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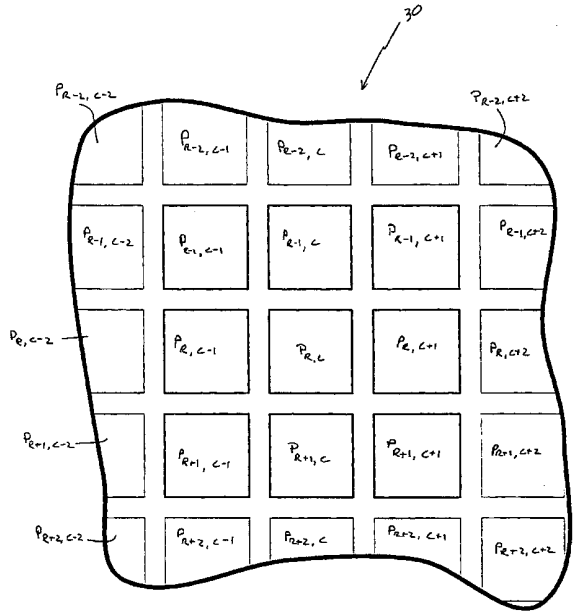
(54) Title: THERMAL PRINTHEAD COMPENSATION



(57) Abstract: The present invention is directed to a method of controlling a thermal printhead (18) of an identification card printing system (10) to provide improved image sharpness. In one step (32) of the method a pixel level of a non-compensated pixel $P_{R,C}$ is adjusted based upon a pixel level of one or more proximal pixel levels to form a compensated pixel $P'_{R,C}$. In another step (34) of the method, the thermal printhead (18) is controlled to print the compensated pixel $P'_{R,C}$. The present invention is further directed to an identification card printing system (10) which utilizes the above-described method to improve contrast in images printed with a thermal printhead (18).

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THERMAL PRINTHEAD COMPENSATION

FIELD OF THE INVENTION

The present invention relates to identification card printing systems having a thermal printhead. More particularly, the present invention relates to compensating the thermal printhead of an identification card printing system to improve and control image sharpness.

BACKGROUND OF THE INVENTION

Identification cards are widely used to carry information typically relating to the cardholder. The use of such identification cards is becoming more and more wide spread and they are used for many purposes, such as drivers' licenses and identification badges. Identification card printing systems are used to print and image, which contains textual and graphical information, on card-like substrates, such as plastic cards.

Typical identification card printing systems are thermal based printing systems, which use a thermal printhead to print the desired image that is formed of an array of pixels. Typical thermal printheads include a line of resistive heating elements, each of which can print one pixel of the image at a time. The resistive heating elements are uniformly deposited closely together in a single line having, for example, a resolution of 200 or 300 heaters per inch. A ribbon having primary color panels is positioned between the resistive heating

elements and the substrate. When the ribbon is heated by the resistive heating elements, black, white, and colored dye or other material is presented to the substrate to form a pixel at each of the resistive heating elements. The color and gray level (intensity) of the pixels is controlled by an electric current that is selectively and controllably applied to each of the resistive heaters. The array of pixels that form the image is printed on the substrate a line at a time. Each of the lines forms several rows of the pixel array, the number of which corresponds to the number of resistive heating elements used by the printhead.

The sharpness of an image, that is the amount of detail and the maximum contrast between adjacent pixels of the image, is limited by the printhead. Identification card printing systems prefer high contrast and high definition printing to properly present photos and security marks. Unfortunately, low-cost printheads tend to be able to produce only poor contrast images. Consequently, there exist a need for a method of compensating thermal printheads used in identification card printers to improve and control the sharpness of printed images.

SUMMARY OF THE INVENTION

The present invention is directed to a method of controlling a thermal printhead of an

identification card printing system to provide improved image sharpness. In general, a pixel level is compensated based upon the values of adjacent pixel levels to increase contrast therebetween. The present invention is further directed to an identification card printing system which utilizes the above-described method to improve contrast in images printed with a thermal printhead.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an identification card printing system in accordance with embodiments of the invention.

FIG. 2 is a diagrammatic end view of the thermal printhead shown in FIG. 1 in accordance with one embodiment of the invention.

FIG. 3 is a simplified block diagram of a portion of a pixel array.

FIG. 4 is a flowchart illustrating a method of improving thermal printhead performance in accordance with embodiments of the invention.

FIG. 5 is a flowchart illustrating a method of improving thermal printhead performance in accordance with various embodiments of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates an example of an identification card printing system, generally designated as 10, in accordance with one embodiment of

the present invention. Printing system 10 generally includes microcomputer 12, memory 14, input devices 16, thermal printhead 18, card substrate (card) 20, and card feeder mechanism 22. Printing system 10 is adapted to print text and images onto card 20 using thermal printhead 18. The present invention improves the performance of thermal printhead 18 such that images produced by thermal printhead 18 have greater contrast than would otherwise be possible.

