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(54) **Method and device for controlling a carriage motor and paper feed motor of a printer.**

(57) A control device for a carriage motor and paper feed motor of a printer includes; a unit for calculating, when the output of a paper presence/absence detector is indicative of paper absence, the length of a printable space remaining on a paper, a unit for predicting, on the basis of the calculated remaining space length and a paper feed amount of paper feeding being expected to be performed, the presence/absence of the printable space after the paper feeding expected to be performed is performed, a unit for controlling, when the prediction result is indicative of space presence, the driving of the paper feed motor to perform the paper feeding expected to be performed, and a unit for starting, when the print action is to be performed subsequently to the paper feeding, the driving of the carriage motor in advance of the termination of the paper feeding such that the speed of the carriage motor reaches a level adapted for the print action when the paper feeding terminates. When the print action is to be performed subsequently to the execution of the paper feeding, a judgement of printability after the execution of the paper feeding is made before the execution of that paper feeding, so that the speed of the carriage motor is made to reach a level adapted for the print action just at the moment (t3) when that paper feeding terminates. Therefore, the print action can be started immediately after the termination of the paper feeding.

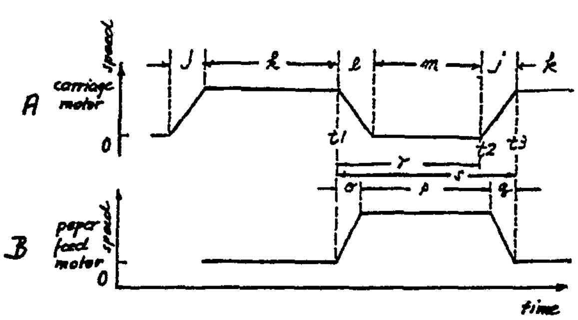

FIG. 4

EP 0 373 558 A2

METHOD AND DEVICE FOR CONTROLLING A CARRIAGE MOTOR AND PAPER FEED MOTOR OF A PRINTER

This invention relates to a method and device for controlling a carriage motor and paper feed motor of a printer.

Conventional control sequences of a carriage motor (hereinafter referred to as a CR motor) and a paper feed motor (hereinafter referred to as a PF motor) are shown in Figs. 1(A) and (B) which show the situation wherein a paper feed action is performed in the course of printing. Specifically, as soon as deceleration c begins in the drive sequence of the CR motor (Fig. 1(A)), acceleration e begins in the drive sequence of the PF motor (Fig. 1(B)), and then, when the deceleration g of the PF motor ends, the driving a of the CR motor begins.

That is, after the paper feed action is completely terminated, it is judged whether the printer is in a printable position. When the judgement result is YES, the driving of the CR motor is started to re-start printing.

According to the foregoing prior art, there are the deceleration time of the PF motor and the time of judging whether the printer is in the printable position between the paper feeding (paper feed action) and the beginning of acceleration of the CR motor. Such an interval of time is a cause to decrease the real print speed of the printer because it is dependent on the drive time of the CR motor.

Is is an object of the present invention to remedy these problems of the prior art and to provide a control method and device which allow to improve the real print speed of a printer by shortening the dead time between the paper feeding and the beginning of shift of a carriage.

This object is achieved with a control device and control method as claimed.

As will be appreciated, in the printer control system according to the present invention, a judgement of printability after the execution of paper feeding is made before the execution of that paper feeding. When a next print action is to be performed after the paper feeding, the driving of the carriage motor is started in advance of the termination of the paper feeding, so that the speed of the carriage motor reaches a level adapted for the print action just at the moment when the paper feeding terminates. Therefore, no judgement of printability is made between the paper feeding and the subsequent shifting of the carriage, and no waste time for acceleration of the carriage motor is spent between them.

One way of carrying out the invention is described in detail below with reference to drawings which illustrate one specific embodiment only, and in which:

Figs. 1(A) and (B) are diagrams showing a conventional drive sequence of a CR motor and that of a PF motor, respectively;

Fig. 2 is a general block diagram of an embodiment of the present invention;

Figs. 3(A) and (B) are a perspective view and a side view, respectively, showing the relationship in arrangement between a carriage, a paper and a PE detector;

Figs. 4(A) and (B) are diagrams showing the drive sequence of a CR motor and that of a PF motor, respectively, according to the embodiment of the present invention; and

Fig. 5 is a flowchart showing the operation process of a CPU according to the embodiment of the present invention.

