim Valentine Angst and Demetrios Troupes.
4. The basic application referred to in paragraph 3 of this Declaration was the first application made in a Convention country in respect of the invention the subject of this application.

Declared at Markham, this day of March, 1988.


.....
Alexander Kerr

(11) AU-B-13899/88
(10) 600809

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computing a first time, which is required for said print element to move from said end position of said first print line to said first end position of said next print line prior to printing said next print line along a first path beginning at said first end position, by adding an acceleration time to a first displacement and subtracting a deceleration time, said first displacement being a time required to move said print element at a constant velocity between said end position of said first print line and said first end position of said next print line;

computing a second time, which is required for said print element to move from said end position of said first print line to said second end position of said next print line prior to printing said next print line along a second path beginning at said second end position, by summing said acceleration time, said deceleration time, a compensation factor and a second displacement, said second displacement being a time required to move said print element at said constant velocity between said end position of said first print line and said second end position of said next print line;

selecting either said first path or said second path corresponding to the shorter of said first time and said second time; and printing said next line along said selected path.

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FORM 10

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952

COMPLETE SPECIFICATION

(ORIGINAL)

FOR OFFICE USE:

Class Int Class

Complete Specification Lodged:
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Priority:

Related Art:

This document contains the
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Section 49 and is correct for
printing.

Name and Address
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Complete Specification for the invention entitled:

Printer with Enhanced Bidirectional Logic Seeking for
Increased Through-Put

The following statement is a full description of this invention, including the
best method of performing it known to me/us

PRINTER WITH ENHANCED BIDIRECTIONAL
LOGIC SEEKING FOR INCREASED THROUGH-PUT

Technical Field

1 This invention relates to bidirectional serial printers and particularly to the controls for such printers.

Background Art

Serial printers are printers of the type having a number of printing elements less than is necessary for printing across an entire line. In the operation of a serial printer, the print element moves over a certain distance along a line and is actuated to effect printing at a plurality of locations during its travel. There are two types of serial printers; fully formed character printers and matrix printers. Fully formed character printers print the entire character in one print operation; an example would be the popular daisy wheel printers. Serial matrix printers, in general, print by composing a character by means of the actuation of a plurality of wires, ink jets, heating elements or other actuating means that print less than an entire character so that the characters are composed of elements such as dots. This invention is useful with either fully formed character or matrix printers.

Originally serial printers printed from a left position or starting point and sequentially printed until the line was complete. At the completion of the print line, the paper was indexed and the print element was returned to the starting point before printing the next print line. To increase through-put, it is known to print bidirectionally; that is, the next print line is printed backwards instead of returning the print element to the starting position. United States Patent No. 3,708,050 to McCarthy for Printer Control With Monodirectional and Bidirectional Printing Compatibility describes a printer that can accept a data stream formatted for a monodirectional printer yet print the data bidirectionally. United States Patent No. 4,463,444 to Daniels et al. for Word

1 Processing System Having A Formatting Bidirectional Printer is
a further enhancement.

In order to further increase through-put of bidirectional
printers, it is known to position the print element based on
5 stored information relative to the right and left margins of
the next print line. At the completion of a print line, a
comparison of the current print line end position is made with
the right and left end positions of the next print line to
determine the closest end position. On the basis of that
10 distance comparison, the print element is directed to proceed
to the closest end position of the next print line. This
technique also known as bidirectional logic seeking, is fully
explained in United States Patent No. 3,764,994 to Brooks et
al. for Serial Printer With Bi-Directional Drive Control.

15 A further improvement to the bidirectional logic seeking
printers is described in United States Patent No. 4,376,588 to
Moeller for Bi-Directional Serial Printer With Look-Ahead. The
conventional bidirectional logic seeking printer described by
Brooks et al., is modified to determine the distance between
20 the end position of the current print line and the beginning
print position of the next print line in the direction of print
element travel. If the determination indicates that the
distance is less than a specified maximum distance, the print
element is continued in the same direction past the end print
position of the current line to the beginning position of the
25 next line. This determination must be made prior to the print
element reaching the end position of the current print line.
Looking ahead to the next print position, prior to stopping the
print element, and continuing the print element in the current
30 direction if that distance is small, increases over all printer
through-put.

In United States Patent No. 4,469,460 to Hughes et al. for
Matrix Printer With Optimum Printing Velocity a technique is
described for further enhancing printer through-put by
35 selecting the print element velocity as a function of print
line length, so that for short line lengths, a low velocity is
selected. By selecting a low velocity, less time is spent
accelerating and decelerating the print element. For short
enough line lengths the time lost printing at a lower velocity
40 is compensated by the time gained in not having to accelerate
to a high velocity and decelerate therefrom; thus, printer

through-put is enhanced. For longer print lines, it is worth accelerating the print element to the maximum constant speed.

A disadvantage of the foregoing techniques has been the inability of printers to print at the theoretical limit set by the repetition rate of the print element. In an impact printer for example, the repetition rate is determined by the minimum time between print actuator firings. Some of the factors limiting the printer through-put are (1) the time required to index the record medium, (2) the turn-around settling time, (3) the time to accelerate to constant velocity and (4) the time to decelerate from constant velocity.

One approach to overcoming these disadvantages is described in an article entitled Print Head Speed And Stopping Distance Specification For Voltage-Drive Motor Control Systems disclosed in IBM Technical Disclosure Bulletin, Vol. 29, No. 6, November 1986, page 2652. The technique described permits printing on the acceleration and deceleration ramps, however, accurate position sensors and complicated feed back systems are required.

Summary of the Invention

In accordance with one aspect of the present invention there is disclosed a printer comprising:

a print element for producing characters on a plurality of print lines;

first means for moving said print element in a first direction to an end position of a first print line; and

second means for moving said print element from said end position to a selected one of first and second end positions of a next print line, said selected one end position being determined by the minimum time for said print element to travel from said end position of said first print line to each of said first and second end positions of said next print line even though said selected one end position of said next print line is a greater distance from said end position of said first print line than the other end position of said next print line.

In accordance with another aspect of the present invention there is disclosed a method for controlling a serial printer comprising the steps of:

printing a first print line with a print element moving in a first direction to an end position;

determining a first end position and a second end position of a next print line;



computing a first time, which is required for said print element to move from said end position of said first print line to said first end position of said next print line prior to printing said next print line along a first path beginning at said first end position, by adding an
5 acceleration time to a first displacement and subtracting a deceleration time, said first displacement being a time required to move said print element at a constant velocity between said end position of said first print line and said first end position of said next print line;

computing a second time, which is required for said print element to
10 move from said end position of said first print line to said second end position of said next print line prior to printing said next print line along a second path beginning at said second end position, by summing said acceleration time, said deceleration time, a compensation factor and a second displacement, said second displacement being a time required to move
15 said print element at said constant velocity between said end position of said first print line and said second end position of said next print line;

selecting either said first path or said second path corresponding to the shorter of said first time and said second time; and

printing said next line along said selected path.

20 Brief Description of the Drawings

Referring now to the drawings, wherein like reference numerals are used to designate like parts, a preferred embodiment of the invention is described.

Fig. 1 is a diagrammatic representation of the logic and apparatus
25 for practicing the present invention.