Microcomputer 12 is preferably a microprocessor-based device of a type well-known in the art. However, in other embodiments, microcomputer 12 can be any analog or digital circuitry capable of implementing the method of the present invention. Memory 14 is coupled to microcomputer 12 and can be any of a large variety of conventional data storage devices for temporarily and/or permanently storing data for use by microcomputer 12. In other embodiments, memory 14 can be integrated within microcomputer 12 instead of being a separate device. Microcomputer 12 can be adapted to run a software application that produces image files which can be processed by microcomputer 12. In preferred embodiments, a separate personal computer (not shown) is utilized to process data according to the methods of the present invention. The data or image file is then transferred to a microcomputer 12 for processing of the data and actual control of print head 18.

Input devices 16 are coupled to microcomputer 12 and can be any of a wide variety of devices adapted for providing information and/or control data to microcomputer 12. For instance, input devices 16 can include, for example, a keyboard, a keypad entry device, a sensor, and other types of input devices. Additionally, input devices 16 can include a separate computing system which provides image files to microcomputer 12 for processing, as mentioned above.

Printer driver software, stored in memory 14, is adapted to process an image file from the software application. Alternatively, the printer driver software could be stored in a personal computer that is operating as an input device 16 such that data from the printer driver software can be communicated to microcomputer 12. The image file contains data that represents an image which is to be printed by printing system 10. The printer driver is used to process the image file and control printhead 18 to print the image. This is accomplished by converting the image of the image file into a pixel array, formed of rows and columns of individual pixels, which represents the image and can be printed with thermal printhead 18 on card 20. Information relating to the pixel array including color and pixel level is provided to microcomputer 12. The pixel level information relates to the gray level or intensity of the pixel. Microcomputer 12 controls thermal printhead 18 to selectively print the pixels of the pixel array on card

20 (FIG. 1) one line at a time in accordance with data or instructions from the printer driver. Each line of the pixel array that is printed by printhead 18, is typically formed of several rows of pixels, the number of which depends on the printhead that is being used.

Thermal printhead 18 is of the type well-known in the art having a column of resistive heaters 22 on end 24, as shown in the diagrammatic view of end 24 in FIG. 2. The column of adjacent resistive heaters 22 are designated as H_1 through H_i (where i is equal to the number of heaters on thermal printhead 18 and therefore is also equal to the number of rows of pixels per line to be printed on card 20). Thermally sensitive ribbon 28 is positioned between heaters 22 and card 20 and contains a dye which transfers to card 20 when heated while card 20 is moved, relative to thermal printhead 18 in a direction indicated by arrow 26. The amount of dye transferred, or the pixel level of a pixel, is dependent upon the heat applied by the resistive heaters 22. Accordingly, pixels can be printed on card 20 by controllably heating thermally sensitive ribbon 28 with heaters 22. The pixel level of the pixels printed on card 20 can also be controlled by controlling the intensity and/or duration of heat generated by the resistive heaters 22 on thermal printhead 18.

The printing system 10 of the present invention utilizes a method of controlling the pixel levels of the pixels in the pixel array based upon

proximal pixel levels to provide greater contrast in the resulting printed image. This is generally accomplished by amplifying a difference between the pixel level of the pixels in the pixel array based upon corresponding proximal pixel levels to increase the contrast therebetween. In this manner, a compensated pixel array is generated from the non-compensated pixel array which, when printed by thermal printhead 18, results in a printed image that is sharper and has greater contrast than an image printed using the non-compensated pixel array.

FIG. 3 shows a portion of a pixel array 30 corresponding to a non-compensated pixel array representing an image to be printed. Each non-compensated pixel or pixel level is designated as $P_{R,C}$, where R represents the row of the pixel and C represents the column of the pixel. To simplify the discussion of the various embodiments of the present invention, the following will describe how a pixel level of a single a non-compensated pixel, $P_{R,C}$, can be compensated.