Fig. 2 shows a general structure of a preferred embodiment of the present invention. A printer control device 1 is connected via an interface (I/F) section 3 with an external host computer 5. Supplied from the host computer 5 are print data, print control (e.g. paper feed control) commands, etc. Such data is temporarily stored in the I/F section 3 or a RAM 15.

The I/F section 3 is connected via an address/data bus 7 with a CPU 9. The CPU 9 is connected via the bus 7 with a ROM 11, so that the print action is controlled in accordance with a control program stored in the ROM 11. In control operation, the CPU 9 reads and interprets the data stored in the I/F section 3, and if necessary, refers to the signal from a paper existence (presence/absence) detector (hereinafter referred to as a PE detector) 13, a variety of data (for print control) previously stored in the ROM 11 or RAM 15, etc. Then, the CPU 9 performs calculation on such data in accordance with the control program. Consequently, the CPU 9 sends various control commands through the bus 7 to a CR motor drive circuit 17, a PF motor drive circuit 19 and a head drive circuit 21.

The CR motor drive circuit 17 drives a CR motor 23 in accordance with the command from the CPU 9; as a result, a carriage 25 shifts. The PF motor drive circuit 19 drives a PF motor 27; as a result, a paper 29 is fed. Generally, each of the CR motor 23 and the PF motor 27 is a step motor; in this case, a count of steps of the step motor determines the amount of shift of the carriage, or the amount of feed of the paper. The head drive circuit 21 drives a print head 31 attached to the carriage 25 to perform printing. A print action is carried out in response to the shifting of the carriage 25. The paper feeding is carried out while the carriage 25 is at a stop.

Figs. 3(A) and (B) show the relationship between the paper 29, the carriage 25 and the PE detector 13. As illustrated by the arrow h, the paper 29 is fed from the side of a paper supply guide 33 and inserted between a platen 35 and a paper feed roller 37, and then, fed upward in front of the print head 31 in response to the rotation of the platen 35 caused by the PF motor 27. The feeding of the paper is performed using a line pitch previously stored in the RAM 15 (that is stored after being converted into the form of a step count of the PF motor 27) as a unit.

The carriage 25 reciprocatingly shifts along guide rods 39 in directions i orthogonal to the paper feed direction h. Generally, while the carriage 25 is shifting from left to right with respect to the surface of the paper 29, the print head 31 is driven to perform printing. When the printing of a given line is completed, the carriage 25 stops, the paper is fed to bring about the next new line, and then the carriage 25 is re-shifted to perform printing at the new line. The present invention primarily resides in the control of paper feeding performed between two successive shift actions of the carriage 25. Whether or not the present invention is applicable to such a paper feed control is previously judged on the basis of the print control command read from the I/F section 3 by the CPU 9.

The PE detector 13 is generally made of a microswitch. For example, the PE detector 13 is attached to the back side of the paper supply guide 33 such that its detecting pin 13a projects from the surface of the paper supply guide 33. Thus, when the paper 29 is present on the detecting pin 13a, the PE detector 13 provides a paper presence signal. When the paper 29 was fed and its rear edge has passed over the detecting pin 13a, the output of the PE detector 13 changes from the paper presence signal to a paper absence signal (a PE signal). At this moment of changing, the paper 29 still has a printable space corresponding to the distance L from the detecting pin 13a to a paper retaining plate 40 disposed ahead thereof. The distance L is called an override amount herein. The override amount L is a constant depending on the attached position of the PE detector 13, which is previously stored in the ROM 11 or RAM 15 after being converted into the form of a step count of the PF motor 27.

The number of printable lines permitted within the override amount L varies depending on the line pitch and a marginal width to be left on the side of the rear edge of the paper. Format setting data including the line pitch, the marginal width, the number of characters per line, an inter-character pitch, a character magnifying factor, etc. are supplied from the host computer 5 to the printer control device 1 prior to the entry of print data, print action data such as print control commands, etc. Such format data are sent from the I/F section 3 to the CPU 9 and written in a dedicated area of the RAM 15.

The paper feeding of the embodiment which is performed between two successive shift actions of the carriage 25 will be described with reference to Figs. 4(A) and (B) and Fig. 5.

