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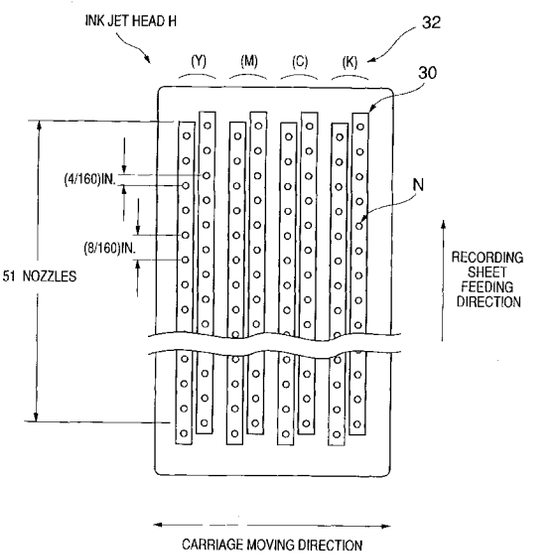
(54) Recording method in ink jet printer

(57) An ink jet printer and its recording method. A control for varying a feeding pitch of a recording sheet and a control of ink ejecting of each nozzle are performed. On the condition that there is no common divisor between the number of nozzles *n* and a pitch interval between nozzles *m* and that a relationship of $n=pm+q$ $(p\geq 1, m\geq 2, 1\leq q\leq m-1)$ is satisfied, recording operation is performed as follows: after all m×n lines are recorded by one pitch feed, *n* pitch feed is performed while only the nozzles not overlapping the recorded lines are allowed to eject ink. After the *n* pitch feed is performed *m-1* times, each n pitch feed is performed while all the nozzles are allowed to eject the ink. All the recorded lines are recorded without being overlapped or generating any gap. No non-recorded area is generated in a top end of the recording sheet. The effect use of recording sheet and the enlargement of recorded area can be realized. At the *i*-th $(1\leq i\leq m-1)$ *n* pitch feed, $[i\times n/m]+1$ nozzles, represented by Gauss' notation, from the downstream side (terminal end) in the recording sheet feeding direction are allowed to eject the ink.

FIG.2



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a recording method in an ink jet printer in which ink is ejected onto a recording sheet or another recording medium from nozzles to perform recording, and an ink jet printer using the method.

Description of the Related Art

[0002] In general, an ink jet printer is used as an output device of a computer, a word processor, or the like because of its quiet recording or for another reason.

[0003] In the conventional ink jet printer, a carriage shaft is disposed in parallel with a flat platen, and a receprocatable carriage is disposed along the carriage shaft. Moreover, an ink jet recording head mounted on the carriage has a plurality of nozzles which can eject ink for use in recording are aligned/arranged at predetermined intervals in a direction parallel with a feeding direction of a recording sheet. The ink jet head is disposed in such a manner that a tip end of each nozzle is opposed to a recording surface of the platen.

[0004] The plurality of ejecting nozzles are used in order to increase the printing speed. In the conventional art, a plurality of ejecting nozzles are arranged adjacent to one another. After a plurality of lines are recorded by ejecting ink via all the nozzles, line feeding operation is performed, before the ink is repeatedly ejected via all the nozzles. In the feeding operation accompanied with such large-scale line feeding operation, however, accuracy in pitch feed becomes a problem. For example, when *n* nozzles are arranged adjacent to one another, *n* pitch feed is repeated. A gap between lines block before or after the n pitch feed needs to be the same as an interval between the adjacent nozzles, which is difficult. When characters and the like are recorded, the accuracy in pitch feed is not such a large problem. When image information such as picture, photograph or other graphical image, is recorded, however, a gap is formed every n pitch feed, or recorded lines are overlapped. This causes a problem that streaks are seen across a printed image. Moreover, when a high recording density (e.g., 160 dpi) is requested for, it is difficult to arrange ejecting nozzles, behind which an ejecting mechanism is provided, at the same interval as the recording density in a sub-scanning direction.

[0005] To solve the problem, a plurality of (*n*) nozzles are arranged at constant intervals (the number of pitches is generally less than *n*), and scanning is performed so as to fill a gap between recorded lines (interlace system).

[0006] A relationship of ink ejecting nozzle position, carriage moving direction and recording sheet moving direction in the conventional ink jet printer will be described with reference to Fig. 7, in which the number of nozzles is five. Additionally, the relationship of nozzle position, carriage moving direction and recording sheet moving direction can be applied in the present invention.

[0007] As shown in Fig. 7, in an ink jet head H, five nozzles N1, N2, N3, N4, N5 in total, which can eject desired ink to form dot image on a recording sheet, are aligned/arranged in a direction parallel with a recording sheet feeding direction. Additionally, code N generically indicates the nozzle, and numerals 1 to 5 affixed to the code N indicate nozzle numbers in sequence from the top of the feeding direction of the recording sheet.

[0008] An interval W between the nozzles (correctly the interval between nozzle centers) is set to a pitch *L* between recorded pixels multiplied by an integer, i.e., $m \times L$. In the example of Fig. 7, $m=4$. Therefore, when feeding is performed at the number of pitches equal to the number of nozzles, i.e., five pitches, that is, when the recording sheet is fed by a distance of $nL=5L$, the nozzles N1 to N4 are moved to just below the positions of the nozzles N2 to N5 before fed.

[0009] During recording operation, the ink jet head H moves along the carriage moving direction shown by a lateral arrow in Fig. 7. During the movement, ink is ejected via the ink ejecting nozzles to form an image for one line of nozzles.

[0010] After the image for one line of nozzles is formed, the recording sheet is fed in a feeding direction shown by an upward arrow in Fig. 7 by line feeding operation. The number of feeding pitches of the recording sheet corresponds to the total number n of nozzles, i.e., *n* pitch or five pitch feed is performed.

[0011] As described above, repeated are the line feeding operation in which the recording sheet is fed by five pitch feed, and the image forming operation in which the carriage with the ink jet head H mounted thereon is moved along the platen and simultaneously operated based on predetermined recording information to eject ink onto the recording sheet and form a line unit recorded image of each nozzle N1, N2, N3, N4, N5 on the recording sheet. Desired image is recorded on the recording sheet in this manner.

[0012] In the ink jet printer, the carriage moves from the left toward the right in the first image forming operation, and all the nozzles N1, N2, N3, N4, N5 eject ink. Therefore, as shown in Fig. 8, the recorded image of each line is formed by each of the nozzles N1 to N5 to first form the recorded image of five lines in total.