FIG. 4 shows a flowchart of the general method of improving thermal printhead performance in accordance with one embodiment of the invention. At step 32, a pixel level of a non-compensated pixel $P_{R,C}$ is adjusted based upon a pixel level of one or more proximal non-compensated pixels to form a compensated pixel. This adjustment generally involves amplifying the difference between the pixel level of the non-

compensated pixel $P_{R,C}$ and the pixel level of at least one proximal pixel. With respect to non-compensated pixel $P_{R,C}$ (FIG. 3), proximal pixels can be any of the pixels located in the vicinity of non-compensated pixel $P_{R,C}$, such as those located, for example, within two pixels of non-compensated pixel $P_{R,C}$. In another embodiment of the invention, the proximal pixels are selected from the pixels that are immediately adjacent to non-compensated pixel $P_{R,C}$. Here, the one or more proximal pixels used to compensate non-compensated pixel $P_{R,C}$ could be selected from the following group of pixels: $P_{R-1,C-1}$; $P_{R-1,C}$; $P_{R-1,C+1}$; $P_{R,C-1}$; $P_{R,C+1}$; $P_{R+1,C-1}$; $P_{R+1,C}$; and $P_{R+1,C+1}$. In a preferred embodiment, these proximal pixels are further limited to the pixels located immediately above ($P_{R-1,C}$), below ($P_{R+1,C}$), and in front ($P_{R,C+1}$) of non-compensated pixel $P_{R,C}$.

In one embodiment of the invention, the adjustment of non-compensated pixel level $P_{R,C}$ is made in accordance with Eq. 1. Here, n represents the number of proximal pixels that are used to adjust the non-compensated pixel level $P_{R,C}$ to establish a compensated pixel $P'_{R,C}$ level. For example, in the embodiment mentioned above where the proximal pixels used to compensate the non compensated pixel $P_{R,C}$ are limited to the pixels located immediately above ($P_{R-1,C}$), below ($P_{R+1,C}$), and in front ($P_{R,C+1}$) of non-compensated pixel $P_{R,C}$, n is three. Although each of the pixel levels used to establish compensated pixel level $P'_{R,C}$ in Eq. 1 is depicted as having unity gain, those skilled in the art

understand that the proximal pixel levels and the non-compensated pixel level $P_{R,C}$ could be multiplied by a scaling factor to increase or decrease the resulting amplification of the difference therebetween.

Eq. 1

$$P'_{R,C} = \left(P_{R,C}(2n + 1) - \sum_{n} proximal\_pixel\_levels \right) \div (n + 1)$$

The number of proximal pixels n, which are available to adjust a given non-compensated pixel $P_{R,C}$ will depend, at least in part, on the location of the pixel $P_{R,C}$ within the pixel array 30. This is due to the fact that the pixels on the periphery of the pixel array 30, will not have as many proximal pixels as those located further away from the peripheral edge of the pixel array 30. As a result, the pixels $P_{R,C}$ positioned at the peripheral edge of pixel array 30 may use a different number of pixels n than are used by the pixels $P_{R,C}$ which are located away from the peripheral edge. Alternatively, the pixels located at the periphery of pixel array 30 could remain uncompensated.

In another aspect of the present invention, a value for a particular pixel $P_{R,C}$ is adjusted to compensate for residual or latent heat in the heating elements as set forth in U.S. Patent No. 5,793,403. These two compensation techniques can be used in conjunction to provide for optimized printing of the pixels resulting in further improvements to image sharpness and accuracy.

Referring again to FIG. 4, the general method continues by controlling thermal printhead 18 (FIG. 1) to print the compensated pixel onto a card 20, as indicated at step 34. The printing of the pixels is controlled by instructions from microcomputer 12 using methods which are understood by those skilled in the art. In order to simplify the discussion of the present invention, the printing of pixels will be discussed with regard to a single resistive heating element 22 (FIG. 2) of thermal printhead 18. Thus, when a compensated pixel is printed, it should be understood that each of the resistive heating elements 22 of thermal printhead 18 will likely be printing their respective compensated pixel thereby printing a column of compensated pixels, corresponding to the number of heating elements 22 of printhead 18, at a time.

Alternative embodiments of the invention relate to printing an entire compensated pixel array onto the card substrate 22. These embodiments include: printing a single pixel at a time once compensated; printing a row of the pixels once compensated; printing a line of the pixels once compensated; and printing the entire pixel array once all of the pixels have been compensated. These embodiments will be discussed with reference to the flowchart of FIG. 5. At step 40, a starting pixel of the non-compensated pixel array 30 (FIG. 3) is selected. The starting pixel could be, for example, the pixel $P_{R,C}$ located at row one (R=1) and column one (C=1), but other starting positions are

possible. At step 42, the non-compensated pixel $P_{R,C}$ is compensated based on one or more proximal pixels to form a compensated pixel in the manner discussed with regard to step 32 of the flowchart of FIG. 4. In one embodiment of the invention, the compensated pixel can be printed prior to compensating another pixel, as indicated at optional step 44. Next, at step 46, it is determined whether all of the pixels in the row R have been compensated. If they haven't, then the column C of the pixel array is incremented by one at step 48 to select the next pixel in the row R, and the method returns to step 42. If all of the pixels in the row R have been compensated, the column C of the pixel array 30 is reset to one, at step 50.