Fig. 2 is a block diagram of the logic structure for a printer using the present invention.

Figs. 3 through 9 are flow charts describing a preferred embodiment of the invention.

Fig. 10 is a timing chart illustrating the change in velocity with
30 time during the printing of a typical print line; and

Fig. 11 shows alternative paths followed by a print element in a system using the invention and in a system using the techniques of the prior art.

35 Detailed Description of the Preferred Embodiment

The details of constructing a printer that would incorporate this invention are well known to those skilled in the art. An example of prior art printers that could usefully



1 adopt this invention are the IBM Model 4201 and Model 4202
Proprinter. In the preferred embodiment, this invention
includes a program controlled microprocessor such as an Intel
8031, for directing the operation of the electronic and
5 electromechanical devices associated with a printer.

Referring to Figs. 1 and 2, a diagrammatic representation
of the logic and apparatus for practicing the invention is
described. A host computer (not shown), such as an IBM
Personal Computer, communicates with a microprocessor
10 controlled printer via host communication hardware 2 by
transmitting to the printer a data stream comprised of print
characters and printer control codes. Host communication
hardware 2 can be a serial or parallel printer port which are
well known to those skilled in the art. The data stream is
15 processed by microprocessor 4 to generate the appropriate
control signals for directing the operation of electronic
mechanism controller 6. Based on the signals received from
microprocessor 4, controller 6 drives the various elements of
mechanism 8 which results in printing characters on record
20 medium 1.

Referring now to Fig. 2, a block diagram of the program
logic structure for controlling microprocessor 4 is described.
When power is first applied to the printer, initialization
routine 100 is implemented for testing the various components
25 of the printer and resetting the various control parameters.
When initialization is complete, monitor 102 is activated to
perform master control functions such as supervising the
various program functions in the system by calling the
different routines in sequential order and passing temporary
30 control to the selected module.

Receive parser 104 determines whether data is available at
host interface 105. If data is available, receive parser 104
reads, processes and stores the data in buffer 14 (Fig. 1).
Receive parser 104 continues reading, processing and storing
35 data as long as data is available at interface 105 or until
buffer 14 is full. Upon the occurrence of either event,
control is returned to monitor 102 which in turn passes control
to print builder 106.

The data in buffer 14 is taken by print builder 106 for
40 further processing. Print builder 106 is responsible for
passing correctly formatted and terminated print buffers to

1 mechanism control 108. Print builder 106 returns control to
monitor 102 when all data in buffer 14 is formatted, or the
print buffer is unavailable or when a print buffer is complete
and ready for printing. When the print buffer is ready for
5 printing, monitor 102 passes control to mechanism control 108.

All aspects of producing printed characters on record
medium 1 are handled by mechanism control 108, including
control of the record medium handling system 110, print element
112 and print element carrier 114. When printing is initiated,
10 mechanism control 108 returns control to monitor 102.

Referring again to Fig. 1, host communications module 10
of microprocessor 4 supervises the reception of data from the
host via host interface 105 (Fig. 2). Communications module
10, which is a functional component of receive parser 104 (Fig.
15 2) performs any error checking that is deemed necessary,
transmits the appropriate acknowledgements or error codes to
host communication hardware 2 and passes the received data to
data stream analyzer 12, also a component of receive parser 104
(Fig 2). The printer control codes and the character data are
20 parsed by data stream analyzer 12 and parsed to buffer 14. The
control codes and character data of buffer 14 are used by
builder 16 equivalent to print builder 106 (Fig. 2), to fill
print buffer 18 with properly formatted information
representing the print lines of characters to be printed on
25 record medium 1. Print buffer 18 is partitioned into two
parts, current line buffer 18A stores the data representing
characters and control codes for producing a first print line;
next line buffer 18B stores the data representing characters
and control codes for producing the next print line. With this
30 structure, the system uses the FIFO (first-in first-out) method
for data handling.

Based on the data stored in print buffer 18, mechanism
master controller 20 activates modules 22, 24 or 26 to produce
appropriate signals for directing the operation of electronic
35 mechanism controller 6. To increase the over all printing
through-put, mechanism master controller 20 calls on module 30
to set up the activation sequence for carrier motor controller
26. Module 30 performs the enhanced bidirectional logic
seeking that achieves the substantial increase in through-put.

40 Module 30 consists of three sub-modules that, based on the
current print line end position, the current direction of the

1 print element and the two end positions for the next print line
determines the fastest route for the print element, directed by
carrier motor controller 26, to follow. Sub-module 32
determines the time necessary to begin printing the next line
5 if print element 52 continues in the current direction.

Sub-module 34 determines the time required to begin
printing the next line if the print element reverses direction.
And sub-module 36 selects the quickest path based on the least
amount of time. Mechanism master controller 20 instructs
10 carrier motor controller 26 to follow the quickest path
selected by sub-module 36.

Carrier motor hardware ~~46~~⁴⁴ of electronic mechanism
controller 6 translates the signals of carrier motor controller
26 to the appropriate number of pulses for driving carrier
15 motor 54, which in the preferred embodiment is a stepper motor,
in the proper direction for positioning print element 52.

Referring now to Fig. 10, a timing chart illustrating the
change in velocity with respect to time during the printing of
a typical print line will be described in preparation for an
20 explanation of the method described in the flow charts of Figs.
3 through 9. From a rest position, the print element must
accelerate to a constant print speed before printing can begin.
To accommodate the necessary acceleration, the print element
must be positioned ahead of the first actual print position by
25 a distance corresponding to acceleration ramp 900.

In the preferred embodiment, printing occurs only while
the print element is moving at a constant velocity, depicted as
902. Actual printing beginning at 903, is somewhat delayed
after the print element reaches constant velocity to allow for
30 settling time, this is shown as 904.

When printing is completed, position 906, and while the
print element continues to move a constant velocity, a
determination is made for positioning the print element at one
end or the other of the next line according to the present
35 invention. If the enhanced bidirectional logic seeking, module
30 of Fig. 1, determines that the print element must change
direction, an immediate stop is performed at position 908.
Time must be allowed for the print element velocity to reach
zero, deceleration ramp 910.

40 The basic concept of this invention recognizes that
acceleration ramp 900, and deceleration ramp 910 affect printer



1 through-put and that by taking these factors into account,
through-put is enhanced. Furthermore, it is recognized that in
those instances where the print element must decelerate, stop,
turn around and accelerate there is an additional settling time
5 that must be taken into account. In this invention that
settling time is included as a portion of the compensation
factor of block ~~44~~⁴⁰⁰, Fig. 5 and block 600, Fig. 7.

In the preferred embodiment, time is measured by counting
time-steps of carrier motor 54 corresponding to units of time.
10 This can best be visualized by the sweep second hand of an
analogue clock. As the second hand traverses stepped
distances, time is measured. In this invention, time-steps are
counted to measure the time for the print element to reach
different positions.