Fig. 4(A) shows the drive sequence of the CR motor 23, in which j is an acceleration zone, k is a constant-speed zone, l is a deceleration zone, and m is a stop zone. Fig. 4(B) shows the drive sequence of the PF motor 27, in which o is an acceleration zone, p is a constant-speed zone, and q is a deceleration zone. As illustrated in Figs. 4(A) and (B) , the PF motor 27 is started to accelerate at a deceleration beginning moment t1 of the CR motor 23, the CR motor 23 is started to accelerate a second time at a moment t2 before the PF motor 27 stops, and the CR motor 23 comes to a constant-speed state just at a moment t3 when the PF motor 27 stops. The foregoing drive sequence system includes no waste time between the termination of the paper feeding and the next shifting of the carriage; thus, its temporal efficiency is very high. To realize such a drive sequence system, it is necessary both to previously calculate the time r from the acceleration beginning moment t1 of the PF motor 27 to the acceleration beginning moment t2 of the CR motor 23 and to judge whether or not after the paper feeding the paper 29 departs from the platen 25 within the time r to result in a nonprintable state.

Fig. 5 shows the operation process of the CPU 9 performed to realize the drive sequence of Fig. 4. The CPU 9 performs the process of Fig. 5 when it is instructed by the print control commands read out of the I/F section 3 to shift the carriage, feed the paper, and re-shift the carriage.

In step S 1 the driving of the CR motor 23 is started to shift the carriage. Then it is judged whether the paper is present or not on the basis of the signal from the PE detector 13 (step S2). When the paper is present, the drive sequence of the CR motor and PF motor shown in Figs. 4(A) and (B) are performed, that is, the CR motor 23 is accelerated (zone j) to come to the constant-speed state (zone k). To obtain an instructed shift amount of the carriage (generally given in the form of a step count of the CR motor 23), the CR motor 23 is started to decelerate at a proper moment t1. Concurrently with the beginning of deceleration, the PF motor 27 is started to accelerate (step 53). While the PF motor 27 is in the constant-speed zone (p), the CR motor 23 is at a stop (zone m). During the paper feeding, the time r (called a precedence time) from the acceleration beginning moment t1 of the PF motor 27 to the next acceleration beginning moment t2 of the CR motor 23 is calculated (step S4). The calculation of the precedence time r is made on the basis of a paper feed amount instructed by, for example, the print control command (that is generally given in the form of a line pitch amount from the host computer 5 and is converted by the CPU 9 into the form of a step count of the PF motor 27 on the basis of the line pitch data stored in the RAM 15) and on the basis of the running characteristic data of the CR motor and PF motor previously stored in the ROM 11 or RAM 15, in the following manner. That is, a required paper feed time S (from the moment t1 to the moment t3) necessary to obtain the instructed paper feed amount is calculated on the basis of the instructed paper feed amount and the characteristic data, relating to acceleration, constant-speed and deceleration, of the PF motor 27. The precedence time r is calculated by subtracting the acceleration time j of the CR motor 23 from the required paper feed time S. Then, at the moment t2 when the elapsed time from the moment t1 reaches the calculated precedence time r, the CR motor 23 is started to accelerate (step S4). Subsequently, the PF motor 27 is started to decelerate (step S5), and at the position when the PF motor 27 stops, there is obtained the instructed paper feed amount. At the stop moment t3 of the PF motor 27, the CR motor 23 is put in the constant-speed drive state.

When in step S2 it is judged that the paper is absent, the following process is performed. First, a remaining override amount stored in the RAM 15 is read (step 56). This remaining override amount is indicative of the distance from the rear edge of the paper 29 after the paper absence is detected by the PE detector 13 to the paper retaining plate 40. Although not shown in Fig. 5, when first starting the printing in relation to the paper 29, the override amount L is initially used and set as the remaining override amount. Accordingly, the remaining override amount read out corresponds to the override amount L at the moment of first paper feeding after the detection of paper absence, but to the remaining override amount updated in step S11 (hereinafter described) at the moments of second paper feeding and so on.

In next step S7, it is judged whether or not the space corresponding to the remaining override amount minus the paper feed amount is printable. This judgement may be made as follows. First, the paper feed amount instructed by the print control command is subtracted from the remaining override amount, and further, the marginal width on the side of the paper rear edge stored in the RAM 15 is subtracted from the above. The thus calculated amount is indicative of the space for printing. If this space is greater than the size of characters based on the character magnifying factor stored in the RAM 15, this is judged to be printable.

When in step S7 it is judged that the paper is printable, similarly to the case of the paper being present, the sequences shown in Figs. 4(A) and (B) are performed (steps S8, S9, S10). Then, in preparation for a next paper feed control, the (current) remaining override amount minus the current paper feed amount is written in the RAM 15 as a new remaining override amount (step S11).

