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Ink jet recording method and apparatus
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Procédé et appareil d'enregistrement à jet d'encre

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Institute of Electrical and Electronics Engineers;
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optimum method for two-level rendition of
continuous-tone pictures"

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an ink jet recording apparatus including record means having a plurality of discharge ports (or discharge orifices) arranged therein for discharging ink to a recording medium to record information.

Related Background Art

Office automation equipments such as computers, word processors and copiers have recently been widely used and a number of recording methods of recording apparatus therefor have been developed. An ink jet recording apparatus is characterized by that it is more easy to attain fine recording than other recording method, of higher speed and more silent, and is less expensive. A need for color is also increasing and many color ink jet recording apparatus have been developed. The ink jet recording apparatus discharges ink from a nozzle to deposit the ink to a record sheet to form an image. In order to enhance the recording speed, a recording head (multi-head) having a plurality of recording elements integrated therein is used so that a plurality of ink discharge ports and ink paths are integrated. For color printing, a plurality of such multi-heads are arranged.

However, unlike a monochromatic printer for printing only characters, various factors such as hue (coloring or color development), tonality and uniformity must be considered in printing a color image. As to the uniformity, even a slight variation among nozzle units due to a difference among multi-head manufacturing processes affects the amount of ink discharged from the nozzle and the direction of discharge in printing and it finally appears as uniformity of density in the printed image, which causes to degrade an image quality.

A specific example is explained with reference to Figs. 25 and 26. In Fig. 25A, numeral 91 denotes a multi-head which is assumed to comprise eight multi-nozzles. Numeral 93 denotes an ink droplet discharged from the multi-nozzle 92. Ideally, the ink is discharged with a uniform amount of discharge in a uniform direction as shown in Fig. 25A. If such discharge is attained, dots of uniform size reach a record sheet as shown in Fig. 25B so that a uniform image free of ununiformity in density is formed overall (Fig. 25C). However, in actual, there is a variation among nozzles as described above, and if the printing is done in the manner described above, there occurs variation in the size and direction of the ink droplets discharged from the nozzles, and the droplets reach the record sheet in a manner shown in Fig. 26B. As seen from Fig. 26B, a white area which does not meet an area factor of 100 % appears periodically relative to a head main scan direction, or dots overlap more than required, or a white band appears as shown at a center of the drawing. An aggregation of the dots reached on the record sheet has a distribution of density in the direction of nozzle arrangement as shown in Fig. 26C, and it appears as ununiformity of density when it is observed by human eyes.

The following method has been proposed as a countermeasure for the ununiformity of density. It is explained with reference to Figs. 27 and 28. In this method, the multi-head 91 is scanned three times to complete the print area shown in Figs. 25 and 26 but half of the print area (four-pixel unit area) is completed in two passes. The eight nozzles of the multi-head are divided into an upper four-nozzle group and a lower four-nozzle group, and the number of dots to be printed by one nozzle in one scan is reduced to approximately one half of the dots of the given image data in accordance with a predetermined image data arrangement. In the second scan, dots are printed in accordance with the remaining half of the image data to complete the printing of the four-pixel unit area. The above recording method is hereinafter referred to as a divisional recording method.

In accordance with this recording method, the effect of the nozzle inerency to the printed image is reduced to one half even if the same multi-head as that shown in Fig. 26 is used, and the printed image appears as shown in Fig. 27B in which the black stripes and the white stripes shown in Fig. 26B are not very prominent. As a result, the ununiformity of density is also significantly reduced compared to that of Fig. 26, as shown in Fig. 27C.

In such recording method, the image data is divided for the first scan and the second scan in accordance with a predetermined arrangement so that they complement each other. The image data arrangement (thinned pattern) is usually a checker pattern (or zigzag pattern) for each vertical and horizontal pixel as shown in Fig. 28. Accordingly, the printing in the unit print area (four-pixel unit in the present example) is completed by the first scan in which the checker pattern is printed and the second scan in which the reverse checker pattern (or complementary zigzag pattern) is printed. Figs. 28A, 28B and 28C show how the recording of a given area is completed by the checker pattern and the reverse checker pattern, when the eight-nozzle multi-head is used as it is in Figs. 25 to 27. In the first scan, the checker pattern is recorded by using the lower four nozzles (Fig. 28A). In the second scan, the sheet is fed by four pixels (1/2 of the head length) and the reverse checker pattern is recorded (Fig. 28B). In the third scan, the sheet is further fed by four pixels (1/2 of the head length) and the checker pattern is recorded again (Fig. 28C).

In this manner, the sheet feed of the four-pixel length and the recording of the checker pattern and the reverse checker pattern are sequentially and alternately conducted so that the printing of the four-pixel unit record area is completed for each scan. As described above, since the printing in one area is completed by
two different groups of nozzles, a high quality image which is free from the ununiformity of density is attained.


Although the above method can reduce the ununiformity of density due to the reach precision (for example, landing deviation) and the amount of discharge, it still has a problem in that regular ununiformity of color appears when a half-tone color is printed in an entire area, due to the fact that inks of different colors are overlapped and put adjacentely.

Fig. 29 shows a printing method (hereinafter referred to as an L/n sheet feed printing method, where n is the number of divisions) by the prior art head division.

In this method, the recording section (L) of the recording head is divided into two sections, and each recording head records the checker pattern or the reverse checker pattern in the first scan, and after the sheet feed by the L/2 width, it records the remaining reverse (or complementary) checker pattern or checker pattern by the different nozzles in the second scan to complete the printing. The discharge port line is not visible in the drawing but it is shown as a vertical perspective view for convenience sake.

More specifically, in the first scan, the thinned half printing of the checker pattern is conducted by the nozzles in the recording section (1) of the printing heads. Then, the sheet is fed by L/2 width. In the second scan, the thinned half printing of the reverse checker pattern is conducted by the recording heads in each of the recording sections (1) and (2). At this point, the printing by the recording section (2) is completed. The sheet is further fed by L/2 width. In the third scan, the thinner printing of the checker pattern is made for the entire area of the record area. The same steps are repeated. In Fig. 29, the indices in the parentheses in the second and third scan indicate the previously printed ones.

A reason why the ununiformity of half-tone color takes place in the prior art method is explained below for an eight-nozzle multi-nozzle head. In this example, an image to be recorded is blanket print (or solid print) of a half tone color (yellowish green) having Cy 62.5 % and Y 100 % in print duty factor superimposed. The half-tone color is divided into two parts by using a checker pattern mask and a reverse checker pattern mask, and they are overprinted in two scans.

Fig. 30 shows discharge positions of a Cy recording head and a Y recording head in the first scan in the L/2 sheet feed printing method and the resulting dot formation on a recording medium. A thick hatching mark shows that Cy and Y are recorded on the same pixel. Cy dots recorded by the recording section (1) reach the sheet without any adjacent dots. In the first scan, the recording head uses four nozzles of the recording section (1) to discharge the ink in the checker pattern so that the Cy-Y overlapped dots are formed in the checker pattern on the recording medium. Then, a L/2 width sheet feed is effected and the image area on the sheet recorded in the first scan is moved toward the recording section (2).