15 The flow charts for describing the sequence of program
steps followed by microprocessor 4 (Fig. 1) in implementing the
enhanced bidirectional logic seeking of module 30 are depicted
in Figs. 3 through 9. Referring now to Fig. 3, decision block
200 determines whether the current line is finished printing.
20 When the current line is completed, decision block 202
determines whether the next buffer is ready. If the next
buffer is not ready, the routine exits to point E, Fig. 9;
otherwise, the routine continues. In the next step, decision
block 204, the next buffer is tested to determine whether it
25 contains only line feed information. When the next buffer has
only line feed information, the program exits to point E if the
next buffer contains more than line feed information the
routine continues.

Referring now to Fig. 4, at decision block 300, which
30 determines the direction of travel of print element 52, the
program branches. If the element is traveling right, decision
block 302 determines whether the next print line requires
printing in the rightward direction only; otherwise, the
program follows a separate branch beginning at point F of Fig.
35 6.

Still referring to Fig. 4, if the next print line does not
require only right printing, the routine begins to determine
how much time is required for the print element 52 to reach the
left end and the right end of the next print line.

40 In block 304, the number of steps to decelerate from the
current speed, CD, is subtracted from the number of steps to

1 accelerate to constant speed for the next line, NA. This
value, NA-CD, corresponds to a number of time-steps. This
value is added to the right end position of the next line, also
expressed in steps, and stored in RSTORE, block 306. In block
5 306, the end position of the current line is subtracted from
the value in RSTORE. This represents the number of time-steps
required to reach the right start position for the next print
line. If this value is negative, meaning that the next is
entirely to the left of the current end position, the print
10 element stops immediately, by exiting to point D, Fig. 8; this
determination is made in decision block 308.

In blocks 310 and 312, calculations analogous to the
calculations of blocks 304 and 306 will be performed for the
left end position of the next line. Decision block 314
15 determines whether the next print line is entirely to the right
of the current end position. If the next line is entirely to
the right of the current end position, the routine exit to
point D to stop the print element immediately; otherwise the
program continues to determine which of two paths will result
20 in the shortest amount of travel time.

Referring now to Fig. 5, in block 400, a compensation
factor is added to LSTORE to account for one deceleration time,
one acceleration time and the settling time associated with
print element 52 and carrier motor 54. This compensation
25 factor will be a constant value for a particular printer and is
determined by empirical measurements well known to those
skilled in the art. The value in LSTORE is representative of
the amount of time for print element 52 to be in position for
printing the next line from left to right while the value in
30 RSTORE is representative of the amount of time for print
element 52 to be in position for printing from right to left,
both values are expressed in time-steps. In decision block
402, LSTORE is compared with RSTORE. If LSTORE is less than
RSTORE, meaning it is quicker to turn around and print from
35 left to right, the program exits to point D, Fig. 8, to stop
immediately.

If it is quicker to print from right to left, block 404
says continue right. In decision block 406, the program tests
to determine whether print element 52 is moving at less than
40 the maximum constant speed. If so, decision block 408
determines the remaining number of steps to reach the intended

1 position and whether there are more than enough steps to
accelerate. If there are enough steps, the print element is
accelerated to maximum speed, block 410. In block 412, the
actual stopping position for print element 52 is determined.

5 Referring now to Fig. 11, arrow 1000 represents the
current direction of print element 52 in printing character
along current print line 1002. Next print line 1004 has begin
slice 1006 and endslice 1008. Current endslice 1010 of current
print line 1002 will be the reference point for measuring the
10 time to reach begin slice 1006 along path A and the time to
reach endslice along path B.

Also referring now to the flow chart of Figs. 4 and 5,
block 304 adds the next acceleration (NA), minus the current
deceleration (CD) to the next endslice. In Fig. 11, the next
15 acceleration 1012 consists of 48 time-steps; from this value is
subtracted the current deceleration 1014 consisting of 14
time-steps to yield a value of 34 time-steps. The value of 34
time-steps is added to the value representing endslice 1008.
From this total is subtracted the current endslice to yield the
20 time for the print element to reach right end position 1016.
In this example the next endslice minus the current endslice
equals 255 time-steps, plus the 34 time-steps previously
determined equals 289 time-steps to reach right end position
1016 continuing in the current direction; this corresponds to
25 path B and is the value stored in RSTORE.

In blocks 310 and 312 of Fig. 4, and block 400 of Fig. 5,
the time required to traverse path A, Fig. 11 is determined.
In block 310, the next acceleration 1012 is added to the
current deceleration 1014, yielding a value of 62 time-steps.
30 This value is added to the leftward displacement 1018, leftward
displacement 1018 equals 180 time-steps and is determined by
subtracting next begin slice 1006 from current endslice 1010.
The addition of leftward displacement 1018, next acceleration
1012 and current deceleration 1014 yields 242 time-steps. This
35 is the value stored in LSTORE. Next, in block 400, Fig. 5, a
compensation factor equal to 55 time-steps is added to the
value in LSTORE making the new value in LSTORE equal to 297
time-steps. The compensation factor for this example is
determined empirically, but is generally comprised of an
40 acceleration time, a deceleration time and a settling time
associated with a particular device. LSTORE is then compared

1 with RSTORE. In this example, LSTORE equals 297 time-steps and
RSTORE equals 282 time-steps. Inasmuch as RSTORE is less than
LSTORE, it will be faster to continue in the current direction
and print from right to left.

5 Under the bidirectional logic seeking methods of the prior
art, the leftward displacement 1018 would be compared with the
rightward displacement 1020, if leftward displacement 1018 is
less than rightward displacement 1020, as is true in this
example, printing would be along path A and not path B taking
10 more time and thus resulting in slower through-put.

Referring now to Fig. 6, point F is the branch the program
takes if the print element is moving left. In block 500, the
value NA-CD, which is the number of time-steps to decelerate
from the maximum current speed is subtracted from the number of
15 time-steps to accelerate to constant speed for the next line;
this value is added to the current end position and stored in
LSTORE. The right end position of the next line is subtracted
from the value in LSTORE and the new value is stored in LSTORE,
block 502. The current value in LSTORE represents the time
20 required for print element 52 to continue leftward and start
printing the next line at the left end position.

In decision block 504, it is determined whether the next
print line is entirely to the right of the current print
position; if so, the program exits to an immediate stop
25 routine, point D, Fig. 8. If the next print line does not lie
entirely to the right, the routine determines the time required
to reach the right end position of the next print line, blocks
506 and 508. In block 506, the time required to accelerate to
constant speed for the next line, NA, is added to the time to
30 decelerate from the current constant speed, CD. This value,
NA+CD, is added to the right end position of the next line and
stored in RSTORE. In block 508, the current end position is
subtracted from RSTORE and stored back in RSTORE. If the next
line is entirely to the left of the current line than the value
35 in RSTORE is negative and the program branches, decision block
510, to an immediate stop; otherwise, the program continues to
the routine for determining which end position will result in
the quickest path to begin printing.

Referring now to Fig. 7, block 600, a compensation factor
40 comprised of the time required for print element 52 to
decelerate, accelerate and settle is added to the value in

1 RSTORE. The compensation factor is determined empirically for
the particular motors that are used. In decision block 602,
the quickest path is determined. If RSTORE is ^{not} less than
LSTORE, print element 52 continues to the left, block ⁶⁰³/~~602~~;
5 otherwise the program exits to D, Fig. 8, to stop immediately.