On the other hand, when in step S7 the space is judged to be non-printable, concurrently with the starting of deceleration of the CR motor 23 (moment t1), the PE motor 27 is started to accelerate (step S12) to feed the paper by the remaining override amount, and then, the PF motor 27 is decelerated and stopped (step S13). That is, in this case, the paper 27 is detached from the platen 35. However, if desired, the step S13 may be modified such that the PF motor 27 is immediately stopped and the print control action is terminated. The next shifting of the carriage that is instructed by the print control command will be carried out after a new paper 29 is set.

In the foregoing manner, the control sequence is performed to shift the carriage, feed the paper, and re-shift the carriage. In case another or subsequent sequence of feeding the paper and shifting the carriage is to be performed subsequently to the last sequence, the starting of acceleration of the CR motor in step S4 or S9 of the last sequence is considered to have corresponded to that of step S1 of the subsequent sequence. Therefore, following the step S5 or S11 of the last sequence, the step S2 and so on of the subsequent sequence are performed.

Although the foregoing is one preferred embodiment of the present invention, it is not intended to have the present invention limited to the specific embodiment, and many changes and modifications may be made. For example, although the embodiment judges the presence/absence of the paper in step S2 of Fig. 5, each time the sequence of feeding the paper and shifting the carriage is reached, another system may be used in which a no-paper flag is set when the absence of the paper is detected, during this flag being in the set state each sequence of feeding the paper and shifting the carriage is repeatedly performed through step S6 to step S11, and if the judgement of step S7 is NO, the no-paper flag is reset. Further, where the processing speed of the CPU is sufficiently high, instead of individually performing each sequence of feeding the paper and shifting the carriage, such individual sequences may be combined beforehand into one longer sequence which is handled at one time. The foregoing embodiment makes a judgement of printability after the paper feeding while considering the marginal width on the side of the paper rear edge, the character magnifying factor, etc. so that it can handle where these parameters are variable. However, where these parameters are fixed, the override amount $\underline{L}$ may be previously set by subtracting these parameters, and a judgement of printability may be made by simply comparing the remaining override amount with the paper feed amount; in this case, the judgement is "printable" if the former is larger, otherwise "non-printable". Further, where the host computer is managing the paper rear margin, the character magnifying factor, etc. so that the printer is not required to consider such parameters, a judgement of printability can be made simply on the basis of the override amount or the remaining override amount.

Claims

1. A control device of a printer configured so that printing is performed on a paper (29) by shifting a carriage (25) with a print head (31) attached thereto by means of a carriage motor (23), a next print action is performed after the paper is fed by means of a paper feed motor (27) subsequently to the last print action if necessary, there is included a paper detecting means (13) for detecting the presence/absence of the paper, and a given printable space still remains on the paper when the output of the detecting means changes from paper presence to paper absence, comprising;
an arithmetic means (9) for calculating, when the output of the detecting means (13) is indicative of paper absence, the length of a printable space remaining in the paper on the basis of the given printable space and a paper feed amount of paper feeding having been performed after the output of the detecting means changes from paper presence to paper absence,
a predicting means (9) for predicting, when the output of the detecting means is indicative of paper absence, and on the basis of the remaining length and a paper feed amount of paper feeding being expected to be performed after the print action, the presence/absence of a printable space on the paper after the paper feeding expected to be performed is performed,
a paper feed motor control means (9) for controlling, when the predicting means predicts the presence of printable space, the driving of the paper feed motor (27) to perform the paper feeding expected to be performed, and
a carriage motor control means (9) for the execution of the next print action subsequent to the execution of the paper feeding expected to be performed, which starts the driving of the carriage motor (23) in advance of the termi nation of the paper feeding expected to be performed such that the speed of the carriage motor reaches a level adapted for the print action when the paper feeding expected to be performed terminates.

2. A control device according to claim 1, wherein the paper feed motor control means (9) always performs the paper feeding expected to be performed when the output of the detecting means (13) is indicative of paper presence.

3. A control device according to claim 1, wherein the paper feed motor control means (9) concurrently starts the driving of the paper feed motor (27) for the beginning of execution of the paper feeding expected to be performed and the deceleration of the carriage motor (23) for the termination of the preceding print action.

4. A control device according to claim 1, wherein the carriage motor control means (9) predicts, on the basis of the paper feed amount of the paper feeding expected to be performed and the running characteristic data of the paper feed motor (28) and of the carriage motor (23), the time from the execution beginning moment of the paper feeding expected to be performed to the beginning moment of the driving of the carriage motor, and starts the driving of the carriage motor when the elapsed time from the execution beginning moment of the paper feeding reaches the predicted time.