Fig. 31 shows the discharge positions in the second scan and the resultant dot formation on the recording medium. A dark mesh pattern in the recording section (2) shows that Cy and Y are recorded on the same pixel between the adjacent pixels in which Cy and Y or Y were printed in the first scan in the recording section (1), and a light hatching pattern shows a pixel in which only Y is printed. A dark hatching pattern in the recording section (1) is same as that in the first scan, and a light hatching pattern shows a pixel in which only Y is printed. At this time, the printing head prints the reverse checker pattern in the entire area of the recording sections (1) and (2). As a result, dots are overprinted in the recording section (2) to interpolate image data to the checker pattern dots recorded in the first scan in the first image area.

Then, a L/2 sheet feed is effected so that the first image area is moved out of the recording section and the second image area having the reverse checker pattern printed in the recording section (1) is moved toward the recording section (2) and the third image area comes into the recording section (1), Fig. 32.

The hue (coloring or color development) which is important in the color printing is now explained. When a dot is overlapped on a previously recorded dot, there is a trend that the later printed dot sinks more deeply in the depthwise direction of the sheet than the early print ed dot and it spreads around the early printed dot. The same is true when a dot reaches on an adjacent dot. Fig. 33 shows a sectional view for illustrating the spread of the ink when a new dot is printed on an early reached dot. Pigments such as dyes in the discharged ink physically and chemically couple with the recording medium but since the coupling of the recording medium and the pigments is definite, the coupling of the early discharged ink pigments and the recording medium is preferential unless there is a big difference in the coupling force depending on the type of pigment so that the early discharged ink pigments remain on the surface of the recording medium more than the later printed ink pigments, which are hard to couple on the surface of the recording medium and sink in the depthwise direction of the sheet.

In Fig. 31, the Cy-Y mixed pixel which is heavily related to the density is shown by a dark hatching pattern as recorded in the first scan, and by a dark mesh pattern as recorded in the second scan.

Fig. 32 shows the discharge positions in the third scan and the resulting dot formation on the record medium.

At this time, the checker pattern which is complementary to that in the second scan is printed in the entire area of the recording sections (1) and (2). As a result, dots reach in the recording section (1) adjacentely to the reverse checker dots recorded in the second scan to complete the printing.
Similarly, other image areas are sequentially printed by the two-pass scan by the recording head in the recording sections (1) and (2).

However, between the second image area in which the printing is completed in the third scan and the first image area in which the printing is completed in the second scan, the hues may be different in spite of the fact that the same amount of ink is injected, and the ununiformity of color may take place.

This is because a difference in the shapes of the dots having connection with the hue of the new dots which are injected onto the image area having adjacent dots previously recorded thereon and the dots injected to the image area having nothing recorded thereon appears as a difference of hue between the image areas since the numbers of dots injected to the respective image areas in each scan are different. In the present example, since the numbers of Cy dots injected to the respective image areas in the respective recording scans are different, the numbers of Cy dots which are injected to the areas having the Cy or Y dots formed adjacent thereto to form definite shape dots are different between the two image areas, and hence a difference in hue appears. In the present example, the numbers of the Cy-Y mixed pixels in the respective image areas differ significantly between the first image area (hatching: 16, mesh: 4) and the second image area (hatching: 4, mesh: 16).

As explained above, in the prior art L/n sheet feed printing method, when the printing is made by a plurality of recording scans in the same image area, the ununiformity of color occurs in the mixed color recorded area because of the difference in the number of dots injected in each recording scan, and this causes the degradation in the color recorded image.

Further, in the prior art L/n sheet feed printing method, substantially a double number of recording scans is needed to solve the problem of the ununiformity of density due to the variation in the nozzles, and this causes the reduction of the recording speed. Thus, reciprocal scan recording may be considered to improve the recording speed but there exists a problem of difference in hue due to a difference in the sequence of injection of the ink between the forth run and the back run, which is a problem inherent to the color ink jet recording. The reciprocal scan recording has been put into practical use in a monochromatic ink jet recording apparatus, but in the color recording, the difference in the hue between the image areas appears because the sequence of injection of the inks in the color mixed areas is different between the forth scan and the back scan. Accordingly, there are few cases where such color printing has been put into practical use. This is due to the fact that the later injected ink spreads around and depthwise of the early injected dot as described above. Japanese Laid-Open Patent Publication JP-A-58-194541 discloses a recording method for relieving the difference in hue in the reciprocal recording. In this method, a smaller number of
dots than a total number of dots to be recorded in at least one of each row and each column of a recording dot matrix are intermittently recorded for each color in a forth pass of the reciprocal recording scan, and the remaining dots for each color are intermittently recorded in the back pass so that the dots having different sequences of ink overlap are mixed together.

This method is effective to a blanket print image in which dots of respective colors are finely recorded in a given area, but in the half-tone image data which requires the area gradation recording, the image to be recorded is inherently thinned by a predetermined gradation pattern because of the gradation representation of the image to be recorded. As a result, the gradation pattern and the thinned pattern of each reciprocal recording scan may interfere with each other to create the ununiformity of color as described above. Further, the ununiformity of density due to the variance in the nozzles is not resolved in spite of the reciprocal two-run recording scan to the given image area. Accordingly, this method cannot be simply applied and it has not been put into practical use.

It is a concern of the present invention to provide an improved ink jet recording method and apparatus.


In accordance with a first aspect of the present invention there is provided an ink jet recording method as set out in claim 1.

In accordance with a second aspect of the present invention there is provided ink jet recording apparatus as set out in claim 6.

An embodiment of the present invention provides an ink jet recording method and apparatus which prevent non-uniformity of density, non-uniformity of color and the occurrence of connecting lines so as to enable to record a high quality color image recording.

In order that the present invention may be more readily understood embodiments thereof will now be described by way of example and with reference to the accompanying drawings, in which:

Fig. 1 shows a recording method in a first embodiment of the present invention.

Fig. 2 shows discharge positions in a first scan in the first embodiment, and dot formation, thereby.

Fig. 3 shows discharge positions in a second scan in the first embodiment and dot formation thereby.

Fig. 4 shows discharge positions in a third scan in the first embodiment and dot formation thereby.

Fig. 5 shows a specific example of image data.