Current speed is tested, in decision block 604, to
determine whether print element 52 is traveling at less than
maximum speed. If print element 52 is travelling at the slower
rate, decision block 606 determines whether there are enough
10 steps left to accelerate to top speed. If there are enough
steps left, the print element is speeded up, block 608. The
last step before exiting the routine is to set up the actual
stopping position, block 610.

Block 700, Fig. 8 represents an immediate stop which is
15 performed for those conditions that require the print element
to change direction. Block 800, Fig. 9, represents a routine
for testing the current print element position relative to the
sideframe of the printer. As is illustrated in Fig. 11, at
least one deceleration and one acceleration is required to stop
20 and start. The routine of block 800 insures that there is
enough room between the sideframe and the next start position
to allow for acceleration.

From the above description it will be seen by those having
skill in the art that under the present invention, through-put
25 of a bidirectional serial printer is maximized by minimizing
the time required to traverse between print positions,
notwithstanding the fact that a greater distance needs to be
traversed. Since the invention may be incorporated into a
microprocessor controlled printer, this increased through-put
30 may be realized with little added cost.

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



The claims defining the invention are as follows:

1. A printer comprising:

a print element for producing characters on a plurality of print lines;

first means for moving said print element in a first direction to an end position of a first print line; and

second means for moving said print element from said end position to a selected one of first and second end positions of a next print line, said selected one end position being determined by the minimum time for said print element to travel from said end position of said first print line to each of said first and second end positions of said next print line even though said selected one end position of said next print line is a greater distance from said end position of said first print line than the other end position of said next print line.

2. The printer of claim 1 wherein said second means includes:

third means for adding an acceleration time to a first displacement and subtracting a deceleration time to determine a first time, said first displacement being a time required to move said print element at a constant velocity between said end position of said first print line and said first end position of said next print line;

fourth means for summing said acceleration time, said deceleration time, a compensation factor and a second displacement to determine a second time, said second displacement being a time required to move said print element at said constant velocity between said end position of said first print line and said second end position of said next print line; and

fifth means for moving said print element along said next print line in said first direction if said first time is less than said second time and in said second direction if said second time is less than said first time.

3. The printer of claim 2 wherein said compensation factor is a function of said acceleration time, said deceleration time and a settling time for said print element.

4. A method for controlling a serial printer comprising the steps of:

printing a first print line with a print element moving in a first direction to an end position;



determining a first end position and a second end position of a next print line;

computing a first time, which is required for said print element to move from said end position of said first print line to said first end position of said next print line prior to printing said next print line along a first path beginning at said first end position, by adding an acceleration time to a first displacement and subtracting a deceleration time, said first displacement being a time required to move said print element at a constant velocity between said end position of said first print line and said first end position of said next print line;

computing a second time, which is required for said print element to move from said end position of said first print line to said second end position of said next print line prior to printing said next print line along a second path beginning at said second end position, by summing said acceleration time, said deceleration time, a compensation factor and a second displacement, said second displacement being a time required to move said print element at said constant velocity between said end position of said first print line and said second end position of said next print line;

selecting either said first path or said second path corresponding to the shorter of said first time and said second time; and printing said next line along said selected path.

5. The method of claim 4 wherein said compensation factor is a function of said acceleration time, said deceleration time and a settling time for said print element.

6. The method of claim 4 or 5 wherein said steps of determining, computing and selecting are performed while said print element continues to move in said first direction.

7. A printer substantially as hereinbefore described with reference to the accompanying drawings.

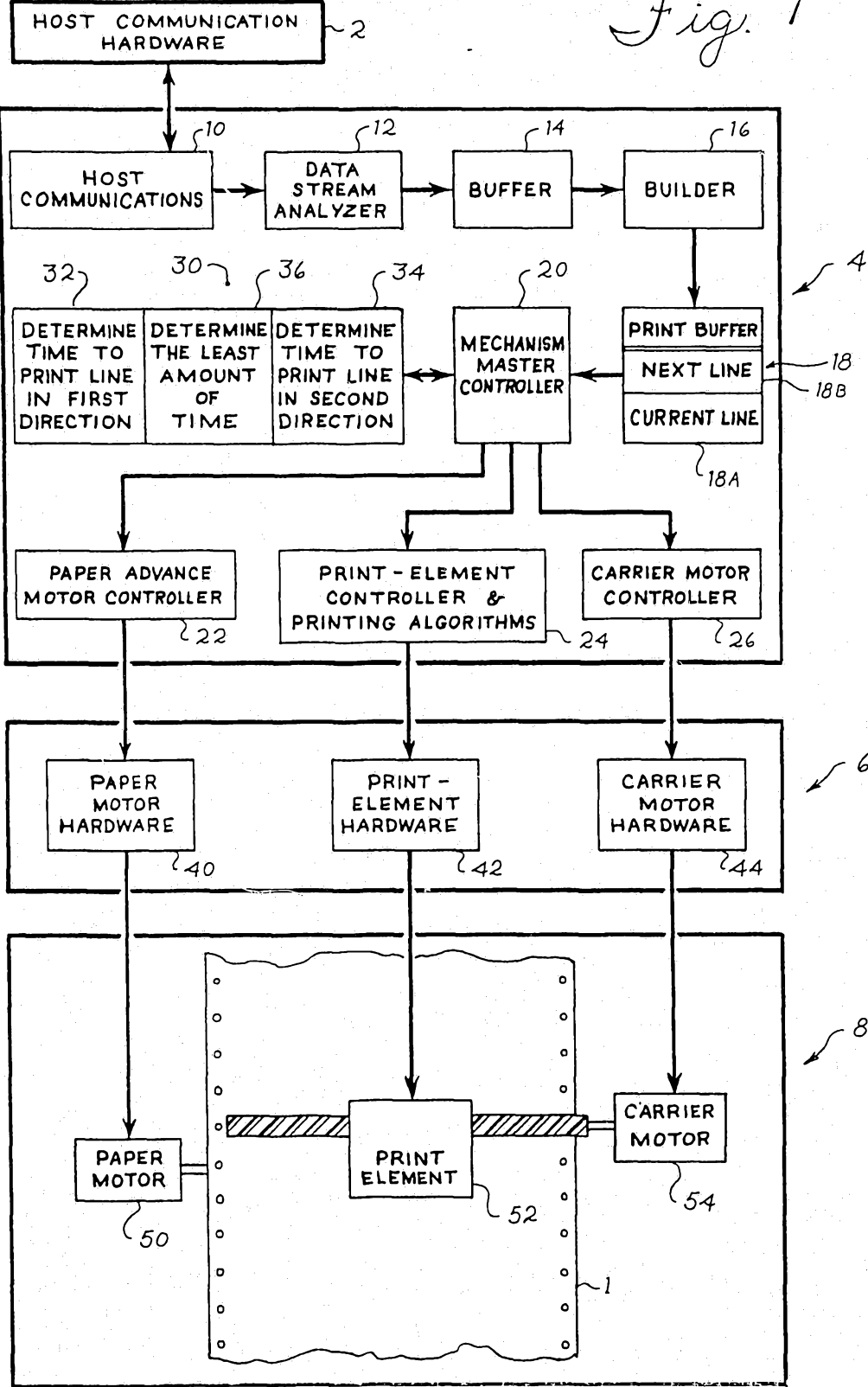
8. A method for controlling a serial printer substantially as described herein with reference to the accompanying drawings.