5. A control method of a printer configured so that printing is performed on a paper (29) by shifting a carriage (25) with a print head (31) attached thereto by means of a carriage motor (23), a next print action is performed after the paper is fed by means of a paper feed motor (27) subsequently to the last print action if necessary, the presence/absence of the paper is detected, and when the result of paper detection changes from paper presence to paper absence, a given printable space still remains in the paper, comprising the steps of;
calculating, when the detection result is indicative of paper absence, the length of a printable space remaining on the paper on the basis of the given printable space and a paper feed amount of paper feeding having been performed after the paper changes from presence to absence,
predicting, when the detection result is indicative of paper absence, on the basis of the remaining length and a paper feed amount of paper feeding being expected to be performed after the print action, the presence/absence of a printable space on the paper after the paper feeding expected to be performed is performed,
controlling, when the prediction result is indicative of space presence, the driving of the paper feed motor to perform the paper feeding expected to be

performed, and
starting, to perform the next print action subsequently to the execution of the paper feeding expected to be performed, the driving of the carriage motor in advance of the termination of the paper feeding expected to be performed such that the speed of the carriage motor reaches a level adapted for the print action when the paper feeding expected to be performed terminates.

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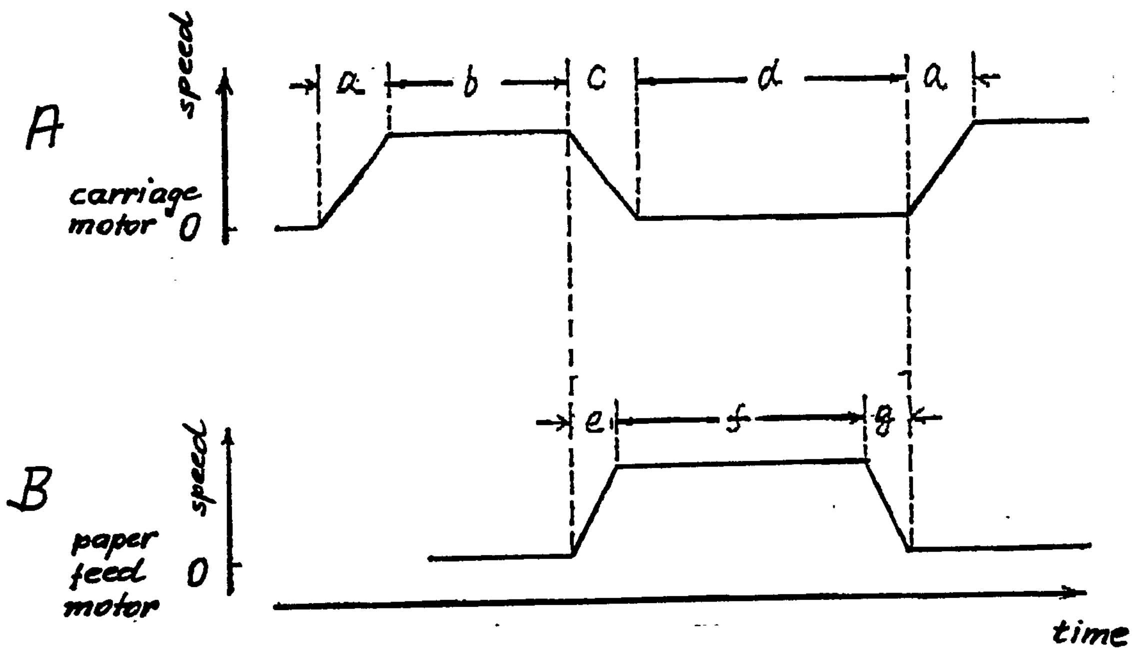