[0013] Subsequently, the line feeding operation is performed. Specifically, the n pitch feed of the recording sheet, i. e., the five pitch feed is performed. In this state, while the carriage is moved from the right toward the left, ink is ejected

from all the nozzles N1 to N5. Therefore, as shown in Fig. 9, each new line of recorded image formed by the nozzles N1 to N4 is recorded just below each recorded image line formed by the nozzles N2 to N5 in the previous image forming operation. A new line by the nozzle N5 is formed five pitches below the line formed by the nozzle N5 in the previous image forming operation.

[0014] When the five pitch line feeding operation (feeding of the recording sheet) and the ejecting operation of all the nozzles N1 to N5 are repeated in the same manner, each line of recorded image is formed as shown in Figs. 10, 11.

[0015] When the line feeding operation for feeding the recording sheet at the constant interval, i.e., by the five pitch feed is performed to sequentially record the recording sheet, as shown in Fig. 11, no recorded image can be formed in an area A of three lines, an area B of two lines, or an area C of one line.

[0016] To solve the problem, in the conventional art, the nozzle N does not actually eject ink while scanning an area denoted by code D in Fig. 11. Specifically, the line of the recorded image first formed by the nozzle N4 is regarded as a recording start position of the recorded image. Therefore, the area D cannot be used in recording, which is wasteful.

[0017] As described above, in the conventional recording method of the ink jet printer, since the feeding pitch of the recording sheet is set constant, a non-recorded area which cannot be used in recording is disadvantageously generated in the top end of the feeding direction of the recording sheet.

SUMMARY OF THE INVENTION

[0018] The present invention has been accomplished in consideration of the above circumstances, and a first object thereof is to provide a recording method of an ink jet printer which can prevent a non-recorded area unable to be used in recording from being generated in a top end of a feeding direction of a recording sheet. A second object is to provide a printer for direct use in implementing the method.

[0019] According to the present invention, the first object is attained by a recording method of an ink jet printer for recording a desired image on a recording sheet by repeating:

a line feeding operation in which the recording sheet is fed at a predetermined feeding pitch; and
an image forming operation in which a plurality of ink ejecting nozzles aligned/arranged at a predetermined interval in a direction substantially parallel with a feeding direction of said recording sheet are moved along a scanning direction which is a direction substantially orthogonal to said feeding direction of the recording sheet, and operated to eject ink to form a line unit image by dots of the ink ejected of each nozzle on said recording sheet.

[0020] In the recording method of the ink jet printer, a control for a variable feeding pitch of the recording sheet and a control of ink ejecting of each nozzle are performed to prevent a non-recorded area unable to be used in recording from being generated in a top end of the feeding direction of the recording sheet.

[0021] The control for the variable feeding pitch and the control of ink ejecting of each nozzle can be performed in the recording method of the ink jet printer, for example, comprising the steps of:

a) providing *n* nozzles arranged at the predetermined interval in the direction substantially parallel with the recording sheet feeding direction, said predetermined interval between the nozzles being set to a pitch between pixcels multiplied by an integer *m; n, m* having no common divisor other than one and having the following relationship:

$$n = pm+q$$

where *p* is an integer of one or more;
m is an integer of two or more; and
q is an integer of one or more and less than *m*;

b) first, allowing said *n* nozzles to eject ink while moving *n* nozzles in the scanning direction so that the line unit image of each nozzle is recorded;

c) subsequently, feeding the recording sheet by one pitch, then, allowing said *n* nozzles to eject the ink while moving *n* nozzles in the scanning direction so that the line unit image of each nozzle is recorded; these operations being repeated *m-1* times, $m \times n$ lines being recorded by the operations of the steps b), c);

d) subsequently, feeding the recording sheet by *n* pitches, then, allowing only the nozzles not overlapping already recorded lines, among said *n* nozzles, to eject the ink while moving *n* nozzles in the scanning direction so that the line unit image each of the non-overlapping nozzles is recorded; these operations being repeated m-1 times; and

e) thereafter, every time the recording sheet is fed by *n* pitches, allowing all of said *n* nozzles to eject the ink while moving *n* nozzles in the scanning direction so that the line unit image of each nozzles is recorded.

[0022] Thereby, all lines are recorded without being overlapped or generating any gap. Moreover, the non-recorded area unable to be used in recording can securely be prevented from being generated in the top end of the feeding direction of the recording sheet. As a result, the effective use of the recording sheet and the enlargement of the recorded area can easily be realized.

[0023] In the step d), in the i-th ($1 \leq i \leq m-1$) n pitch feed, $[i \times n/m]+1$ nozzles, represented by Gauss' notation, from the downstream side (terminal end) in the recording sheet feeding direction can be allowed to eject the ink. Specifically, the number of the ejectable nozzles from the downstream side is obtained only by adding one to an integer portion obtained by dividing $i \times n$ with m.

[0024] The second object of the present invention is attained by an ink jet printer for recording a desired image on a recording sheet by repeating;

a line feeding operation in which the recording sheet is fed at a predetermined feeding pitch; and
an image forming operation in which a plurality of ink ejecting nozzles aligned/arranged at a predetermined interval in a direction substantially parallel with a feeding direction of said recording sheet are moved along a scanning direction which is a direction substantially orthogonal to said feeding direction of the recording sheet, and operated to eject ink to form a line unit image by dots of the ink ejected of each nozzle on said recording sheet.

[0025] The ink jet printer comprises a controller for performing a control for a variable feeding pitch of the recording sheet and a control of ink ejecting of each nozzle.

[0026] The ink jet printer preferably comprises:

a) n nozzles arranged at the predetermined intervals in the direction substantially parallel with the recording sheet feeding direction, said predetermined interval between the nozzles being set to a pitch between pixcels multiplied by an inter m; n, m having no common divisor other than one and having the following relationship:

$$n = pm + q;$$

where p is an integer of one or more;
m is an integer of two or more; and
q is an integer of one or more and less than m;
b) feeding means for feeding the recording sheet at either one pitch or n pitches;
c) nozzle moving means for reciprocating said n nozzles in the scanning direction; and
d) a controller for controlling operations of said n nozzles, said feeding means and said nozzle moving means in the following steps:
1) first, allowing said n nozzles to eject the ink while driving said nozzle moving means to move said n nozzles in the scanning direction so that the line unit image of each nozzle is recorded;
2) subsequently, driving said feeding means to feed the recording sheet by one pitch, then, allowing said n nozzles to eject the ink while driving said nozzle moving means to move said n nozzles in the scanning direction so that the line unit image of each nozzle is recorded; these operations being repeated $m-1$ times, $m \times n$ lines being recorded by the operations of the steps 1), 2);
3) subsequently, driving said feeding means to feed the recording sheet by n pitches, then, allowing only the nozzles not overlapping already recorded lines, among said n nozzles, to eject the ink while driving said nozzle moving means so that the line unit image of each of the non-overlapping nozzles is recorded; these operations being repeated m-1 times; and
4) thereafter, every time said feeding means is driven to feed the recording sheet by n pitches, allowing all of said n nozzles to eject the ink while driving said nozzle moving means, and recording the line unit image.