DATED this TWENTY-NINTH day of MAY 1990
International Business Machines Corporation

Patent Attorneys for the Applicant
SPRUSON & FERGUSON



Fig. 1



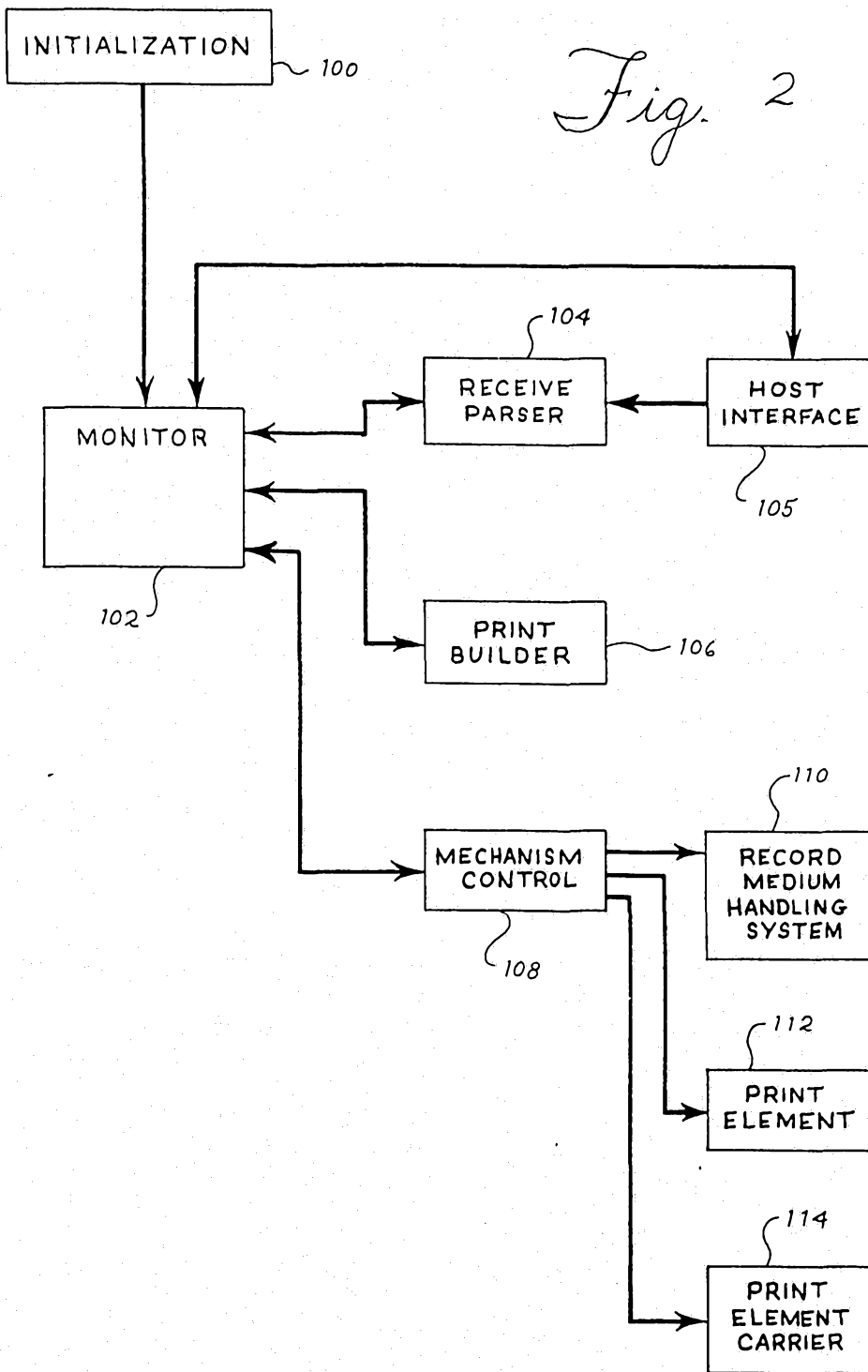


Fig. 2

Fig. 3

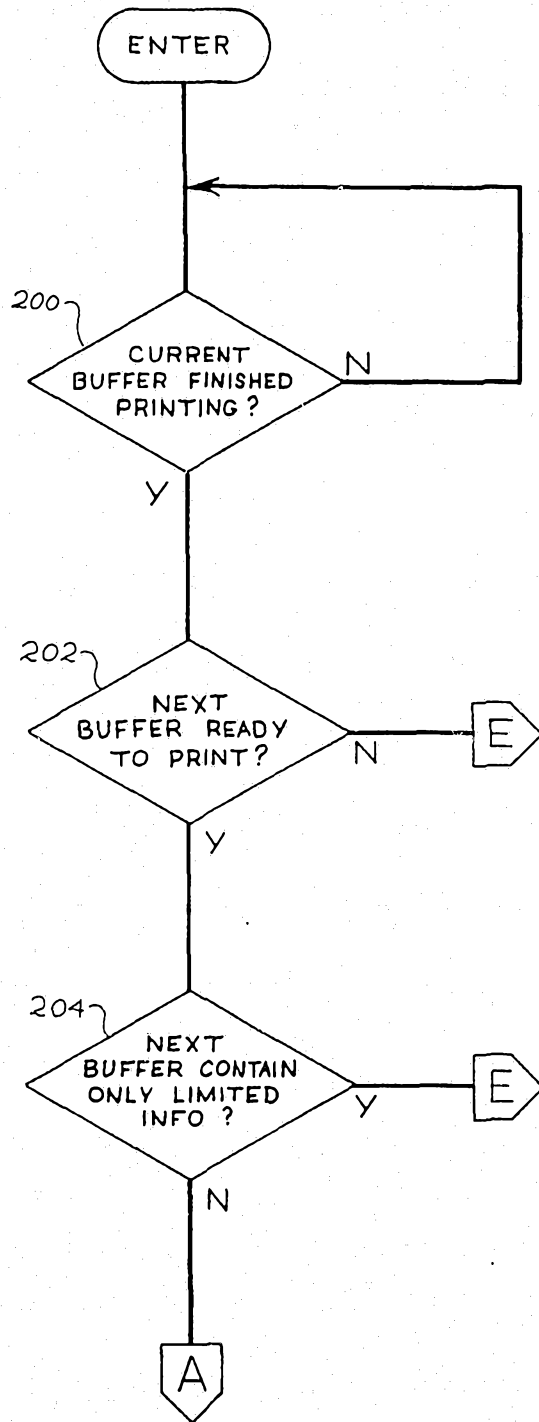


Fig. 4

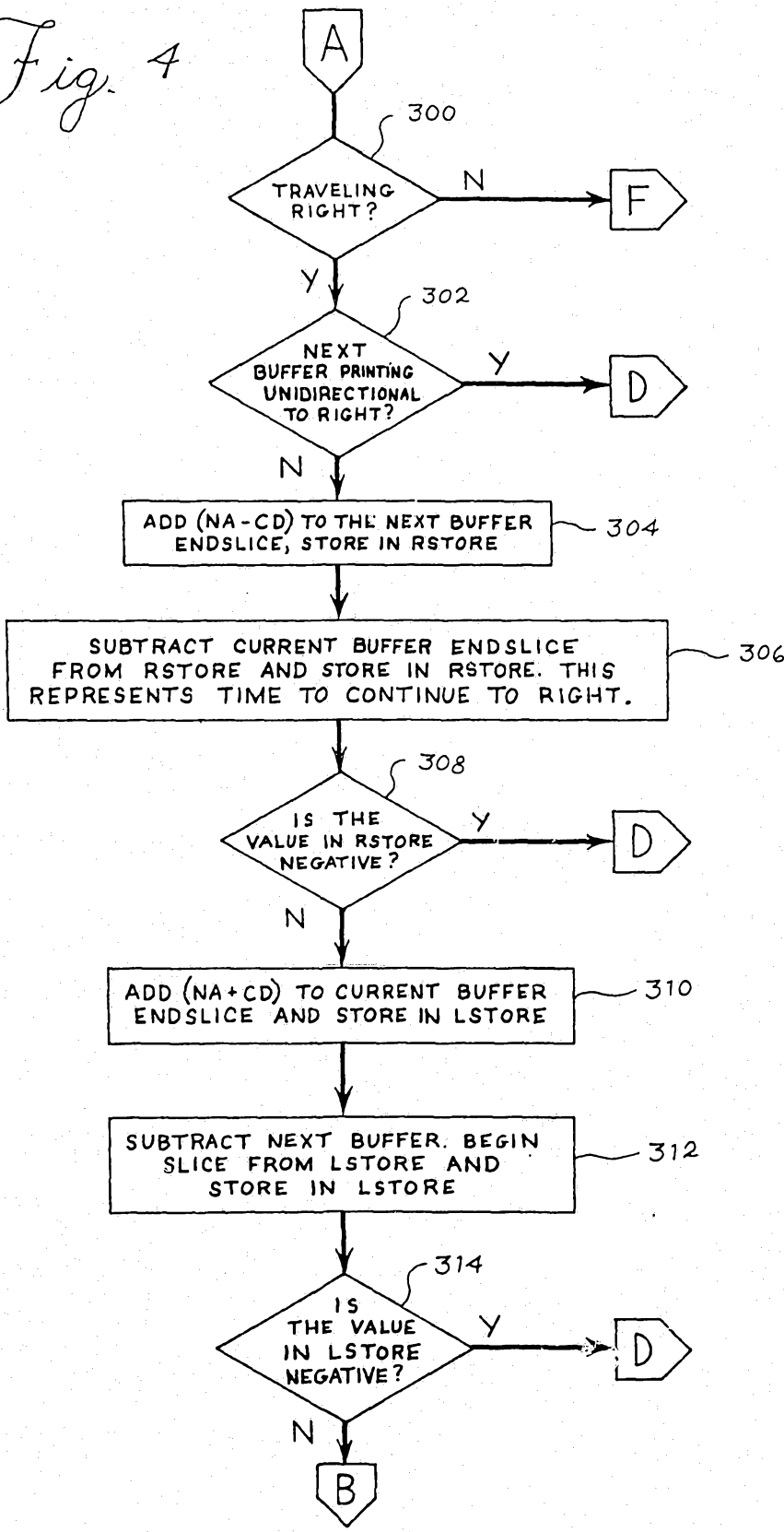