In another embodiment of the invention, the row of pixels that have just been compensated are printed, as indicated at optional step 52. Step 52 can replace step 44.

Next, it is determined at step 54 whether all of the rows R of the pixel array have been compensated. If they haven't, the method moves to step 56 where the row R is incremented by one to move to the next row. Here, row R is incremented such that the resistive heating elements are positioned inline with their respective row R of the next line to be printed. Accordingly, row R is incremented by the number of resistive heating elements 22 of printhead 18 or by the number of rows of the pixel array 30 that are formed when a single line is printed by printhead 18. Once row

R has been incremented, the method returns to step 42 to perform further pixel level compensation. If all of the rows R of the pixel array have been compensated and the printing of the compensated pixels is complete, because either step 44 or step 52 were completed, the method ends. However, if neither of the printing steps 44 or 52 were used, the entire array of compensated pixels can be printed at optional step 58, typically one line of the pixel array at a time.

In summary, the present invention is directed to a method of improving thermal printhead performance of a identification card printing system. In general, a pixel level of a non-compensated pixel is compensated based upon the pixel levels of adjacent pixels to increase contrast therebetween. The present invention is further directed to an identification card printing system which utilizes the above-described method to improve contrast in images printed with a thermal printhead. Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. A method of improving thermal printhead performance of an identification card printing system, the method comprising:

adjusting a pixel level of a non-compensated pixel of an identification image file based upon a pixel level of one of a proximal pixel and a plurality of proximal pixels, located proximate the non-compensated pixel, to form a compensated pixel; and

controlling the thermal printhead to print the compensated pixel.

2. The method of claim 1, wherein the step of adjusting the non-compensated pixel is made in accordance with the relationship:

$$P'_{R,C} = \left(P_{R,C}(2n + 1) - \sum_{n} proximal\_pixel\_levels \right) \div (n + 1)$$

wherein $P'_{R,C}$ represents a compensated pixel level for the compensated pixel, $P_{R,C}$ denotes the pixel level of the non-compensated pixel, and n represents the number of proximal pixel levels that are used to compensate the non-compensated pixel.

3. The method of claim 1, wherein the proximal pixel corresponds to a pixel that is adjacent to the non-compensated pixel.

4. The method of claim 3, wherein the proximal pixel is selected from a group consisting of a preceding pixel, a succeeding pixel, a pixel positioned above the non-compensated pixel, and a pixel positioned below the non-compensated pixel.

5. The method of claim 1, wherein the plurality of proximal pixels correspond to pixels that are adjacent to the non-compensated pixel.

6. The method of claim 5, wherein the plurality of proximal pixels are selected from a group consisting of a preceding pixel in a row of the non-compensated pixel, a succeeding pixel in the row of the non-compensated pixel, a pixel positioned above the non-compensated pixel, and a pixel positioned below the non-compensated pixel.

7. The method of claim 6, wherein the step of adjusting the pixel level of the non-compensated pixel follows the relationship:

$$P'_{R,C} = (P_{R,C} \times 7 - (P_{R,C-1} + P_{R,C+1} + P_{R-1,C})) \div 4$$

wherein $P'_{R,C}$ represents a compensated pixel level for the compensated pixel, $P_{R,C}$ denotes the pixel level of the non-compensated pixel, $P_{R,C-1}$ denotes the pixel level of the preceding pixel, $P_{R,C+1}$ denotes the pixel level of the succeeding pixel, and $P_{R-1,C}$ denotes the pixel level of the pixel positioned above the non-

compensated pixel.

8. In an identification card printing system, a method of printing an image file having improved contrast, comprising:

adjusting at least one non-compensated pixel level of a pixel of the image file based upon one of a proximal pixel and a plurality of proximal pixels, located proximate the non-compensated pixel, to form a compensated image file; and

controlling a thermal printhead of the printing system to print the compensated identification image file.

9. The method of claim 8, wherein the step of adjusting the non-compensated pixel is made in accordance with the relationship:

$$P'_{R,C} = \left(P_{R,C}(2n + 1) - \sum_{n} proximal\_pixel\_levels \right) \div (n + 1)$$

wherein $P'_{R,C}$ represents a compensated pixel level for the compensated pixel, $P_{R,C}$ denotes the pixel level of the non-compensated pixel, and n represents the number of proximal pixel levels that are used to compensate the non-compensated pixel.

10. The method of claim 8, wherein the proximal pixel corresponds to a pixel that is adjacent to the

non-compensated pixel.

11. The method of claim 10, wherein the proximal pixel is selected from a group consisting of a preceding pixel, a succeeding pixel, a pixel positioned above the non-compensated pixel, and a pixel positioned below the non-compensated pixel.