[0027] According to the ink jet printer, all lines can be recorded without being overlapped or generating any gap. Moreover, the non-recorded area unable to be used in recording can securely be prevented from being generated in the top end of the feeding direction of the recording sheet. As a result, the effective use of the recording sheet and the enlargement of the recorded area can easily be realized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028]

Fig. 1 is an entire perspective view showing an ink jet printer to which one embodiment of the present invention

is applied;

Fig. 2 is a schematic view showing a structure of an ink jet head H of the printer of Fig. 1 to show a relationship of ink ejecting nozzle position, carriage moving direction and recording sheet moving direction;

Fig. 3 is a block diagram showing a controller of the printer of Fig. 1;

Figs. 4A to 4C are explanatory views of a principle of a recording method of the ink jet printer according to the present invention; an example of the number of nozzles *n*=5 and pitch between nozzles *m*=4 is shown; circled numerals indicate nozzle numbers for recording each recorded pixel line; non-ejectable nozzles are indicated by crosses while ejectable nozzles are indicated by circles in Figs. 4B, 4C;

Figs. 5A to 5C are explanatory views showing the principle of the recording method of the ink jet printer according to the present invention; an example of the number of nozzles *n*=7 and pitch between nozzles *m*=4 is shown; circled numerals indicate nozzle numbers for recording each recorded pixel line; non-ejectable nozzles are indicated by crosses while ejectable nozzles are indicated by circles in Figs. 5B, 5C;

Fig. 6 is an explanatory view showing the principle of the recording method of the ink jet printer according to the present invention; nozzle positional relationships at the time of one pitch feed and n pitch feed are shown;

Fig. 7 is a schematic view showing a relationship of ink ejecting nozzle position, carriage moving direction and recording sheet moving direction while the number of nozzles is five; and

Figs. 8 to 11 are explanatory views showing recording operations by a conventional ink jet printer; Figs. 8 to 11 show states of recorded images formed by each nozzle in first to fourth recording operations, respectively; circled numbers shown on the left side of each drawing indicate positions of nozzles N1 to N5; circled numbers constituting recorded image (dots) lines on the right side indicate that the lines are recorded by the nozzles N1 to N5, respectively.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

PRINCIPLE OF THE INVENTION

[0029] A principle of a recording method according to the present invention will be described with reference to Figs. 4 to 6.

[0030] In Figs. 4A to 4C, circled numbers indicate nozzle numbers for recording each recorded pixel line when the number of nozzles *n* is set to five and the pitch between nozzles m is set to four. Positions of nozzles N1 to N5 have a relationship shown in Fig. 2.

[0031] In the first image forming operation, while a carriage is moved, ink is ejected from each nozzle, so that lines 1, 5, 9, 13, 17 are recorded. Subsequently, when a recording sheet is fed by one pitch, and the ink is ejected while the carriage is moved, each of the nozzles N1 to N5 records a line next to each line formed in the previous image forming operation (middle section of Fig. 4A). When the one pitch feed operation and the subsequent line forming operation are repeated three times in total, lines 1 to 20 are recorded without any gap (right side of Fig. 4A).

[0032] Subsequently, *n* pitch feed is performed. Specifically, the recording sheet is fed only by *n*=five pitches. As shown in Fig. 4B, the nozzle N1 positioned in the line 4 is fed by five pitches and positioned in the line 9. Similarly, the nozzles N2, N3, N4, N5 are positioned in the lines 13, 17, 21, 25, respectively. In the state, if ink is ejected from all the nozzles N, the nozzles N1 to N3 eject and overlap the ink onto areas in which image is already formed.

[0033] Therefore, in the present invention, the nozzles N1, N2, N3 are set non-ejectable, while only the nozzles N4, N5 are set ejectable (in Fig. 4B, the non-ejectable nozzles are shown by crosses, while the ejectable nozzles are shown by circles). As a result, as shown in Fig. 4B, only new lines 21, 25 of recorded image by the nozzles N4, N5 are formed, and the recorded image is formed in 22 lines in total.

[0034] The subsequent recording operation is all accompanied with the *n*=five pitch feed or line feeding operation. The nozzle positioned on the line with the image already formed thereon is controlled not to eject the ink. As the recording operation proceeds, the ejecting nozzles on the upstream side (top end of the feeding direction) are allowed to be operated. Specifically, in the second n=five pitch feed, the three nozzles N3 to N5 are used, and in the third feed, four nozzles N2 to N5 are used.

[0035] At the fourth *n* pitch feed, any of the nozzles N1 to N5 does not overlap the recorded lines. Therefore, all the nozzles are used for recording (Fig. 4C).

[0036] After the recorded image is formed by the fourth n pitch feed, there is one blank line under the line 28 formed by the nozzle N2. Similarly, there are two and three blank lines under the lines 32, 36 formed by the nozzles N3, N4, respectively. When the recording sheet is fed by five pitches, any nozzle does not overlap the recorded lines. Therefore, when the recorded image is formed by the fifth *n* pitch feed, the ink can be ejected from all the nozzles N1 to N5.

[0037] Thereafter, when the line feeding operation each of five pitches is repeated, all the nozzles N1 to N5 fail to overlap the recorded lines, and can record the image in a non-recorded area without any gap.

[0038] As described above, the recorded image can easily and securely be formed from the first recording operation

and from an origin of nozzle N1 without any interruption among the lines of the recorded image. Recording can securely be performed even in the non-recorded area which is heretofore generated in the top end of the feeding direction of the recording sheet and which cannot be used in recording. As a result, the effective use of the recording sheet and the enlargement of the recorded area can easily be realized.

[0039] Figs. 5A to 5C show a recorded image forming operation when the number of nozzles *n* is set to seven and the pitch between nozzles *m* is set to four. Nozzle numbers for recording recorded pixel lines are shown by circled numerals.

[0040] In the first image forming operation, lines 1, 5, 9, 13, 17, 21, 25 are recorded. Subsequently, when one pitch feed operation and image forming operation are repeated three times in total, lines 1 to 28 are recorded without any gap (right side of Fig. 5A).