Fig. 6 illustrates a thinning method in the first em-
bodiment,

Fig. 7 illustrates another thinning method,

Fig. 8 shows discharge positions in the first scan when the thinned pattern shown in Fig. 7 is recorded and dot formation thereby,

Fig. 9 shows discharge positions in the second scan when the thinned pattern shown in Fig. 7 is recorded and dot formation thereby,

Fig. 10 shows discharge positions in the third scan when the thinned pattern shown in Fig. 7 is recorded and dot formation thereby,

Fig. 11 illustrates a thinning method in a second embodiment,

Fig. 12 shows dot formation in the first scan in the second embodiment,

Fig. 13 shows dot formation in the second scan in the second embodiment,

Fig. 14 shows dot formation in the third scan in the second embodiment,

Fig. 15 shows dot formation in a fourth scan in the second embodiment,

Fig. 16 shows dot formation in a fifth scan in the second embodiment,

Fig. 17 shows dot formation in a sixth scan in the second embodiment,

Fig. 18 shows an area gradation pattern 1 and a thinned pattern 1 in an illustrative example which does not fall within the scope of the claimed invention,

Fig. 19 shows the area gradation pattern 1 and a thinned pattern 2 in the illustrative example,

Fig. 20 shows an area gradation pattern 2 and the thinned pattern 1 in the illustrative example,

Fig. 21 shows the area gradation pattern 2 and the thinned pattern 2 in the illustrative example,

Fig. 22 shows a block diagram of an image data flow of an ink jet recording apparatus in the illustrative example,

Figs. 23A and 23B show an ink jet recording apparatus of the present invention,

Fig. 24 shows a block diagram of a control unit of the ink jet recording apparatus,

Figs. 25A to 25C show an ideal print condition of the ink jet printer,

Figs. 26A to 26C show a print condition of the ink jet printer with non-uniformity of density,

Figs. 27A to 27C illustrate the reduction of the non-uniformity of density by a prior art L/n sheet feed printing method,

Figs. 28A to 28C illustrate the reduction of the non-uniformity of density by the L/n sheet feed printing method,

Fig. 29 shows a prior art L/n sheet feed recording method,

Fig. 30 shows discharge positions in the first scan in the prior art L/n sheet feed method and dot formation thereby,

Fig. 31 shows discharge positions in the second scan in the prior art L/n sheet feed method and dot formation thereby,

Fig. 32 shows discharge positions in the third scan in the prior art L/n sheet feed method and dot formation thereby, and

Fig. 33 shows a sectional view of a recording medium for illustrating dot overlap.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is now described by citing the preferred embodiments. Those embodiments are intended to explain the present invention in further detail and not intended to limit the present invention to those embodiments.

Fig. 23A shows a perspective view of a configuration of an ink jet recording apparatus to which the present invention is applied. In the drawing, numeral 701 denotes an ink cartridge which comprises an ink tank filled with one of four color inks, black (BK), cyan (Cy), magenta (M) and yellow (Y), and a multi-head 702 for those colors. Multi-nozzles arranged on the multi-heads, an viewed along a Z-axis is shown in Fig. 23B, in which numeral 801 denotes the multi-nozzles arranged on the multi-head 702. Turning back to Fig. 23A, numeral 703 denotes a sheet feed roller which is rotated in a direction of an arrow while it pinches a print sheet P together with an auxiliary roller 704 to feed the print sheet P in a Y-direction. Numeral 705 denotes a sheet supply roller which supplies the print sheet and also
functions to press the print sheet P as the rollers 703 and 704 do. Numeral 706 denotes a carriage which supports the four ink cartridges and drives them as the printing proceeds. It is retracted to a home position h shown by broken lines when the printing is not effected or during a recovery operation of the multi-head. In the present embodiment, a recording head of each of the ink jet cartridges discharges ink droplets when a status change in the ink is caused by thermal energy.

The four ink jet cartridges mounted on the carriages 706 are arranged such that inks are overprinted in a sequence of black ink, cyan ink, magenta ink and yellow ink. A half-tone color is attained by appropriately overprinting Cy, M and Y color ink dots. Namely, red is attained by overprinting M and Y, blue by Cy and M, and green by Cy and Y.

Usually, black is attained by overprinting three colors, Cy, M and Y, but if the hue (or coloring) for black is bad, precise overprinting is hard to attain and colored edges appear and an ink injection density per unit time is too high. Accordingly, black is separately injected.

Fig. 24 shows a block diagram of a control unit of the ink jet recording apparatus shown in Fig. 23A. Numeral 201 denotes the control unit which comprises a CPU, a ROM and a RAM and controls the units of the apparatus in accordance with a program stored in the ROM. Numeral 202 denotes a printer for driving a carriage motor 205 to drive the carriage 706 in an X-direction (main scan) in accordance with a signal from the control unit 201, numeral 203 denotes a printer for driving a carriage motor 206 to drive the sheet supply motor 705 and the sheet feed roller 703 to feed the recording sheet in a Y-direction (sub-scan) in accordance with a signal from the control unit 201, numeral 204 denotes a printer for driving color multi-heads 207 - 210 in accordance with print data from the control unit 201, and numeral 211 denotes a host apparatus for supplying the print data to the control unit 201.

When a start of print command is issued, the carriage 706, which was at the position shown in the drawing (home position) prior to the start of printing, is driven (forth run) in the X-direction to print for each divided record area on the sheet by n multi-nozzles 801 on the multi-heads 702. When data is printed up to an end of the sheet, the carriage is reversely driven (back run) to print in the X-direction. After the end of the first printing and before the start of the second printing, the sheet feed roller 703 is rotated in the direction of arrow to feed the sheet in the Y-direction by a width of the divided record area. In this manner, the printing by the multi-heads and the sheet feed (sub-scan) are repeated for each scan (main scan) by the forth run or the back run of the carriage to complete the printing of data on one sheet.

Fig. 1 shows a recording method in the present embodiment. In the present invention, color recording is effected by reciprocal scan by the reciprocal movement of the carriage 706. Odd-numbered scan corresponds to the forth run scan, and even-numbered scan corresponds to the back run scan. In the forth run scan, the inks are injected in a sequence of Bk-Cy-M-Y, and in the back run scan, the inks are injected in a sequence of Y-M-Cy-Bk. A checker pattern (or zigzag pattern) thinned from original image data is first printed to a first image area by recording sections (1) (low half nozzles) of the recording heads in a first scan (forth run scan). A checker thinned dot image is formed in the first image area on the recording medium P in the sequence of Bk-Cy-M-Y. Then, the sheet is fed by L/2 width by the rollers 703 - 705. In a second scan (back scan), the recording heads thin the image data in a reverse checker pattern (or complementary zigzag pattern) to interpolate the checker pattern of the first scan and print to the first image area by recording sections (2) (upper half nozzles) of the recording heads and a second image area by the recording sections (1) (lower half nozzles) of the recording heads. At this time point, in the first image area, the thinned reverse checker image data is printed in the sequence of Y-M-Cy-Bk to those record pixels which were not printed in the first scan so that the recording of the image data is completed. The dots recorded in the first image area were printed in the checker record pixels in the sequence of Bk-Cy-M-Y, and in the reverse checker record pixels in the sequence of Y-M-Cy-Bk.

The sheet is then further fed by L/2 width by the rollers 703 - 705, and in a third scan (forth run scan), the image data is thinned to the same checker pattern as that of the first scan, and the second image area is printed by the upper half nozzles and a third image area is printed by the lower half nozzles. The printing to the second image area is completed in the third scan. The dots recorded in the second image area were printed in the reverse checker record pixels in the sequence of Y-M-Cy-Bk and in the checker record pixels in the sequence of Bk-Cy-M-Y. The above steps are repeated to sequentially record on the image areas on the recording medium P divided by the half width (L/2) of the recording head so that the recording of the entire image data is completed. Indices in parentheses the second and third scans in Fig. 1 indicate previously printed ones.

In the present embodiment, in order to unify the number of injected dots in each recording scan, an ink jet recording head having a double recording density compared to an image data recording density is used and each pixel of the image data is divided into four recording pixels which are recorded by the same data. By using the recording head having the double recording density, the number of injected dots for each recording scan in each recording section can be unified for any image data to be recorded even when the interpolation is made by the simple checker and reverse checker thinned patterns.