Fig. 5

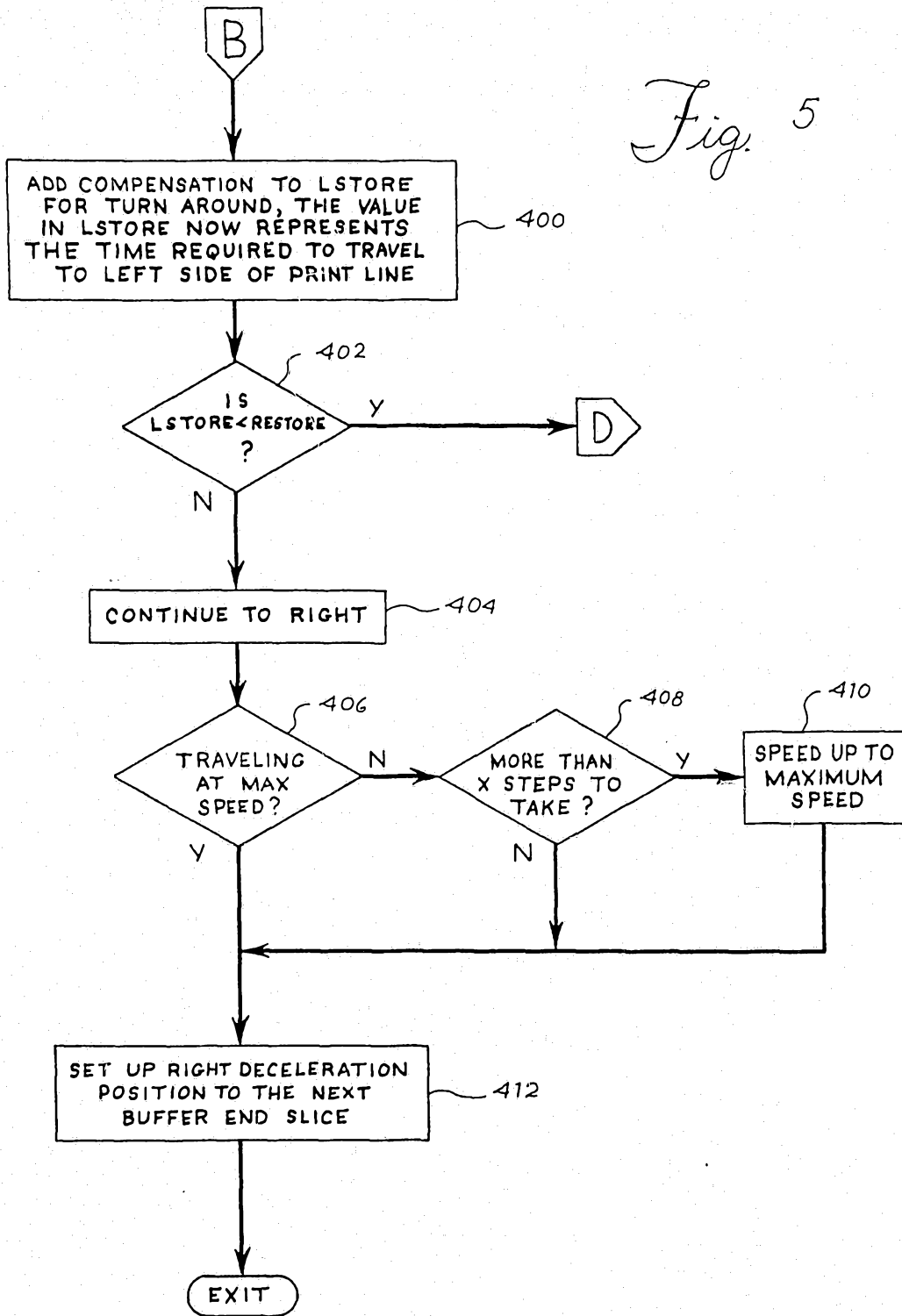


Fig. 6

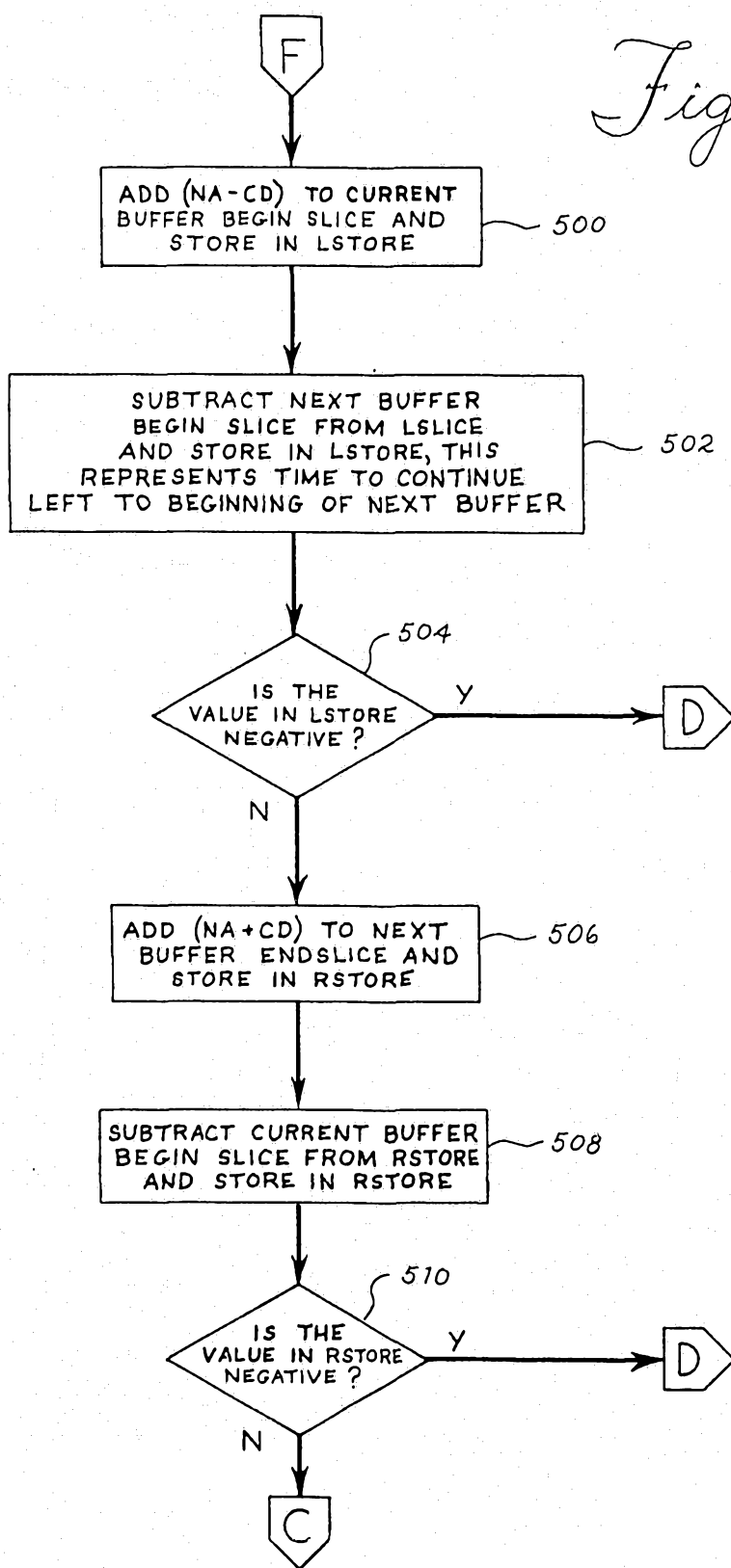
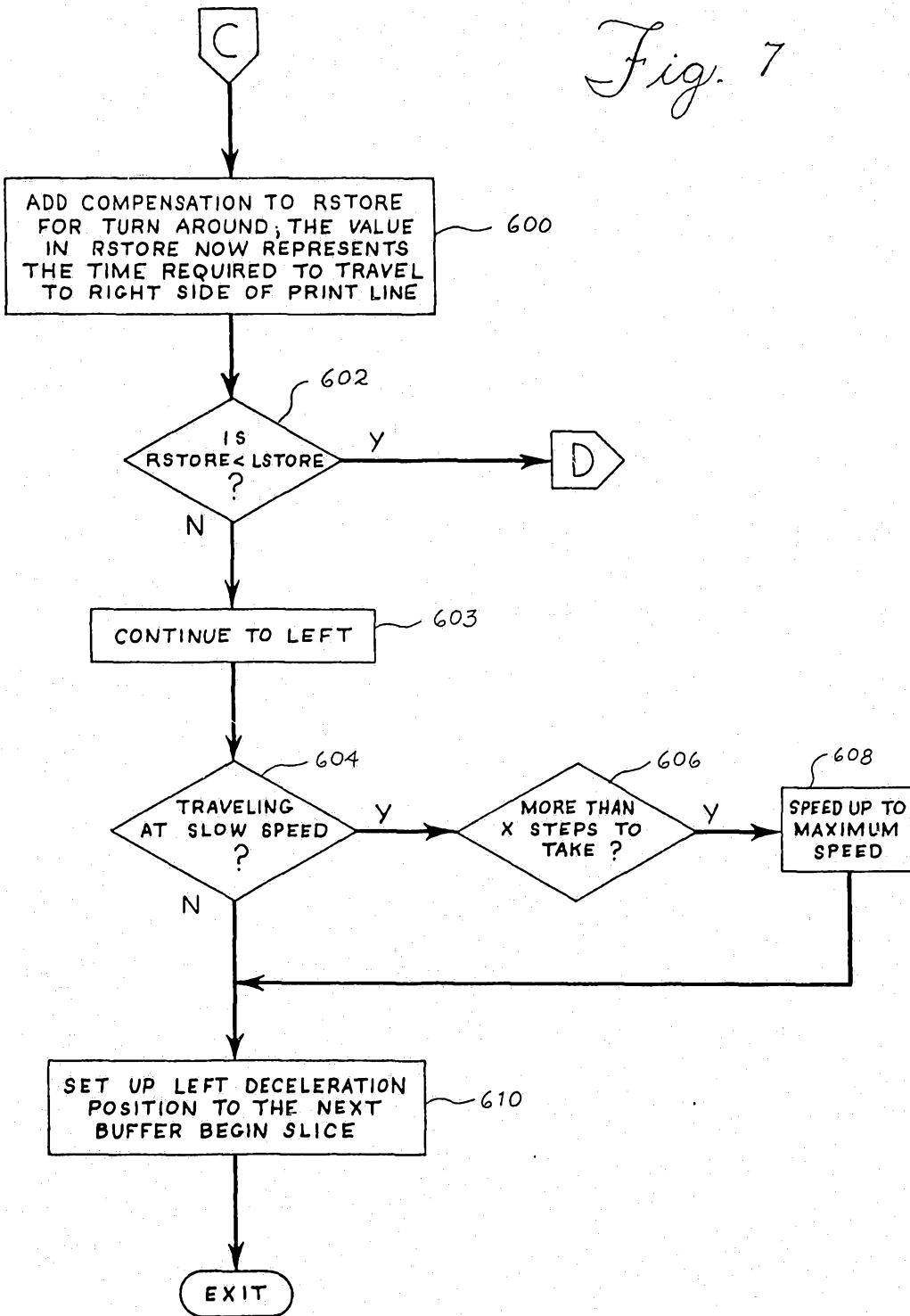