[0041] Subsequently, when *n*=seven pitch feed is performed, only the nozzles N6, N7 fail to overlap the recorded lines. Therefore, the image forming operation is performed by ejecting the ink only via the nozzles N6, N7 (the left side of Fig. 5B). Thereafter, while the *n*=seven pitch feed is repeated, the recorded image is formed in such a manner that the ink is prevented from being ejected from the nozzles positioned on the recorded lines. Then, at the fourth n pitch feed, any one of the nozzles N1 to N7 does not overlap the recorded lines. Therefore, all the nozzles are used to perform recording (Fig. 5C). Thereafter, when the line feeding operations each of seven pitches are repeated, all the nozzles N1 to N7 fail to overlap the recorded lines, and the non-recorded area can be recorded without any gap.

[0042] The example in which the number of nozzles *n* is five and the pitch between nozzles *m* is four and the example in which the number of nozzles *n* is seven and the pitch between nozzles *m* is four have been described, but the recording method of the present invention can be performed as long as the number of nozzles *n* and the pitch between nozzles *m* have the following relationship:

$$n = pm + q$$

n,m having no common divisor other than one;

where *p* is an integer of one or more;
m is an integer of two or more; and
q is an integer of one or more and less than m.

[0043] These conditions will next be described.

[0044] The present invention makes it an object to finally allow all the nozzles to eject the ink while repeating the *n* pitch feed. Namely, the area of $m \times n$ lines can be recorded without any gap by performing the n pitch feed *m* times. During this operation all the nozzles are ejectable. To attain this object, the condition of $m \neq n$ is first necessary. If the line feeding of *n* pitch is performed on the condition of *m=n,* the nozzle position after the line feeding overlaps the position of the next nozzle before the line feeding. After the line feeding of *n* pitch, only the lowermost nozzle Nn can eject the ink.

[0045] Moreover, it is necessary that the number of nozzles *n* is indivisible by the number of pitches *m,* i.e., it should not be *m* multiplied by an integer:

$n \neq p \times m$, in which *p* is an integer.

[0046] More correctly,

$n = pm + q$, in which *q* is smaller than *m,* and *p, q* are integers.

[0047] If *n* is a multiple of *m* (e.g., in case of $n = p \times m$), the uppermost nozzle overlaps the already recorded line after the n pitch feed is repeated p times.

[0048] Fig. 6 shows the positional relationship of each nozzle at the time of one pitch feed and *n* pitch feed. As seen from Fig. 6, at the first n pitch feed, the position of the uppermost nozzle N1 is *m+n.* When the *n* pitch feed is repeated *p* times, the position of the uppermost nozzle N1 is:

$$m + pn \qquad (1).$$

[0049] When the *n* pitch feed is repeated p-1 times, the position of the uppermost nozzle N1 is *m+(p-1)n.* In this case, since the (*p+1*)-*th* nozzle Np+1 is positioned on the downstream side by *pm* pitches from N1,

$$m + (p-1)n + pm \qquad (2).$$

Assuming that n is a multiple of m and $n = p \times m$, equation (2) becomes the same as equation (1):

$$m + (p-1)n + pm = m + pn - n - pn = m + pn \quad (3).$$

Specifically, when the n pitch feed is repeated p times, the uppermost nozzle N1 necessarily overlaps the previous nozzle Np+1 when the n pitch feed is repeated $p-1$ times. Thereafter, even when the n pitch feed is repeated, all the nozzles are not ejectable.

[0050] Therefore, it is necessary that the number of nozzles n is indivisible by the pitch between nozzles m, that is, the following relationship is necessary:

$$n = pm + q \quad (4),$$

in which

$p \geq 1$, $m \geq 2$, $1 \leq q \leq m-1$.

[0051] Furthermore, it is necessary that there is no common divisor other than one between the number of nozzles n and the pitch between nozzles m. If the common divisor exists, the recorded lines overlap one another as follows:

[0052] Assuming that the common divisor between the number of nozzles n and the pitch between nozzles m is a, the number of nozzles is $n=ab$, and the pitch between nozzles is $m = ac$, $a = n/b = m/c$, then:

$$bm = cn \quad (5).$$

[0053] As seen from Fig. 6, when one line feeding is performed $m-1$ times, mn lines are recorded, then the n pitch feed is performed c times, each nozzle is positioned on the following line:

nozzle N1	$m + nc$
nozzle N2	$m + nc + m$
.	.
.	.
nozzle Nb	$m + nc + (b-1)m$
nozzle Nb+1	$m + nc + bm$
.	.
.	.
nozzle Nn-1	$m + nc + (n-2)m = nc + nm - m$ ...(6)
nozzle Nn	$m + nc + (n-1)m = nc + nm$ ...(7)

[0054] Furthermore, when the n pitch feed is repeated, each nozzle at the $(ac=m)$-th feed is positioned as follows:

nozzle N1 $m + nm$

nozzle N2 $m + nm + m$

. .

. .

nozzle Nb-1 $m + nm + (b\text{-}2)m = nm + bm - m$

$= nm + cn - m$ ...(8)

nozzle Nb $m + nm + (b\text{-}1)m = nm + bm$ ...(9)

nozzle Nb+1 $m + nm + bm$

. .

. .

nozzle Nn-1 $m + nm + (n\text{-}2)m$

nozzle Nn $m + nm + (n\text{-}1)m$

Here, since equation (5) indicates $bm = cn$, equations (7) and (9) indicate the same numeric value. Equations (6) and (8) also indicate the same numeric value.

[0055] Consequently, the *m*-th nozzle Nb is sure to overlap the c-th nozzle Nn. Moreover, the nozzle Nb-1 overlaps the c-th nozzle Nn-1. The number of overlapped nozzles is *b*. The generation of the overlapped lines indicates that a gap is generated by non-recorded lines.

[0056] It can be understood from the above description that the recording method of the present invention can be performed when the number of nozzles *n* and the pitch between nozzles *m* have the following relationship:

n,m have no common divisor other than one;

$$n = pm + q;$$

p is an integer of one or more;
m is an integer of two or more; and
q is an integer of one or more and less than *m*.

[0057] On the condition that the above relationship is satisfied, the recording operation is performed as follows:

[0058] First, all the *n* nozzles are made ejectable, scanning is performed in a scanning direction which is a direction substantially orthogonal to the recording sheet feeding direction, and the line unit image of each nozzle is recorded.

[0059] Subsequently, after the recording sheet is fed one pitch, scanning is performed while all the nozzles are made ejectable, and the line unit image is recorded. When the one pitch feed is repeated *m-1* times, $m \times n$ lines are recorded without any gap (Figs. 4A, 5A).

[0060] Subsequently, the recording sheet is fed *n* pitches, scanning is performed while only the nozzles not overlapping the already recorded line are made ejectable, and the line unit image is recorded. These operations are repeated m-1 times.