12. The method of claim 8, wherein the plurality of proximal pixels correspond to pixels that are adjacent to the non-compensated pixel.

13. The method of claim 11, wherein the plurality of proximal pixels are selected from a group consisting of a preceding pixel, a succeeding pixel, a pixel positioned above the non-compensated pixel, and a pixel positioned below the non-compensated pixel.

14. The method of claim 13, wherein the step of adjusting the pixel level of the non-compensated pixel follows the relationship:

$$P'_{R,C} = (P_{R,C} \times 7 - (P_{R,C-1} + P_{R,C+1} + P_{R-1,C})) \div 4$$

wherein $P'_{R,C}$ represents a compensated pixel level for the compensated pixel, $P_{R,C}$ denotes the pixel level of the non-compensated pixel, $P_{R,C-1}$ denotes the pixel level of the preceding pixel, $P_{R,C+1}$ denotes the pixel level of the succeeding pixel, and $P_{R-1,C}$ denotes the pixel level of the pixel positioned above the non-

compensated pixel.

15. An identification card printing system comprising:

a substrate feeder mechanism adapted to transport a substrate along a printing path;

a thermal printhead in line with the printing path and having a plurality of resistive heaters arranged in a line on a substrate;

a microcomputer;

a memory; and

a printer driver stored in the memory and including instructions executable by the microcomputer to perform the steps of:

adjusting a pixel level of a non-compensated pixel of an image file based upon one of a proximal pixel and a plurality of proximal pixels, located proximate the non-compensated pixel, to form a compensated pixel; and

controlling the thermal printhead to print the compensated pixel.

16. The identification card printing system of claim 15, wherein the step of adjusting a pixel is made in accordance with the relationship:

$$P'_{R,C} = \left(P_{R,C}(2n + 1) - \sum_{n} proximal\_pixel\_levels \right) \div (n + 1)$$

wherein $P'_{R,C}$ represents a compensated pixel level for the compensated pixel, $P_{R,C}$ denotes the pixel level of the non-compensated pixel, and n represents the number of proximal pixel levels that are used to compensate the non-compensated pixel.

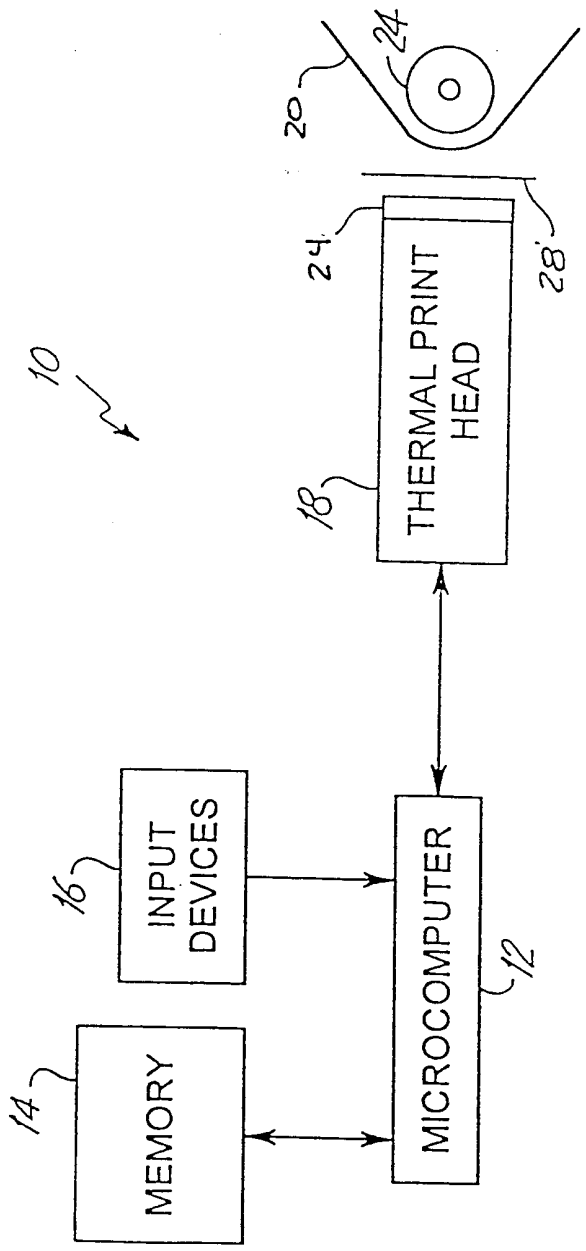
17. The identification card printing system of claim 15, wherein the proximal pixel corresponds to a pixel that is adjacent to the non-compensated pixel.