Fig. 7



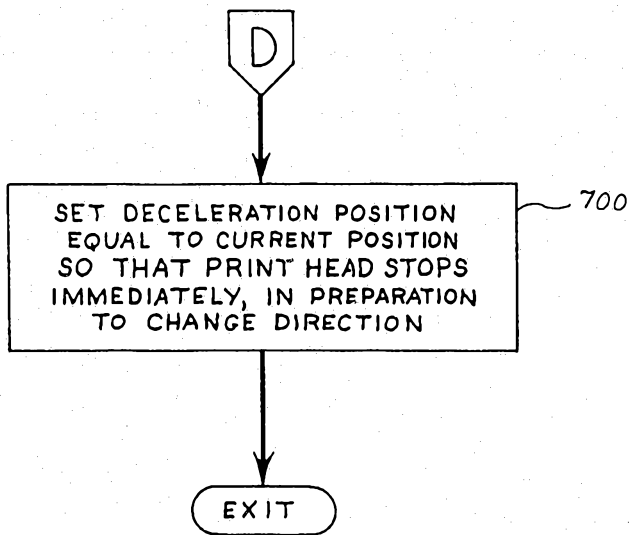


Fig. 8

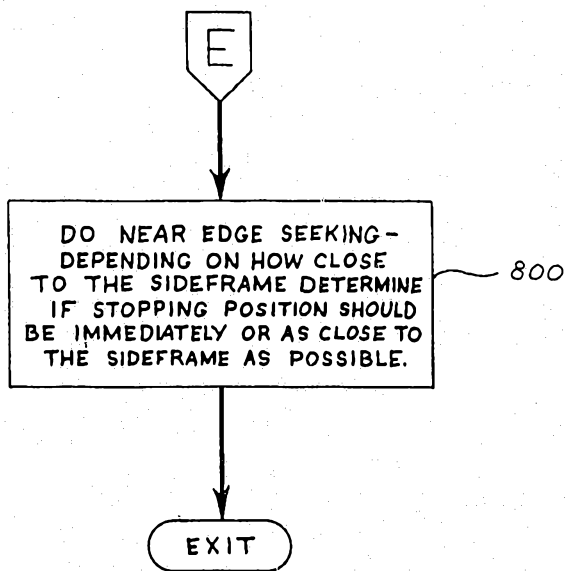


Fig. 9

Fig. 10

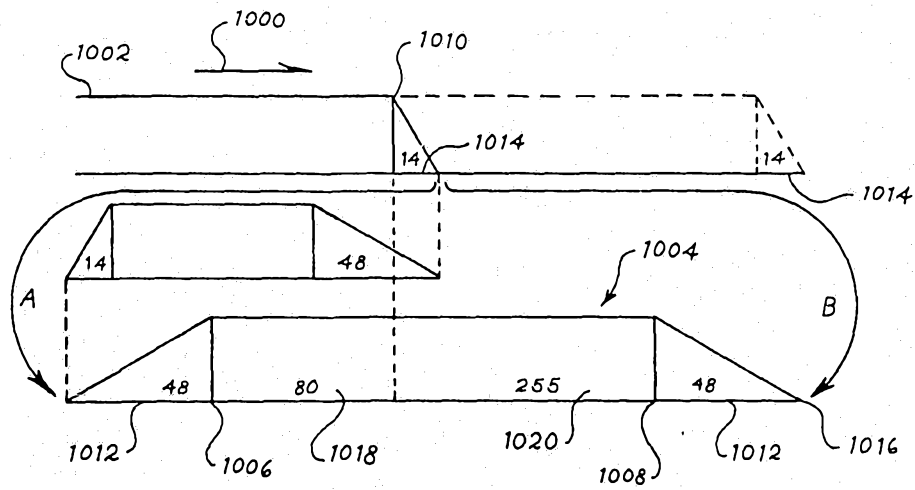
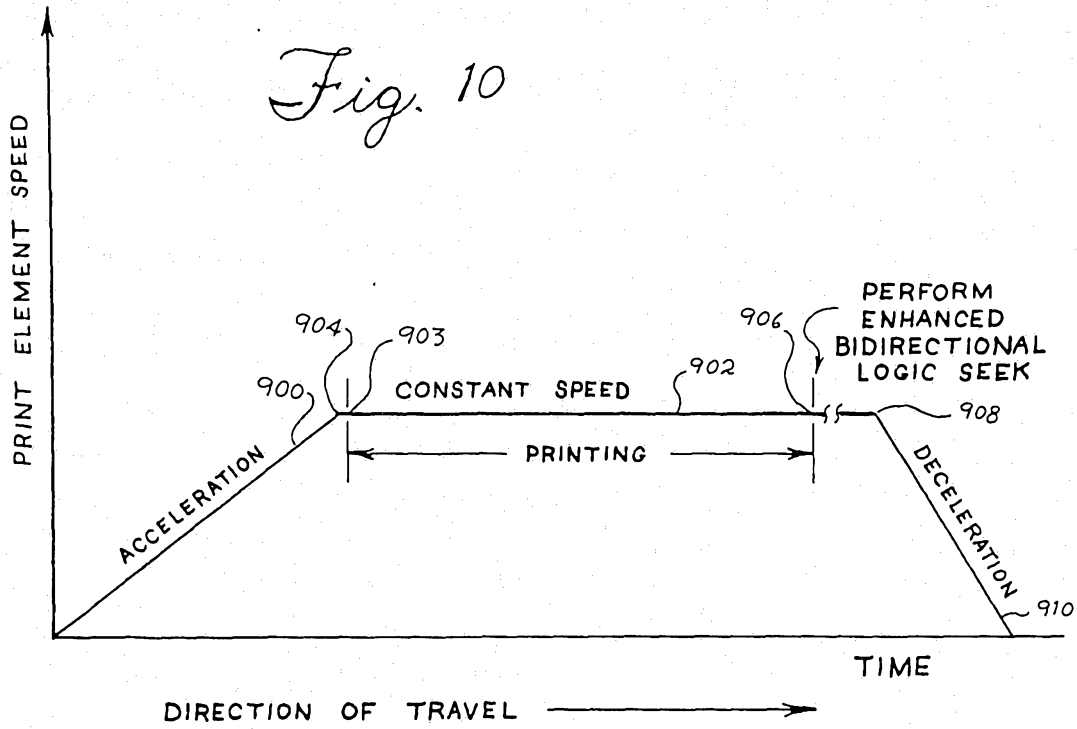


Fig. 11