In the color ink jet recording apparatus of the present invention, a difference of hue does not occur although the image is recorded by the reciprocal scan. This is explained below.
In the present embodiment, the 180 dpi image data is printed at the 360 dpi recording density. Accordingly, as described above, whenever pixel arrangement of the image data is, the numbers of injected dots in the first image area are equal in the first scan (forth run scan) and the second scan (back run scan). Accordingly, the hue in the first image area is an average of the hue of the dots printed on the checker recording pixels in the sequence of Bk-Cy-M-Y in the forth run scan and the hue of the dots printed on the reverse checker recording pixels in the sequence of Y-M-Cy-Bk in the back run scan.

Similarly, the hue in the second image area is an average of the hue of the dots printed on the reverse checker recording pixels in the sequence of Y-M-Cy-Bk in the back run scan and the hue of the dots printed on the checker recording pixels in the sequence of Bk-Cy-M-Y in the forth run scan. Consequently, the hues of the first image area and the second image area are equal although the sequences of the thinned patterns are opposite.

An effect of the present embodiment is now specifically explained. To simplify the explanation, it is assumed that a 360 dpi 16-nozzle multi-nozzle head is used to record 180 dpi image data. It is also assumed that a half-tone color (yellowish green) having Cy 62.5 % and Y 100 % in print duty overprinted is printed as it is in the explanation of the prior art. Since the recording density of the recording head is double that of the image data, the recording pixels of the same data always comprise adjacent 2 x 2 = 4 pixels, as shown in Fig. 5. Fig. 6 shows a thinned pattern of an image having the recording density of 360 dpi in the present embodiment.

Fig. 2 shows recording pixels recorded by the Cy recording head and the Y recording head in the first scan in the L/2 sheet feed printing method of the present embodiment and resulting dot formation on the recording medium. A dark hatching pattern shows the recording by Cy and Y on the same recording pixel, and a light hatching pattern shows the recording by only Y. In the first scan, each recording head uses the eight nozzles of the recording section (1) to discharge the ink to the checker recording pixels of the first image area in the sequence of Bk-Cy-M-Y. As a result, in the recording pixel on the recording medium at which the Cy and Y image data are overlapped, the Y ink spreads around and beneath the Cy dots. Namely, the Cy dot recorded in the first scan in the first image area reaches the recording medium while no ink is present even at adjacent pixels. Thus, a relatively sharp image (Cy dot shape 1) appears. Then, the sheet is fed by L/2 width so that the first image area recorded in the first scan is moved toward the recording section (2).

Fig. 3 shows recording pixels recorded in the second scan and the resulting dot formation on the recording medium. In the second scan (back run scan), inks are discharged to the reverse checker recording pixels by the eight nozzles of the recording section (2) for the first image area, and by the eight nozzles of the recording section (1) for the second image area, in the sequence of Y-M-Cy-Bk. The Cy dot recorded in the first image area in the second scan is recorded immediately after the Y dot in the second scan has reached in the reverse checker pattern on a gap adjacent to the Y dots printed in the checker pattern in the first scan. Accordingly, it is slightly larger and relatively obscure (Cy dot shape 4). The Cy dot recorded in the second image area in the second scan is recorded immediately after the Y ink has reached. Accordingly, it is less sharp than the Cy dot shape 1 but less obscure than the Cy dot shape 4 (Cy dot shape 2). Then, the sheet is fed by L/2 width so that the second image area is moved toward the recording section (2) and the third image area is moved toward the third image area.

Fig. 4 shows recording pixels recorded in the third scan and resulting dot formation on the recording medium. In the third scan (forth run scan), inks are discharged to the checker recording pixels of the second image area by the four nozzles of the recording section (2), and of the third image area by the eight nozzles of the recording section (1), in the sequence of Bk-Cy-M-Y. The Cy dot recorded in the second image area in the third scan is recorded to a gap adjacent to the Y dots of the reverse checker pattern printed in the second scan. Accordingly, it is as sharp as the Cy dot shape 2 or slightly more obscure than the Cy dot shape 2 (Cy dot shape 3). The Cy dot recorded in the third image area in the third scan is injected to the recording medium while no ink is present even in adjacent pixels like the first image area in the first scan. Accordingly, it is relatively sharp (Cy dot shape 1).

Then, the sheet is further fed by L/2 width, and the image areas are sequentially recorded by the two-run (forth run and back run) recording head scan.

As described above, four different shapes of Cy dots are distributed in the respective image areas in the present embodiment. In the present embodiment, the numbers of Cy dots are equal in all image areas because uniform yellowish green image data is printed and they are equal in all recording scans because the checker pattern and the reverse checker pattern are printed by the recording head having the double recording density to that of the image data. The distribution of the Cy dot shapes in the respective image areas is now considered. In the odd-numbered image area, there are 40 Cy dot shapes 1 and 40 Cy dot shapes 4, and in the even-numbered image area, there are 40 Cy dot shapes 2 and 40 Cy dot shapes 3. As to the sharpness of the Cy dot shape, the Cy dot shape 1 is sharpest, and the larger the numeral is, the more obscure is the shape. Assuming that when viewed in macro the sharpness of the Cy dot shapes in each image area appears in average, the Cy dot shapes in all image areas appear equal when viewed in macro. Accordingly, in the present embodiment, it is seen that a difference between hues of
the image areas is small even if color recording which results in prominent ununiformity of color is done in the reciprocal scan.

In the present invention, the feature of the L/L sheet feed printing method, that is, the reduction of the ununiformity of density due to the reach precision such as landing deviation and the amount of discharge is maintained and inks of different colors are properly overprinted or adjacent printed so that high quality color image recording is attained by the reciprocal scan without the regular ununiformity of color which is otherwise easily produced for each scan when a half-tone color is blanket-printed. Thus, the recording speed and the image quality are improved.

In the present embodiment, the image data is thinned to the simple checker and reverse checker pattern, although the patterns are not limited to the checker patterns so long as the image data is thinned such that the numbers of dots in the recording scans are substantially equal. Namely, it is sufficient that the recording section (1) and the recording section (2) are complementary to each other and the numbers of dots when the image data is recorded in division are equal.

In the present invention, the thinned print factor in each recording section of the recording head is set to 50% so that the recorded image is completed in two scans. Where it is desired to increase the amount of ink injection to improve the print density, although fidelity to the image data is somewhat lost, the thinned print factor may be set to 75% so that the print factor reaches 150% in two scans. Conversely, where it is desired to reduce the ink injection amount to eliminate the spread at the boundary of the inks, the thinned print factor may be set to 40% so that the print factor reaches 80% in two scans.

Where the recording medium is an OHP sheet or a non-coated sheet which has a low ink acceptance, the ink injection amount is set lower by thinning the recording pixels without damaging the image data as shown in Figs. 7 to 10 while unifying the numbers of recording dots in the respective recording scans.