FIG. 1

FIG. 2

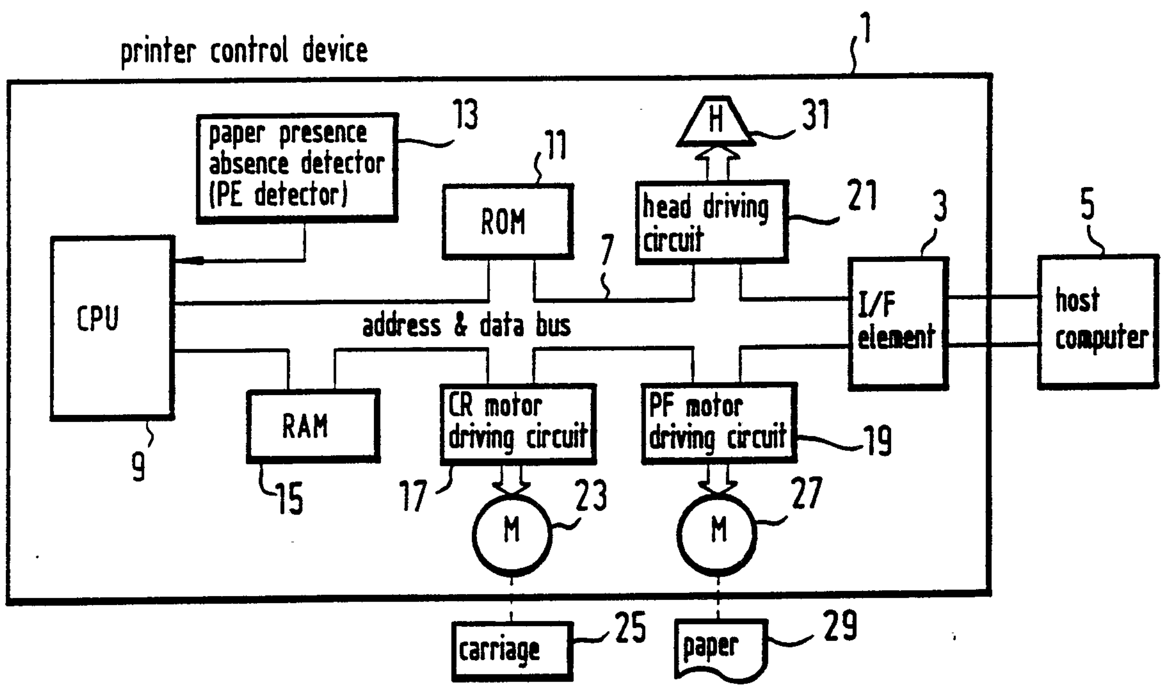

printer control device
1
paper presence
absence detector
(PE detector)
13
ROM
11
H
31
head driving
circuit
21
3
5
CPU
7
I/F
element
host
computer
address & data bus
RAM
CR motor
driving circuit
PF motor
driving circuit
19
9
15
17
M
23
M
27
carriage
25
paper
29

FIG.3A

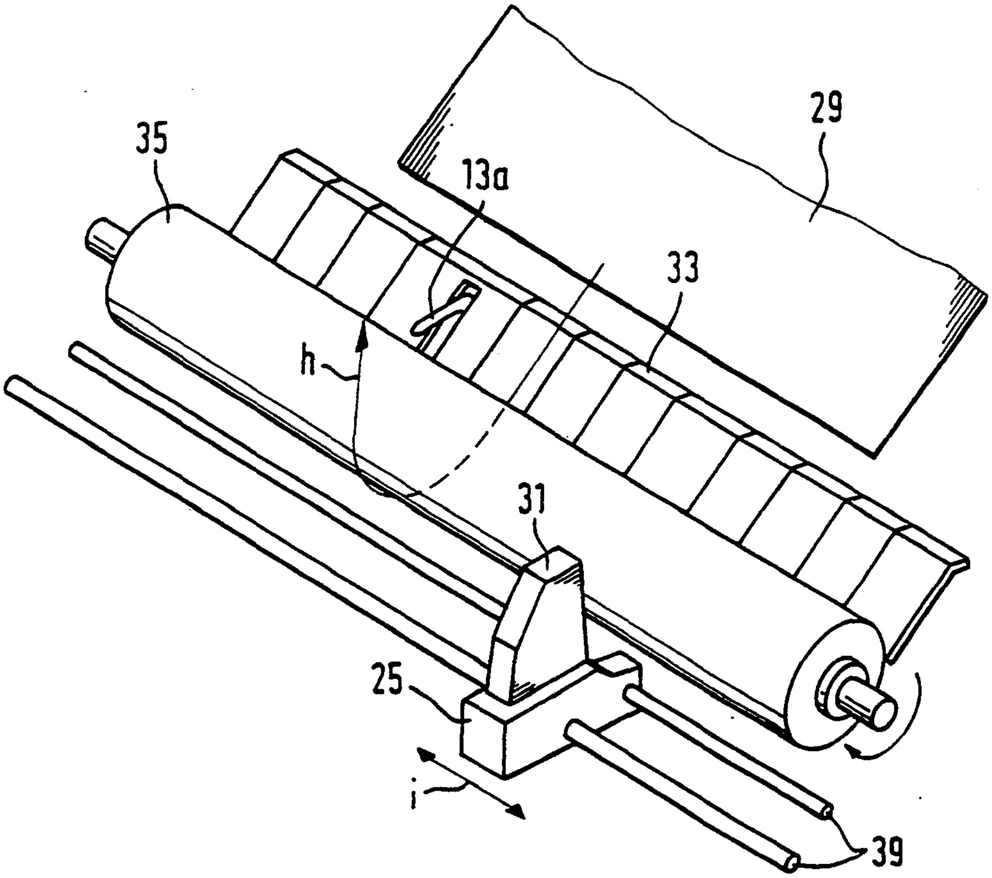
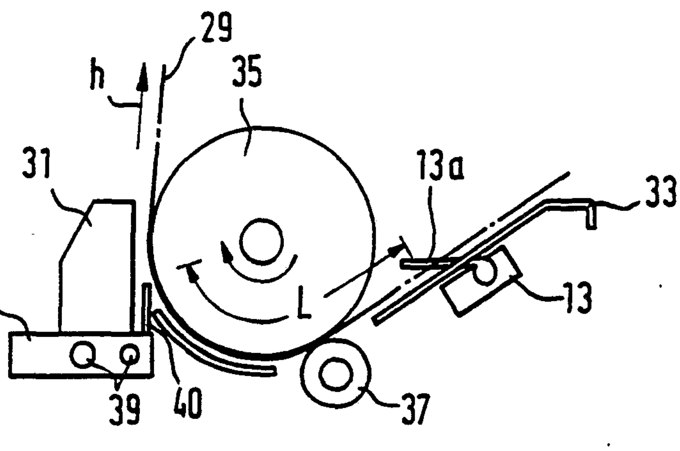