[0061] At the *m*-th *n* pitch feed, no nozzle overlaps the mxn lines recorded in the first one pitch feed operation. Therefore, all the nozzles become ejectable.

[0062] Thereafter, every time the recording sheet is fed n pitches, scanning is performed while all the nozzles are made ejectable, and the line unit image is recorded. Thereby, all the lines are recorded without overlapping one another and without any gap. No non-recorded area is generated in the top end of the recording sheet.

[0063] Till the *(m-1)*-th *n* pitch feed, some nozzles are ejectable, while the other nozzles are non-ejectable. The nozzles ejectable in this stage are determined as follows:

[0064] As shown in Fig. 6, after one pitch feed is performed *m-1* times to record $m \times n$ lines, the *n* pitch feed is performed once. The result is shown on the right side of Fig. 6. The amount fed in the downstream direction is *n* pitches. Only the nozzles positioned along the length of *n* pitches are ejectable. The number of nozzles along the length can be obtained by dividing the fed amount of *n* pitches by the pitch between nozzles *m*. Since $n=pm+q$, the following results:

$$n/m = (pm + q)/m = p + q/m.$$

Since *q* is smaller than *m*, there are *p* nozzles in the *n* pitches. However, since the nozzle Nn is positioned in the line $mn+n$, this nozzle is added. Therefore, it can be seen that $p+1$ nozzles are ejectable.

[0065] When the *n* pitch feed is performed twice, the number of nozzles positioned in *2n* pitches ahead of the *mn* lines is as follows:

$$2n/m = 2(pm+q)/m = 2p + 2q/m.$$

When $2q$ is smaller than *m*, the number is *2p*. The nozzle Nn is added, then the number of ejectable nozzles is $2p+1$. In case of $2q \geq m$, the number is $2p+1$, and the number of ejectable nozzles is $2p+2$.

[0066] When this is generalized, the number of nozzles positioned in $i \times n$ pitches ahead of the *mn* lines at the *i-th n* pitch feed is an integer portion of the following:

$$i \times n/m = i(pm+q)/m = ip + iq/m.$$

This value differs with values of *q* and *m*. When this is represented by Gauss' notation, the following results:

$$[i \times n/m] = [i(pm+q)/m].$$

When the nozzle Nn positioned in $mn+in$ line is added, the number of ejectable nozzles is:

$$[i \times n/m]+1.$$

The number of non-ejectable nozzles should be:

$$n - ([i \times n/m]+1).$$

[0067] Specifically, at the *i*-th $(1 \leq i \leq (m-1))n$ pitch feed, the number of ejectable nozzles from the downstream side of the recording sheet feeding direction is:

$$[i \times n/m] + 1 \quad (10),$$

while the number of non-ejectable nozzles from the upstream side of the feeding direction is:

$$n - ([i \times n/m]+1) \quad (11).$$

[0068] In the example of the number of nozzles $n=5$, the pitch between nozzles $m=4$ shown in Fig. 4, the number of ejectable nozzles in the first *n* pitch feed is $[1 \times 5/4]+1=2$. The number of ejectable nozzles in the second *n* pitch feed is $[2 \times 5/4]+1=3$. The number of ejectable nozzles in the third *n* pitch feed is $[3 \times 5/4]+1=4$ (refer to Fig. 4B).

[0069] In the example of the number of nozzles $n=7$, the pitch between nozzles $m=4$ shown in Fig. 5, the number of ejectable nozzles in the first *n* pitch feed is $[1 \times 7/4]+1=2$. The number of ejectable nozzles in the second *n* pitch feed is $[2 \times 7/4]+1=4$. The number of ejectable nozzles in the third *n* pitch feed is $[3 \times 7/4]+1=6$ (refer to Figs. 5B, 5C).

[0070] In an embodiment described later (the number of nozzles *n=51,* the pitch between nozzles *m=4*), the number of ejectable nozzles in the first *n* pitch feed is *[1×51/4]+1=13*, The number of ejectable nozzles in the second *n* pitch feed is *[2×51/4]+1=26*. The number of ejectable nozzles in the third *n* pitch feed is *[3×51/4]+1=39*.

EMBODIMENT

[0071] Preferred embodiment of the present invention will be described hereinafter with reference to Figs. 1 to 3.

[0072] Fig. 1 shows one embodiment of an ink jet printer according to the present invention. A printer unit 2 of an ink jet printer 1 is supported by a pair of stands 4, 4. A plurality of casters 3, 3 ... are attached to the stands 4, 4. The stands 4, 4 are interconnected via an auxiliary frame 5 which is positioned in substantially the middle of each stand 4 in the vertical direction.

[0073] A plate-like platen 6 for defining a record face of a recording sheet is oriented upward in the printer unit 2. A plurality of suction holes 7, 7 ... are formed in the top surface of the platen 6. When a recording sheet (not shown) fed on the surfece of platen 6, the sheet is sucked onto the top surface of the platen 6 by the action of the negative pressure in the suction hole 7. Accordingly, the recording sheet is fixedly adheres to the top surface of the platen 6.

[0074] A pair of carriage shafts 8, 8 extending parallel relative to the longitudinal direction of the platen 6 are disposed behind the platen 6 of the printer unit 2. A reciprocatable carriage 9 is disposed along the carriage shafts 8. A carriage drive belt 10 positioned between the carriage shafts 8 is secured to the carriage 9. The carriage drive belt 10 is operated by a drive device (not shown) and, as a result, the carriage 9 is reciprocated along the carriage shafts 8. Specifically, the carriage 9 constitutes nozzle moving means in the printer of the present invention.

[0075] An ink jet head H is disposed to the carriage 9 to face the platen 6. Ink ejecting nozzles are assembled in the ink jet head H to face a recording surface 6a of the platen 6. As shown in Fig. 2, the ink jet head H is provided with two head modules 30 provided for each of four colors of yellow (Y), magenta (M), cyan (C) and black (B), and eight head modules 30 are provided in total.

[0076] Each of the modules 30 is provided with twenty six (26) ink ejecting nozzles aligned/arranged in a direction parallel with a recording sheet feeding direction. Nozzle intervals are formed in such a manner that seven recording pixels are positioned between adjacent nozzles. A distance between nozzle centers is eight pitches. Two of the modules 30 are arranged so as to position the nozzle of one module between adjacent nozzles of the other module, and they form a head unit 32 for each color. Therefore, three pixels are positioned between the nozzles N in the head unit 32, and a pitch between nozzles *m* is four. Moreover, the total number of nozzles is 26×2=52, but the lowermost nozzle cannot be used and, therefore, the number of effective nozzles *n* is 51. In the embodiment, recording resolution is set to 160 dpi (dots/inch).