In the present embodiment, the recording head having the double recording density to that of the image data is used to make the numbers of recording dots in the forth and back runs equal. Alternatively, in one-direction printing, the image data may be printed without reducing the pixel density, and when the reciprocal printing is selected, the pixel density of the image data is changed to less than one half in at least one direction and the thinning method is selected such that the numbers of dots in the forth and back runs are equal. The change of the pixel density and the generation of the thinned image data may be effected by the ink jet recording apparatus or by a host apparatus such as a personal computer which sends the image data, in association with the ink jet printing apparatus.

In the description of the present embodiment, a general control method relating to the reciprocal record-
by two dots by the forth run scan and the back run scan. Accordingly, in the present embodiment, the hue is uniform when viewed in macro, and the ununiformity of color is not observed. Unlike the previous embodiment, since each pixel of the original image data is recorded by the four different nozzles, the uniformity of density due to the nozzles and the connecting line due to the sheet feed are not prominent and a high quality of image is attained. In the present embodiment, since the amount of ink injection in each scan is suppressed compared to the first embodiment, the spread at the boundary is more hard to occur.

The features of the L/n sheet feed printing, that is, the reduction of the non-uniformity of density due to the reach precision such as landing deviation and the amount of discharge is maintained while the occurrence of the regular non-uniformity of color which otherwise is caused in printing half-tone color by printing inks of different colors in overlap or adjacently is prevented. Thus, a high quality color image recording is attained by the reciprocal printing.

Illustrative Example

An illustrative example which does not fall within the scope of the invention claimed will now be explained.

In this illustrative example, it is assumed that the pixel density of the image data and the recording density of the recording apparatus are equal. Fig. 22 shows a data flow block diagram of the ink jet recording apparatus of this illustrative example. In this illustrative example, an ink jet recording apparatus 300 receives gradation data from a host apparatus 301 as numeric data s, and the recording apparatus 300 records a specified area by half-tone recording in accordance with a predetermined area gradation method such as a dither method or an error diffusion method. A predetermined half-tone image area is developed into binary data by a binarizing unit 303 in accordance with a gradation pattern selected by a gradation pattern selection unit 303 by a key entry from a console unit and the binary data is stored in a print data register 304. A thinned pattern (masked data) for the gradation pattern is selected from a masked data register 305 in accordance with the gradation pattern and a recording head 307 is driven by a head driver 306. Figs. 18 to 21 show combinations of the area gradation pattern and the thinned pattern. 64 gradations are expressed by 8x8=64 pixel matrices. Dots are generated in the sequence of numerals 1 to 64 in accordance with the designation for the number of gradations. For example, for gradation level 12, dots are generated by pixels 1 to 12, and for gradation level 48, dots are generated by pixels 1 to 48. Recording pixels for the forth run scan and the back run scan are respectively shown in the drawings. Figs. 18 and 19 show a recording method which uses two different thinned patterns (1 and 2) for the gradation pattern 1 in which pixels are relatively scattered. This recording method is same as that of the first embodiment in so far as the recording head is divided into two sections, and the image areas are recorded by the two-run scan (reciprocal scan) while the sheet is fed by one-half of the recording width of the recording head. In Fig. 18, even if the gradation level changes, the difference in the numbers of recorded dots between the forth run scan and the back run scan is one at most, and a difference of hues is very small as described above. On the other hand, in Fig. 19, a difference of the number of recorded dots may be two or more at certain gradation levels and a difference of hues may appear slightly. Thus, the thinned pattern 1 is preferable to the gradation pattern 1. Figs. 20 and 21 show a recording method which uses the thinned patterns 1 and 2 for a gradation pattern 2 in which the number of dots increases starting from a certain pixel, as the gradation level increases. As seen from Figs. 20 and 21, the thinned pattern 2 is better for the gradation pattern 2 because a difference of the number of dots between the forth and back run scans is smaller.

As described above, because the occurrence of the non-uniformity of color in the image is affected by the combination of the gradation pattern and the thinned pattern, the thinned pattern is selected in accordance with the gradation pattern in this illustrative example.

Namely, when the gradation pattern 1 is selected, the thinned pattern 1 is selected, and when the gradation pattern 2 is selected, the thinned pattern 2 is selected.

In the present illustrative example, reciprocal color printing which is free from the non-uniformity of color is attained while the recording density of the recording apparatus is utilized at a maximum level.

In the present illustrative example, the dots of the gradation pattern are developed by the ink jet recording apparatus. Alternatively, this may be done by the host apparatus as shown by broken lines in Fig. 25. In this case, selection information for the gradation pattern may be sent from the host apparatus to automatically select the thinned pattern, or a user may manually set the thinned pattern of the ink jet recording apparatus.

Where the gradation patterns in the host apparatus are substantially fixed, the thinned patterns of the ink jet recording apparatus may be prepared to avoid the interference and fixed.

In an ink jet recording method embodying the present embodiment, the recording means is moved back and forth relative to the recording medium to conduct the main scan for each run, and the color thinned images are sequentially recorded on the same area of the recording medium by using different blocks of the recording means in the plurality of main scans, and the numbers of dots recorded in the respective main scan are maintained equal without regard to the image data. Accordingly, the non-uniformity of density due to the reach accuracy of the recording means and the amount of discharge is eliminated.

Further, since the substantially same number of
dots are recorded in each main scan without regard to the image data, the occurrence of the regular non-uniformity of color due to the difference in the sequence of ink ejection in the forth and back run scans is prevented.

Ink jet recording apparatus which utilizes thermal energy to form flying droplets to record data has been described above. Representative construction and principle thereof are disclosed in US-A-4,723,129 and US-A-4,740,796. The present invention is applicable to both on-demand type and continuous type. In the on-demand type, at least one drive signal which is associated with the record information and imports a rapid temperature rise above a boiling point may be applied to an electro-thermal transducer arranged in association with a sheet which retains liquid (ink) or a liquid path so that thermal energy is generated in the electro-thermal transducer to cause film boiling in a thermal action plane of the recording head. As a result, air bubbles are formed in the liquid (ink) in association with the drive signal. The liquid (ink) is discharged through discharge ports by the growth and shrinkage of the air bubbles to form at least one droplet. Where the drive signal is pulsed, the growth and shrinkage of the air bubbles are effected instantly so that high-ly responsive liquid (ink) discharge is attained.


The construction of the recording head may be a combination of discharge ports, liquid paths and electro-thermal transducers (linear liquid path or orthogonal liquid path) as disclosed in the above-mentioned US patent publications, or a construction in which the thermal action element is arranged in a curved area as disclosed in US-A-4,558,333 or US-A-4,459,600.


In a full line type recording head having a length corresponding to a maximum width of a recording medium which the recording apparatus can print on, the length requirement may be met by a combination of a plurality of recording heads disclosed in the above-mentioned patents, or a single integral recording head may be used.

The present invention is also effective to a replaceable chip type recording head which, when mounted in an apparatus, is electrically connected with the apparatus and supplied with ink from the apparatus, or a cartridge type recording head in which an ink tank is integrally provided in the recording head.

The addition of recovery means to the recording head or auxiliary means is preferable because it further stabilizes the effect of the present invention. Specifically, capping means to the recording head, cleaning means, pressurizing or suction means, preliminary heating means by an electro-thermal transducer or other heating element or a combination thereof, and preliminary discharge mode separately from the recording are effective to attain the stable recording.