FIG.3B



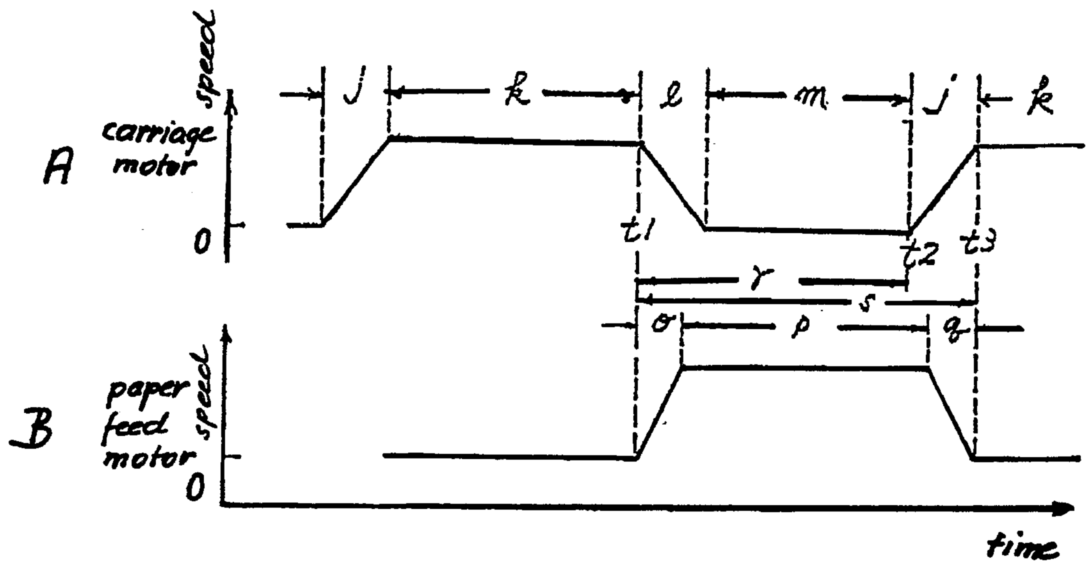

j
k
l
m
j
k
speed
carriage motor
A
0
t1
t2
t3
r
s
o
p
q
paper feed motor
speed
B
0
time