18. The identification card printing system of claim 17, wherein the proximal pixel is selected from a group consisting of a previous pixel in a print line, a succeeding pixel in the print line, a pixel positioned above the non-compensated pixel, and a pixel positioned below the non-compensated pixel.

19. The identification card printing system of claim 15, wherein the plurality of proximal pixels correspond to pixels that are adjacent to the non-compensated pixel.

20. The identification card printing system of claim 19, wherein the plurality of proximal pixels are selected from a group consisting of a preceding pixel in a print line, a succeeding pixel in the print

line, a pixel positioned above the non-compensated pixel, and a pixel positioned below the non-compensated pixel.


10
20
24
24
28
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THERMAL PRINT HEAD
16
INPUT DEVICES
14
MEMORY
MICROCOMPUTER
12

Fig. 1

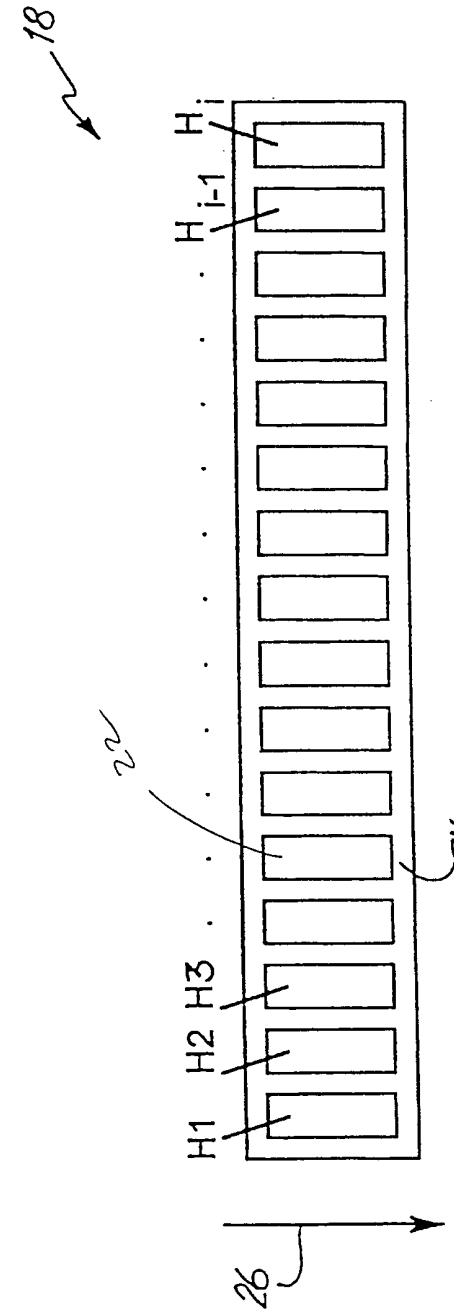
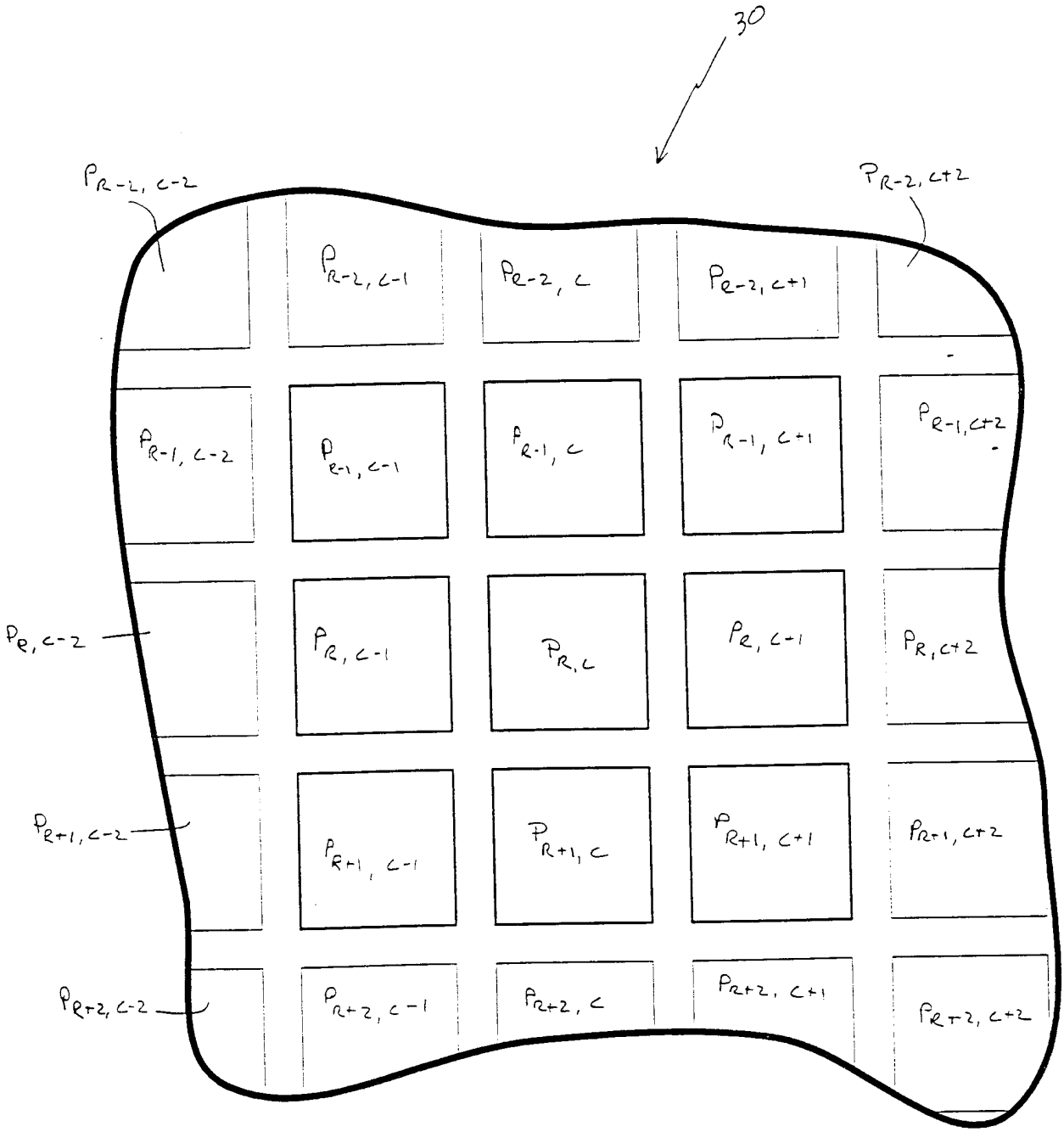