The recording mode of the recording apparatus may include only a principal color recording mode such as black.

In the embodiments of the present invention, the ink is used as a liquid. Ink which is solidified below a room temperature and softened or liquidified at the room temperature, or ink which is in liquid state when a record signal is applied may also be used because the ink jet recording system it is usual to temperature control the ink within a range of 30° C to 70° C to keep the viscosity of the ink within a stable discharge range.

Further alternatively, the temperature rise by the thermal energy may be prevented by using it as energy for a status transition of the ink from a solid state to a liquid state, or ink which is solidified when it is left may be used to prevent vaporization of the ink. In any case, ink which is liquidified by the application of thermal energy in response to a second signal and discharged as liquid ink, or ink which is liquidified by the thermal energy and starts to be solidified before it reaches the recording medium may be used. The ink may be kept to face the electro-thermal transducer while it is held in porous sheet recesses or via-holes in a liquid or solid state, as disclosed in Japanese Patent Publication No. JP-A-54-056847 or Japanese Patent Publication No. JP-A-60-071260. In the present invention, the film boiling system mentioned above is most effective to those inks.

The recording apparatus in the present invention may be comprised in a word processor, an image output terminal of an information handling system such as a computer, either integrally or separately, a copying apparatus combined with a reader, or a facsimile apparatus having transmitting and receiving functions.

Claims

1. An ink jet recording method for recording a colour image corresponding to image data consisting of a plurality of image pixels on a recording medium by reciprocally moving recording means having a plurality of linear ink discharge port arrays each array discharging a different colour ink relative to a recording medium along forward and backward paths in a main scan direction to record each image pixel as a plurality of recording dots formed by ink discharged from the discharge ports, and by moving said recording medium relative to said recording means in a sub-scan direction different from said main scan direction, said recording method com-
prising:

a first step of recording a first thinned image according to a first thinned pattern on a predetermined area of said recording medium using a first set of discharge ports of each of the arrays of said recording means during movement along one of the forward and backward paths of the main scan direction;

a second step of moving said recording medium relative to said recording means in the sub-scan direction after movement along said one of the forward and backward paths; and

a third step of recording a second thinned image according to a second thinned pattern on said predetermined area of said recording medium using a second different set of discharge ports of each of the arrays of said recording means during movement along the other of the forward and backward paths in the main scan direction so that recording dots recorded by discharging ink from respective discharge ports to form the first thinned image do not overlap with dots recorded to form, the second thinned image, the method further comprising setting said first and second thinned patterns so that the numbers of dots recorded for each image pixel on said recording medium by ink discharged by the recording means in said first and third steps are substantially equal irrespective of the arrangement of the image pixels representing the image data being recorded.

2. A method according to claim 1 wherein the recording spatial density of said recording means is double the spatial density of said image data.

3. A method according to claim 2 wherein said first thinned pattern has a dot arrangement by which dots which are not vertically and horizontally adjacent are recorded and the second thinned pattern has a dot arrangement by which the dots not recorded using the first thinned pattern are recorded.

4. A method according to any preceding claim wherein said recording means includes a plurality of recording heads each having a respective one of the plurality of ink discharge port arrays for discharging inks of different colours.

5. A method according to any preceding claim wherein said recording means uses thermal energy to cause a change in state in ink for discharging ink form a discharge port.

6. An ink jet recording apparatus for recording a colour image corresponding to image data consisting of a plurality of image pixels on a recording medium using recording means (307) having a plurality of linear ink discharge port arrays (801) each array arranged to discharge a different colour ink, comprising:

means (706) for reciprocally moving the recording means relative to the recording medium along forward and backward paths in a main scan direction;

control means (201) for causing said recording means to record each image pixel as a plurality of recording dots formed by ink discharged from the discharge ports, the control means being arranged to control said recording means to record a first thinned image according to a first thinned pattern on a predetermined area of said recording medium using a first set of discharge ports of each of the arrays of said recording means during one of the forward and backward paths of the main scan direction and to record a second thinned image according to a second thinned pattern on said predetermined area of said recording medium using a second different set of discharge ports of each of the arrays of said recording means during movement along the other of the forward and backward paths of the main scan direction so that recording dots recorded by discharging ink from respective discharge ports to form the first thinned image do not overlap with dots recorded to form the second thinned image;

means (703-705) for moving said recording medium relative to said recording means in a sub-scan direction between main scans, in which apparatus the control means (201) is arranged to control the setting of the first and second thinned patterns so that the numbers of dots recorded for each image pixel on said recording medium by ink discharged by the recording means according to said first and second thinned patterns are substantially equal irrespective of the arrangement of the image pixels representing the image data being recorded.

7. Apparatus according to claim 6 comprising recording means having a recording spatial density double the spatial density of said image data.

8. Apparatus according to claim 7 wherein said first thinned pattern has a dot arrangement by which dots which are not vertically and horizontally adjacent are recorded and said second thinned pattern has a dot arrangement by which the dots not recorded using the first thinned pattern are recorded.

9. Apparatus according to any one of claims 6 to 8 comprising recording means arranged to use ther-
mal energy to cause a change in state in the ink to
discharge ink from the discharge port.

10. Apparatus according to any one of claims 6 to 9,
comprising recording means including a plurality of
recording heads each having a respective one of
the plurality of ink discharge port arrays for dis-
charging inks of different colours.

Patentansprüche

1. Tintentrahlauzeichnungsverfahren zur Aufzeich-
nung eines Farbbilds entsprechend Bilddaten,
daus einer Vielzahl von Bildelementen bestehen,
auf einem Aufzeichnungsmedium durch Hin- und Her-
bewegen einer Aufzeichnungseinrichtung, die eine
Vielzahl von linearen regelmäßigen Tintenaus-
stoßöffnungs-Anordnungen hat, wobei jede regel-
mäßige Anordnung eine andere Farbtinte relativ zu
einem Aufzeichnungsmedium entlang von Vor-
wärts- und Rückwärtsbewegungen in Haupt-Überstrei-
chungsrichtung abgibt, um jedes Bildelement als ei-
einen ersten Schritt der Aufzeichnung eines er-
sten ausgedünnten Muster in einem vorbestimmten
Bereich des Aufzeichnungsmediums unter
Nutzung einer ersten Gruppe von Ausstoßöff-
nungen von jeder der regelmäßigen Anordnu-
gen der Aufzeichnungseinrichtung während
der Bewegung entlang des Vorwärts- oder Rückwärtswege in Haupt-Überstreichungsricht-

2. Verfahren gemäß Anspruch 1, bei welchem die räumliche Aufzeichnungsdichte der Aufzeichnungsrichtung doppelt so groß wie die räumliche Dichte der Bilddaten ist.

3. Verfahren gemäß Anspruch 2, bei welchem das erste ausgedünnte Muster eine Punktanordnung hat, mittels welcher Punkte aufgezeichnet werden, welche vertikal und horizontal nicht angrenzend sind, und das zweite ausgedünnte Muster eine Punktanordnung hat, mittels welcher die Punkte aufgezeich-

4. Verfahren gemäß einem der vorhergehenden An-
sprüche, bei welchem die Aufzeichnungseinrich-
tung eine Vielzahl von Aufzeichnungsköpfen ent-
hält, von denen jeder eine entsprechende Anordnung aus der Vielzahl von regelmäßigen Tintenaus-
stoßöffnungs-Anordnungen aufweist, um Tinten
verschiedener Farben auszustoßen.