FIG. 4

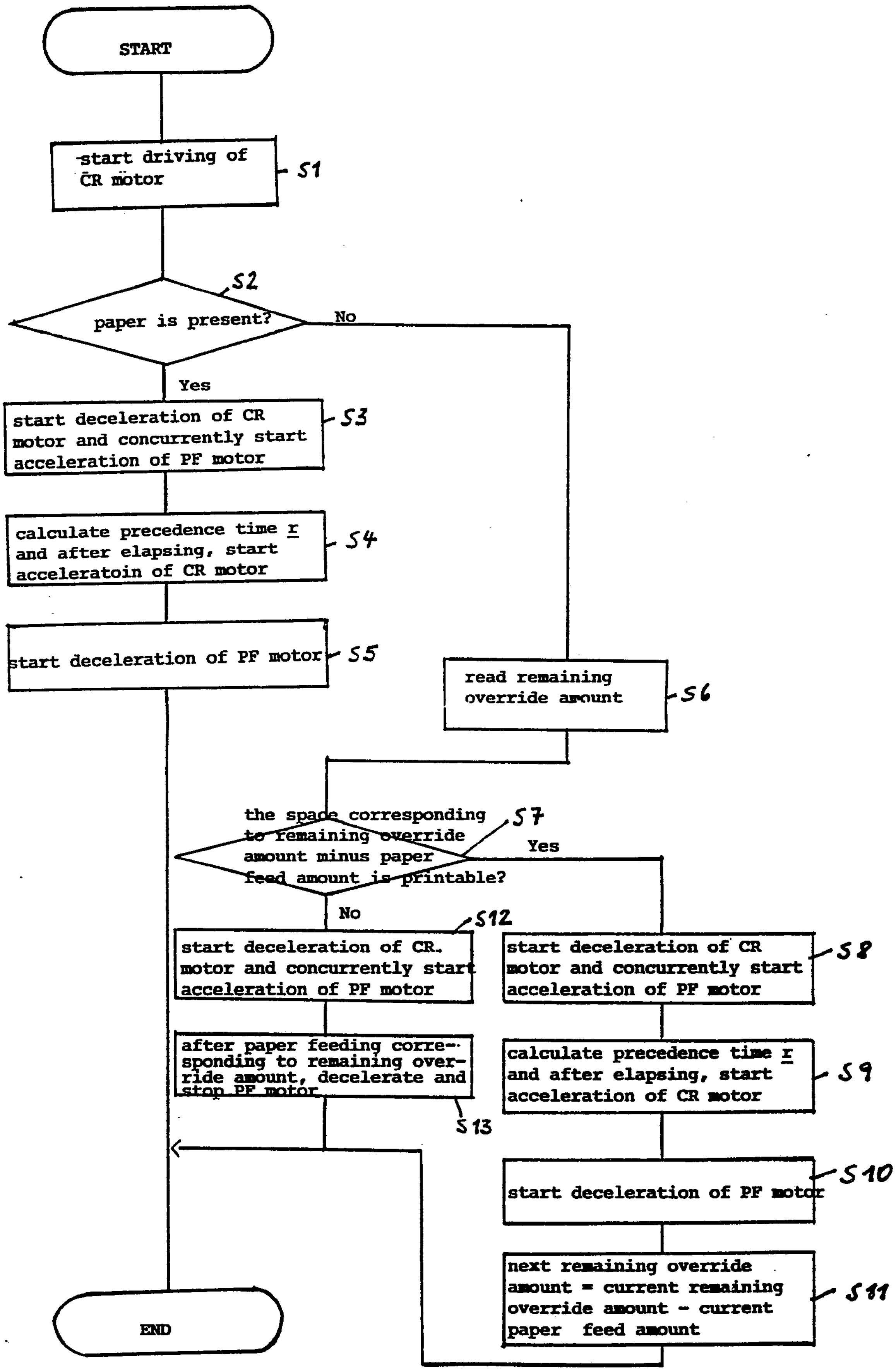

START
start driving of CR motor
S1
paper is present?
S2
No
Yes
start deceleration of CR motor and concurrently start acceleration of PF motor
S3
calculate precedence time r and after elapsing, start acceleratoin of CR motor
S4
start deceleration of PF motor
S5
read remaining override amount
S6
the space corresponding to remaining override amount minus paper feed amount is printable?
S7
Yes
No
start deceleration of CR. motor and concurrently start acceleration of PF motor
S12
start deceleration of CR motor and concurrently start acceleration of PF motor
S8
after paper feeding corresponding to remaining override amount, decelerate and stop PF motor
S13
calculate precedence time r and after elapsing, start acceleration of CR motor
S9
start deceleration of PF motor
S10
next remaining override amount = current remaining override amount - current paper feed amount
S11
END

FIG. 5