[0077] The number *n* of nozzles N and the interval between adjacent nozzles N can optionally be selected in accordance with design concept or another requirement. The structure of the ink ejecting nozzle N is the same as that of the conventional nozzle.

[0078] As shown in Fig. 1, four ink tanks 11, each thereof for each color, are disposed on one side (left side) in the rear of the printer unit 2. The ink tank 11 is communicated with the head module 30 of the ink jet head H via a tube 12. The tube 12 supplies ink to each nozzle N of the head module 30 for each color from each ink tank 11 via the carriage 9.

[0079] One end (left end in Fig. 1) of the platen 6 of the printer unit 2 is set in the home position of the ink jet head H. A cap 13 is disposed in the position corresponding to the home position. The cap 13 covers the head nozzles N, when not in use, to prevent the drying of ink inside the nozzles and the attachment of foreign particles. Moreover, the cap 13 sucks and collects the ink ejected by recovering operation of the nozzles N of the ink jet head H.

[0080] A feeding means or recording sheet feeding mechanism 34 is provided for feeding the recording sheet positioned between the platen 6 and the ink jet head H to the front of the printer unit 2. The sheet can be fed by one pitch or *n* pitches as required.

[0081] The auxiliary frame 5 is provided with a recording sheet wind-up mechanism 14. The wind-up mechanism 14 is provided with a pair of supports 15a, 15b positioned on opposite sides of the auxiliary frame 5. In the embodiment, one support 15a (left support in Fig. 1) is fixed to the auxiliary frame 5, while the other support 15b can be moved along the auxiliary frame 5.

[0082] A shaft support recess 17 open upward is formed in each of the supports 15a, 15b for supporting a wind-up shaft 16, and three support rollers 18 are rotatably arranged inside the shaft support recess 17. The wind-up shaft 16 is rotatably and detachably supported by the support rollers 18.

[0083] A wind-up drive gear 19 is disposed under the shaft support recess 17 of the fixed support 15a, and one end of the wind-up shaft 16 is provided with a wind-up follower gear 20 engaged with the wind-up drive gear 19. The wind-up shaft 16 is rotated/operated via the wind-up follower gear 20 by rotating/operating the wind-up drive gear 19.

[0084] As shown by a dashed line on the left side of Fig. 1, a controller 21 for controlling the operation of each section of the ink jet printer 1 is disposed inside the printer unit 2.

[0085] As shown in Fig. 3, the controller 21 is provided at least with CPU 22, a memory 23 formed of an appropriate

volume of ROM, RAM, and the like, and a drive controller 24 for operating each printer section.

[0086] The memory 23 comprises an operation control program memory 25 for controlling recording operation and feeding operation of the printer. A feeding pitch control program 26 for varying/controlling the feeding pitch of the recording sheet and an ejection control program 27 for controlling the ink ejecting of each nozzle N are stored in the operation control program memory 25.

[0087] These control programs performs the variable control of the feeding pitch of the recording sheet and the ink ejecting of each nozzle in accordance with the principle of the present invention. Thereby, the non-recorded area which cannot be used in recording is prevented from being generated in the top end of the recording sheet feeding direction. All the recorded lines are recorded without overlapping one another or without generating any gap.

[0088] The operation of the ink jet printer will now be described.

[0089] The recording sheet is fed between the platen 6 and the ink jet head H by the sheet feeding mechanism 34 to set the top end of the recording sheet in the feeding direction in a predetermined position. Thereafter, while the carriage 9 is reciprocated along the carriage shafts 8 by driving the carriage drive belt 10, the ink jet head H is operated based on recording information. A desired image is recorded on the recording sheet by repeating the image forming operation in which the line unit recorded image of each nozzle N is formed on the recording sheet by ejecting the ink via the nozzles N and the line feeding operation in which the recording sheet is fed at a predetermined feeding pitch. The wind-up drive gears 19 are rotated/operated in synchronization with the line feeding operation, and the recording sheet is taken up by the wind-up shaft 16 rotated/operated via the wind-up follower gear 20.

[0090] In the present invention, the operation for forming the recorded image onto the recording sheet is performed in accordance with the aforementioned principle. In the embodiment, since the number of nozzles *n* is 51 and the pitch between nozzles *m* is four, the operation is performed as follows:

[0091] In the first image forming operation, the carriage 9 is moved from the left to the right. During the operation, the ink is ejected via all of 51 nozzles by a control instruction transmitted from the controller 21 in accordance with the ejection control program 27.

[0092] Subsequently, the recording sheet is fed by one pitch by the control instruction transmitted from the controller 21 in accordance with the feeding pitch control program 26. Specifically, the recording sheet is fed by one pixel. Thereafter, while the carriage 9 is moved from the right to the left, the controller 21 allows all the nozzles to eject the ink. The *n* pitch feed or feeding operation and the image forming operation using all the nozzles are performed three (=*m-1*) times. As a result, m×n=4×51=204 lines are recorded without any gap.

[0093] Subsequently, the n pitch feed is performed. Specifically, the recording sheet is fed only by n=51 pitches. In the first *n* pitch feed, [1×51/4]+1=13 nozzles on the feeding terminal end of the recording sheet can eject the ink without overlapping the recorded lines by the equation (10). Therefore, 51-13=38 nozzles on the top end of the recording sheet cannot eject the ink.

[0094] In the second *n* pitch feed, [2×51/4]+1=26 nozzles on the terminal end of the recording sheet can eject the ink.

[0095] In the third *n* pitch feed, [3×51/4]+1=39 nozzles on the terminal end of the recording sheet can eject the ink.

[0096] In the fourth *n* pitch feed, any one of the 51 nozzles overlaps the recorded lines. Therefore, the image forming operation is performed using all the nozzles.

[0097] Thereafter, when the line feeding operation each of *n=51* pitches is repeated, all the nozzles N1 to N51 fail to overlap the recorded lines and can perform recording without generating any non-recorded area or gap.

[0098] As described above, the recorded image can easily and securely be formed without any interruption between the lines of the recorded image from thebeginning of the recording operation while the nozzle N1 is used as an origin.

[0099] Additionally, the present invention is not limited to the aforementioned embodiment, and can be modified variously as required.

[0100] As described above, in the recording method of the ink jet printer of the present invention, the control for varying the feeding pitch of the recording sheet and the control of the ink ejecting of each nozzle are performed during the recording operation. Therefore, the non-recorded area which cannot be used in recording can be prevented from being generated on the top end of the recording sheet feeding direction. Recording can be performed even in the non-recorded area which is heretofore generated on the top end of the recording sheet feeding direction and which cannot be used in recording. As a result, the effective use of the recording sheet and the enlargement of the recording area can advantageously be realized.