5. Verfahren gemäß einem der vorhergehenden An-
sprüche, bei welchem die Aufzeichnungseinrich-
tung thermische Energie nutzt, um zum Ausstoß
von Tinte aus einer Ausstoßöffnung eine Zustands-
änderung in der Tinte zu verursachen.

6. Tintentrahlauzeichnungsvorrichtung zur Auf-
zeichnung eines Farbbilds entsprechend Bilddaten,
daus einer Vielzahl von Bildelementen bestehen,
auf einem Aufzeichnungsmedium unter Nutzung ei-
er Aufzeichnungseinrichtung (307), die eine Viel-
zahl von regelmäßigen linearen Tintenausstoßöf-
nungs-Anordnungen (801) aufweist, wobei jede re-
gelmäßige Anordnung dazu vorgesehen ist, eine
 andere Farbtinte auszustoßen, die aufweist,

6. Tintentrahlauzeichnungsvorrichtung zur Auf-
zeichnung eines Farbbilds entsprechend Bilddaten,
daus einer Vielzahl von Bildelementen bestehen,
auf einem Aufzeichnungsmedium unter Nutzung ei-
er Aufzeichnungseinrichtung (307), die eine Viel-
zahl von regelmäßigen linearen Tintenausstoßöf-
nungs-Anordnungen (801) aufweist, wobei jede re-
gelmäßige Anordnung dazu vorgesehen ist, eine
 andere Farbtinte auszustoßen, die aufweist,
dem Aufzeichnungsmedium entlang von Vorwärts- und Rückwärtswegen in Haupt-Überstreichungsrichtung, eine Steuereinrichtung (201), um zu bewirken, daß die Aufzeichnungseinführung jedes Bildelement als eine Vielzahl von Aufzeichnungs- punkten aufzeichnet, die mittels aus den Ausstoßöffnungen ausgestoßener Tinte ausgebildet werden, wobei die Steuereinrichtung vorge sehen ist, um die Aufzeichnungseinführung derart zu steuern, daß ein erstes ausgedünntes Bild gemäß einem ersten ausgedünnten Muster in einem vorbestimmten Bereich des Aufzeichnungsmediums unter Nutzung einer ersten Gruppe von Ausstoßöffnungen von jeder der regelmäßigen Anordnungen der Aufzeichnungseinführung während des Vorwärts- oder Rückwärtswegs in Haupt-Überstreichungsrichtung aufgezeichnet wird, und ein zweites ausgedünntes Bild gemäß einem zweiten ausgedünnten Muster in dem vorbestimmten Bereich des Aufzeichnungsmediums unter Nutzung einer zweiten anderen Gruppe von Ausstoßöffnungen von jeder der regelmäßigen Anordnungen der Aufzeichnungseinführung während der Bewegung entlang des anderen Wegs, des Vorwärts- oder Rückwärtswegs, in Haupt-Überstreichungsrichtung aufgezeichnet wird, so daß Aufzeichnungspunkte, die durch das Ausstoßen von Tinte aus den jeweiligen Ausstoßöffnungen aufgezeichnet werden, um das erste ausgedünnte Bild auszubilden, sich nicht mit Punkten überragen, die aufgezeichnet werden, um das zweite ausgedünnte Bild auszubilden, eine Einrichtung (703-705), um das Aufzeichnungsmedium zwischen den Hauptüberstreichun gen relativ zu der Aufzeichnungseinführung in Neben-Überstreichungsrichtung zu bewegen, wobei in der Vorrichtung die Steuereinrichtung (201) vorgesehen ist, um die Festlegung des ersten und zweiten ausgedünnten Musters derart zu steuern, daß die Anzahl von Punkten, die gemäß dem ersten und zweiten ausgedünnten Muster mittels von der Aufzeichnungseinführung ausgestoßener Tinte für jedes Bildelement auf dem Aufzeichnungsmedium aufgezeichnet werden, unabhängig von der Anordnung der Bildelemente, welche die Bild daten repräsentieren, die aufgezeichnet werden, im wesentlichen gleich ist.

7. Vorrichtung gemäß Anspruch 6, die eine Aufzeichnungseinführung aufweist, die eine räumliche Aufzeichnungsdichte hat, die doppelt so groß wie die räumliche Dichte der Bilddaten ist.

8. Vorrichtung gemäß Anspruch 7, bei welcher das er-
moyen d'enregistrement dans la direction de balayage secondaire après déplacement le long dudit trajet des trajets avant et arrière ; et une troisième étape d'enregistrement d'une deuxième image affinée conformément à une deuxième configuration affinée, sur ladite zone prédéterminée dudit support d'enregistrement, en utilisant une deuxième série différente d'orifices de décharge de chacun des réseaux dudit moyen d'enregistrement au cours du déplacement le long de l'autre trajet des trajets avant et arrière dans la direction de balayage principal, de telle sorte que des points d'enregistrement enregistrés par décharge d'encre à partir d'orifices de décharge respectifs pour former la première image affinée ne recouvrent pas des points enregistrés pour former la deuxième image affinée, le procédé comprenant en outre l'établissement desdites première et deuxième configurations affinées de telle sorte que les nombres de points enregistrés pour chaque pixel d'image, sur ledit support d'enregistrement, par l'encre déchargée par le moyen d'enregistrement au cours des premières et troisièmes étapes, soient sensiblement égaux quel que soit l'agencement des pixels d'image représentant les données d'image en cours d'enregistrement.

2. Procédé selon la revendication 1, dans lequel la densité spatiale d'enregistrement dudit moyen d'enregistrement est le double de la densité spatiale desdites données d'image.

3. Procédé selon la revendication 2, dans lequel ladite troisième configuration affinée a un agencement de points par lequel des points, qui ne sont pas adjacents verticalement et horizontalement, sont enregistrés et la deuxième configuration affinée a un agencement de points, par lequel des points non enregistrés en utilisant la première configuration affinée, sont enregistrés.

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit moyen d'enregistrement comporte une pluralité de têtes d'enregistrement comportant chacune un réseau respectif de la pluralité de réseaux d'orifices de décharge d'encre pour décharger des encres de différentes couleurs.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit moyen d'enregistrement utilise de l'énergie thermique pour provoquer un changement d'état de l'encre pour décharger de l'encre à partir d'un orifice de décharge.