Fig. 2


30
$P_{R-2,C-2}$
$P_{R-2,C-1}$
$P_{R-2,C}$
$P_{R-2,C+1}$
$P_{R-2,C+2}$
$P_{R-1,C-2}$
$P_{R-1,C-1}$
$P_{R-1,C}$
$P_{R-1,C+1}$
$P_{R-1,C+2}$
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$P_{R+1,C}$
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$P_{R+2,C-2}$
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$P_{R+2,C+1}$
$P_{R+2,C+2}$

FIG. 3

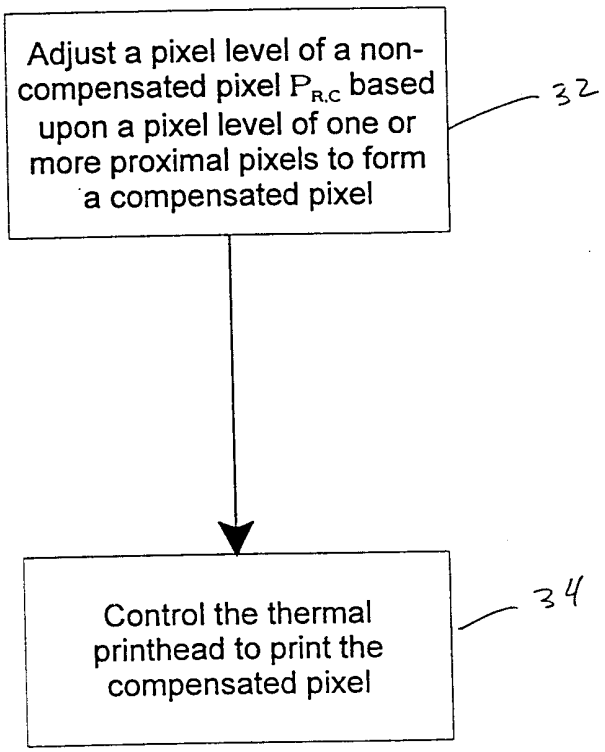
Adjust a pixel level of a non-compensated pixel $P_{R,C}$ based upon a pixel level of one or more proximal pixels to form a compensated pixel
32
Control the thermal printhead to print the compensated pixel
34