Claims

1. A recording method of an ink jet printer for recording a desired image on a recording sheet by repeating:

   a line feeding operation in which the recording sheet is fed at a predetermined feeding pitch; and
   an image forming operation in which a plurality of ink ejecting nozzles aligned/arranged at a predetermined

interval in a direction substantially parallel with a feeding direction of said recording sheet are moved along a scanning direction which is a direction substantially orthogonal to said feeding direction of the recording sheet, and operated to eject ink to form a line unit image by dots of the ink ejected of each nozzle on said recording sheet;

wherein a control for a variable feeding pitch of said recording sheet and a control of ink ejecting of said each nozzle are performed to prevent a non-recorded area unable to be used in recording from being generated in a top end of the feeding direction of the recording sheet.

2. The recording method according to claim 1, comprising the steps of:

a) providing *n* nozzles arranged at the predetermined interval in the direction substantially parallel with the recording sheet feeding direction, said predetermined interval between the nozzles being set to a pitch between pixcels multiplied by an integer *m; n,m* having no common divisor other than one and having the following relationship:

$$n = pm+q$$

where *p* is an integer of one or more;
m is an integer of two or more; and
q is an integer of one or more and less than *m;*

b) first, allowing said *n* nozzles to eject ink while moving *n* nozzles in the scanning direction so that the line unit image of each nozzle is recorded;

c) subsequently, feeding the recording sheet by one pitch, then, allowing said *n* nozzles to eject the ink while moving *n* nozzles in the scanning direction so that the line unit image of each nozzle is recorded; these operations being repeated *m-1* times, $m \times n$ lines being recorded by the operations of the steps b), c);

d) subsequently, feeding the recording sheet by *n* pitches, then, allowing only the nozzles not overlapping already recorded lines, among said *n* nozzles, to eject the ink while moving *n* nozzles in the scanning direction so that the line unit image each of the non-overlapping nozzles is recorded; these operations being repeated *m-1* times; and

e) thereafter, every time the recording sheet is fed by *n* pitches, allowing all of said *n* nozzles to eject the ink while moving *n* nozzles in the scanning direction so that the line unit image of each nozzles is recorded, whereby all lines are recorded without being overlapped or generating a non-recorded line.

3. The recording method according to claim 2, wherein in said step d), at the *i*-th ($1 \leq i < m-1$) *n* pitch feed, $[i \times n/m]+1$ nozzles, represented by Gauss' notation, from the downstream side in the recording sheet feeding direction are allowed to eject the ink.

4. An ink jet printer for recording a desired image on a recording sheet by repeating;

a line feeding operation in which the recording sheet is fed at a predetermined feeding pitch; and
an image forming operation in which a plurality of ink ejecting nozzles aligned/arranged at a predetermined interval in a direction substantially parallel with a feeding direction of said recording sheet are moved along a scanning direction which is a direction substantially orthogonal to said feeding direction of the recording sheet, and operated to eject ink to form a line unit image by dots of the ink ejected of each nozzle on said recording sheet, comprising:
a controller for performing a control for a variable feeding pitch of said recording sheet and a control of ink ejecting of said each nozzle.

5. The ink jet printer according to claim 4, comprising:

a) *n* nozzles arranged at the predetermined intervals in the direction substantially parallel with the recording sheet feeding direction, said predetermined interval between the nozzles being set to a pitch between pixcels multiplied by an integer *m; n, m* having no common divisor other than one and having the following relationship:

$$n = pm + q;$$

where *p* is an integer of one or more;
m is an integer of two or more; and
q is an integer of one or more and less than *m;*

b) feeding means for feeding the recording sheet at either one pitch or *n* pitches;

c) nozzle moving means for reciprocating said *n* nozzles in the scanning direction; and

d) a controller for controlling operations of said *n* nozzles, said feeding means and said nozzle moving means in the following steps:

1) first, allowing said *n* nozzles to eject the ink while driving said nozzle moving means to move said *n* nozzles in the scanning direction so that the line unit image of each nozzle is recorded;

2) subsequently, driving said feeding means to feed the recording sheet by one pitch, then, allowing said *n* nozzles to eject the ink while driving said nozzle moving means to move said *n* nozzles in the scanning direction so that the line unit image of each nozzle is recorded; these operations being repeated *m-1* times, $m \times n$ lines being recorded by the operations of the steps 1), 2);

3) subsequently, driving said feeding means to feed the recording sheet by *n* pitches, then, allowing only the nozzles not overlapping already recorded lines, among said *n* nozzles, to eject the ink while driving said nozzle moving means so that the line unit image of each of the non-overlapping nozzles is recorded; these operations being repeated *m-1* times; and

4) thereafter, every time said feeding means is driven to feed the recording sheet by n pitches, allowing all of said *n* nozzles to eject the ink while driving said nozzle moving means, and recording the line unit image.

6. The ink jet printer according to claim 5, wherein in said step 3), at the *i*-th ($1 \leq i \leq m-1$) *n* pitch feed, $[i \times n/m]+1$ nozzles, represented by Gauss' notation, from the downstream side in the recording sheet feeding direction are allowed to eject the ink.