6. Appareil d'enregistrement à jet d'encre pour l'enregistrement d'une image en couleurs correspondant à des données d'image consistant en une pluralité de pixels d'image, sur un support d'enregistrement, en utilisant un moyen d'enregistrement (207) comportant une pluralité de réseaux linéaires (601) d'orifices de décharge d'encre, chaque réseau étant agencé pour décharger une encre de couleur différente, comprenant : un moyen (706) pour un mouvement de va et vient du moyen d'enregistrement par rapport au support d'enregistrement le long de trajets avant et arrière, dans une direction de balayage principal ;

un moyen de commande (201) pour conduire ledit moyen d'enregistrement à enregistrer chaque pixel d'image sous la forme d'une pluralité de points d'enregistrement formés par de l'encre déchargée à partir des orifices de décharge, le moyen de commande étant agencé pour commander ledit moyen d'enregistrement afin d'enregistrer une première image affinée conformément à une première configuration affinée, sur une zone prédéterminée dudit support d'enregistrement, en utilisant une première série d'orifices de décharge de chacun des réseaux dudit moyen d'enregistrement au cours de l'un des trajets avant et arrière de la direction de balayage principal et afin d'enregistrer une deuxième image affinée conformément à une deuxième configuration affinée, sur ladite zone prédéterminée dudit support d'enregistrement, en utilisant une deuxième série différente d'orifices de décharge de chacun des réseaux dudit moyen d'enregistrement au cours du déplacement le long de l'autre des trajets avant et arrière de la direction de balayage principal, de telle sorte que des points d'enregistrement enregistrés par décharge d'encre à partir d'orifices de décharge respectifs pour former la première image affinée ne recouvrent pas des points enregistrés pour former la deuxième image affinée ;

un moyen (703-705) pour déplacer ledit support d'enregistrement par rapport audit moyen d'enregistrement dans une direction de balayage secondaire entre des balayages principaux, le moyen de commande (201), dans cet appareil, étant agencé pour commander l'établissement des premières et deuxième configurations affinées de telle sorte que les nombres de points enregistrés pour chaque pixel d'image, sur ledit support d'enregistrement, par l'encre déchargée par le moyen d'enregistrement conformément auxdites premières et deuxième configurations affinées, soient sensiblement égaux quel que soit l'agencement des pixels d'image représentant les données d'image en cours d'enregistrement.
7. Appareil selon la revendication 6, comprenant un moyen d'enregistrement ayant une densité spatiale d'enregistrement qui est le double de la densité spatiale desdites données d'image.

8. Appareil selon la revendication 7, dans lequel ladite première configuration affinée a un agencement de points par lequel des points, qui ne sont pas adjacents verticalement et horizontalement, sont enregistrés et ladite deuxième configuration affinée a un agencement de points par lequel les points non enregistrés en utilisant la première configuration affinée, sont enregistrés.

9. Appareil selon l'une quelconque des revendications 6 à 8, comprenant un moyen d'enregistrement agencé pour utiliser de l'énergie thermique afin de provoquer un changement d'état de l'encre en vue de décharger l'encre à partir de l'orifice de décharge.

10. Appareil selon l'une quelconque des revendications 6 à 9, comprenant un moyen d'enregistrement comportant une pluralité de têtes d'enregistrement comportant chacune un réseau respectif de la pluralité de réseaux d'orifices de décharge d'encre pour décharger des encres de différentes couleurs.
FIG. 1

PAPER FEED DIRECTION

L/2

RECORDING SECTION (2)

L/2

RECORDING SECTION (1)

Y M Cy Bk

HEAD SCAN DIRECTION

Bk→Cy→M→Y (1ST SCAN)
C
(1ST IMAGE AREA)

Bk→Cy→M→Y (1ST SCAN)
C
(1ST IMAGE AREA)

Bk→Cy→M→Y (1ST SCAN)
C
(1ST IMAGE AREA)

Bk→Cy→M→Y (2ND SCAN)
C
(2ND IMAGE AREA)

Bk→Cy→M→Y (3RD SCAN)
C
(3RD IMAGE AREA)

Bk→Cy→M→Y (2ND SCAN)
C
(2ND IMAGE AREA)

Bk→Cy→M→Y (3RD SCAN)
C
(3RD IMAGE AREA)

C: CHECKER
RC: REVERSE CHECKER
FIG. 2

HEAD SCAN DIRECTION

Y
CY

RECORDING SECTION (1)

RECORDING SECTION (2)

PAPER FEED DIRECTION

L/2

L/2

(ARRANGEMENT OF RECORDING PIXELS FOR 1ST SCAN)

(1ST IMAGE AREA)

(DOTS FORMED ON SHEET)
FIG. 5

PAPER FEED DIRECTION

HEAD SCAN DIRECTION

Y IMAGE DATA

Cy+Y IMAGE DATA
FIG. 6

L/2
PAPER FEED DIRECTION

(2n-1)TH SCAN

HEAD SCAN DIRECTION

(2n)TH SCAN

FIG. 7

L/2
PAPER FEED DIRECTION

(2n-1)TH SCAN

HEAD SCAN DIRECTION

(2n)TH SCAN
FIG. 11

L/4

PAPER FEED DIRECTION

HEAD SCAN DIRECTION

(4n-3)TH SCAN

(4n-2)TH SCAN

(4n-1)TH SCAN

(4n)TH SCAN
FIG. 12

Y Cy
RECORDING SECTION

PAPER FEED DIRECTION

(4) L/4
(3) L/4
(2) L/4
(1) L/4

HEAD SCAN DIRECTION

(ARRANGEMENT OF RECORDING PIXELS FOR 1ST SCAN)

(DOTS FORMED ON SHEET)

(1ST IMAGE AREA)
FIG. 13

PAPER FEED DIRECTION

RECORDING SECTION

L/4

L/4

L/4

L/4

(1ST IMAGE AREA)

(2ND IMAGE AREA)

(DOTS FORMED ON SHEET)

(ARRANGEMENT OF RECORDING PIXELS FOR 1ST SCAN)

HEAD SCAN DIRECTION

XY
FIG. 15

Y Cu

RECORDING SECTION

PAPER FEED DIRECTION

HEAD SCAN DIRECTION

(ARRANGEMENT OF RECORDING PIXELS FOR 4TH SCAN)

(DOTS FORMED ON SHEET)

L/4

(1)

(2)

(3)

(4)

(1ST IMAGE AREA)

(2ND IMAGE AREA)

(3RD IMAGE AREA)

(4TH IMAGE AREA)
FIG. 18

AREA GRADATION PATTERN 1
AND THINNING PATTERN 1

FIG. 19

AREA GRADATION PATTERN 1
AND THINNING PATTERN 2
**FIG. 20**

<table>
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*AREA GRADATION PATTERN 2 AND THINNING PATTERN 1*

**FIG. 21**

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*AREA GRADATION PATTERN 2 AND THINNING PATTERN 2*
FIG. 29

- PAPER FEED DIRECTION
  - L/2 RECORDING SECTION (2)
  - L/2 RECORDING SECTION (1)

- HEAD SCAN DIRECTION
  - (1ST SCAN)
  - (2ND SCAN)
  - (3RD SCAN)

C: CHECKER
RC: REVERSE CHECKER

- BkRC, BkC
- CyRC, CyC
- MRC, MC
- YRC, YC
- BkC
- CyC
- MRC
- YC
FIG. 30

Y Cy

L/2 RECORDING SECTION (2)

L/2 RECORDING SECTION (1)

HEAD SCAN DIRECTION

(PAPER FEED DIRECTION)

(ARRANGEMENT OF RECORDING PIXELS FOR 1ST SCAN)

(DOTS FORMED ON SHEET)

(1ST IMAGE AREA)
FIG. 33

[Diagram of a process with labeled steps and a labeled section marked 'P'].

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