FIG. 4

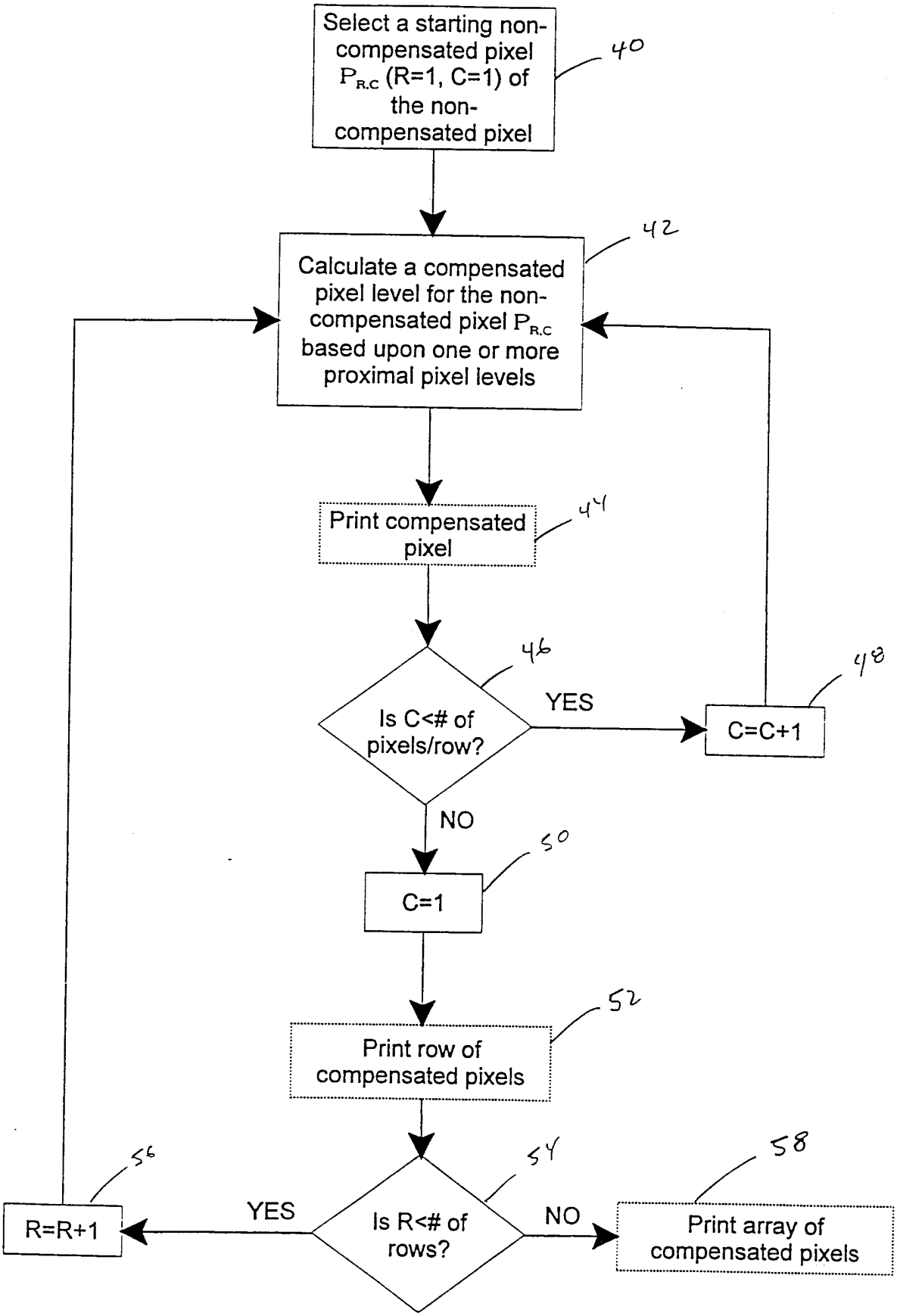
Select a starting non-compensated pixel $P_{R,C}$ (R=1, C=1) of the non-compensated pixel
40
Calculate a compensated pixel level for the non-compensated pixel $P_{R,C}$ based upon one or more proximal pixel levels
42
Print compensated pixel
44
Is C<# of pixels/row?
46
YES
C=C+1
48
NO
C=1
50
Print row of compensated pixels
52
Is R<# of rows?
54
YES
R=R+1
56
NO
Print array of compensated pixels
58

FIG. 5

INTERNATIONAL SEARCH REPORT

Intern nal Application No
PCT/US 00/29966

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B41J2/365

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B41J H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 793 403 A (KLINEFELTER GARY M) 11 August 1998 (1998-08-11) cited in the application the whole document	1,3-6,8, 10-13, 15,17-20
Y	US 5 956 067 A (CHIBA SHIN ICHIRO ET AL) 21 September 1999 (1999-09-21) the whole document	1,3-6,8, 10-13, 15,17-20
A	US 4 567 488 A (HISATAKE MASAYUKI ET AL) 28 January 1986 (1986-01-28) the whole document	1,3-6,8, 10-13, 15,17-20

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 February 2001	15/02/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Didenot, B

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/US 00/29966

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