FIG.1

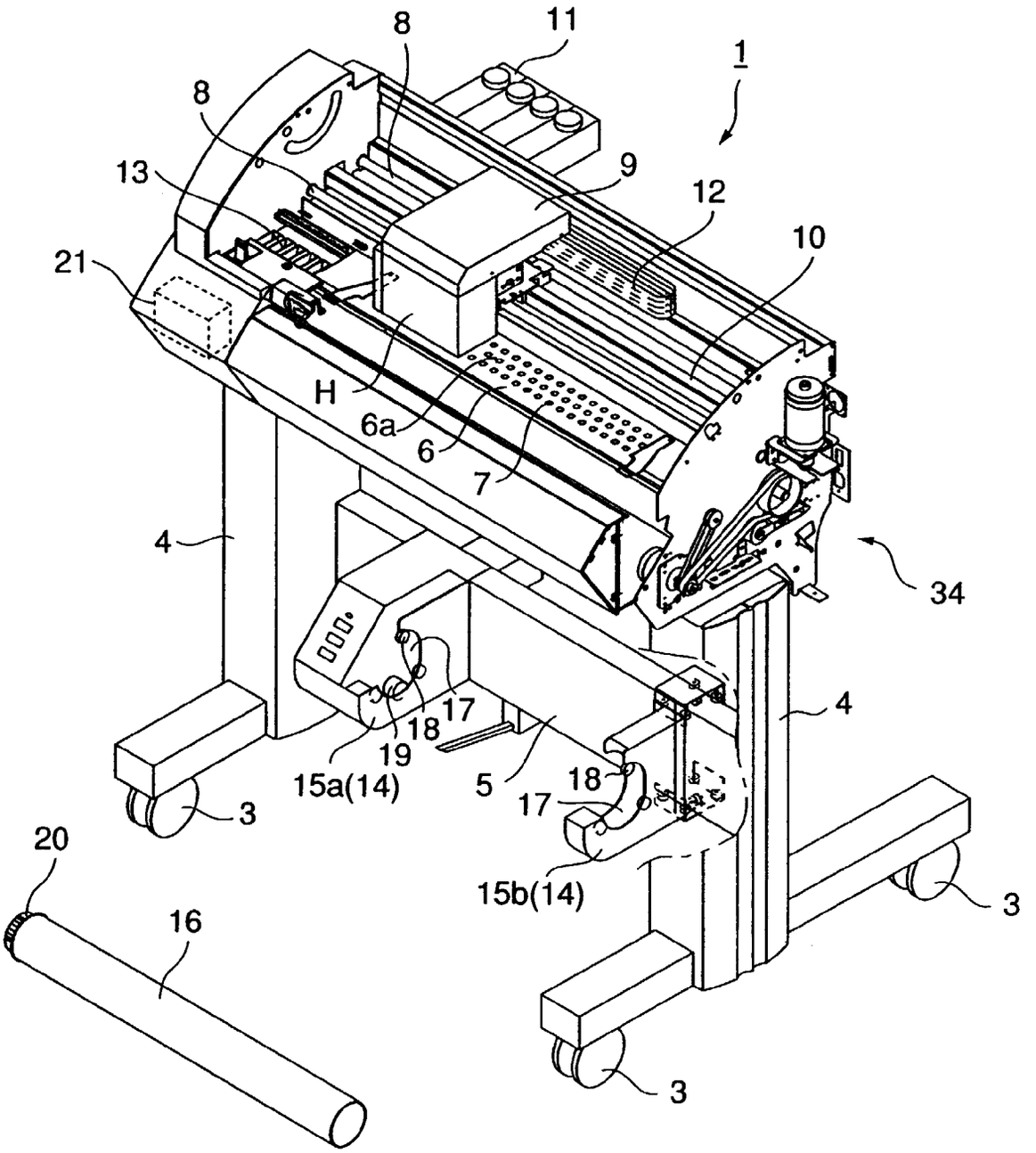
8
11
1
8
13
9
12
10
21
H
6a
6
7
4
34
4
18
17
19
15a(14)
5
18
17
3
20
16
15b(14)
3
3

FIG.2

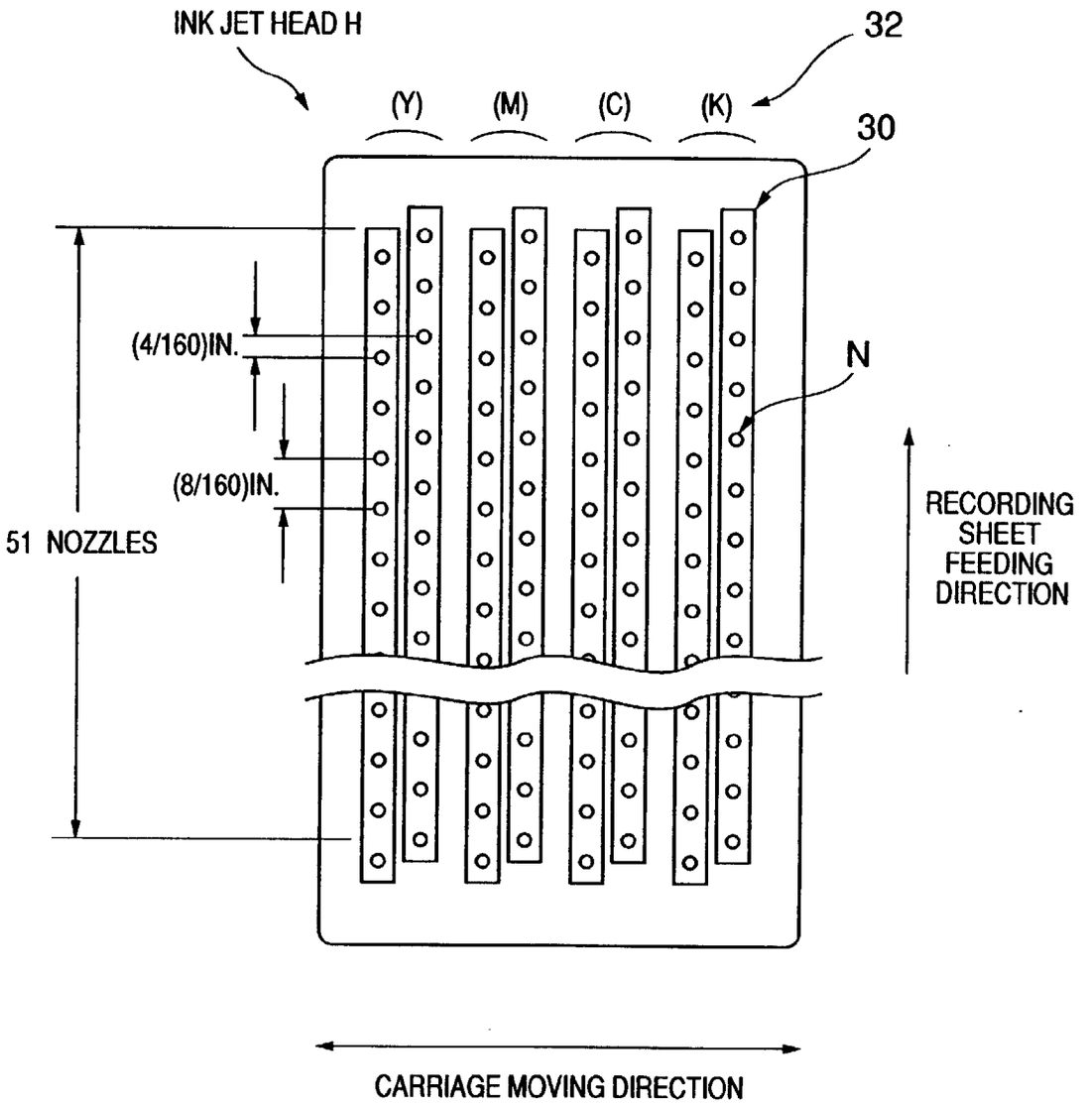
INK JET HEAD H
32
(Y)
(M)
(C)
(K)
30
(4/160)IN.
(8/160)IN.
N
51 NOZZLES
RECORDING SHEET FEEDING DIRECTION
CARRIAGE MOVING DIRECTION

FIG.3

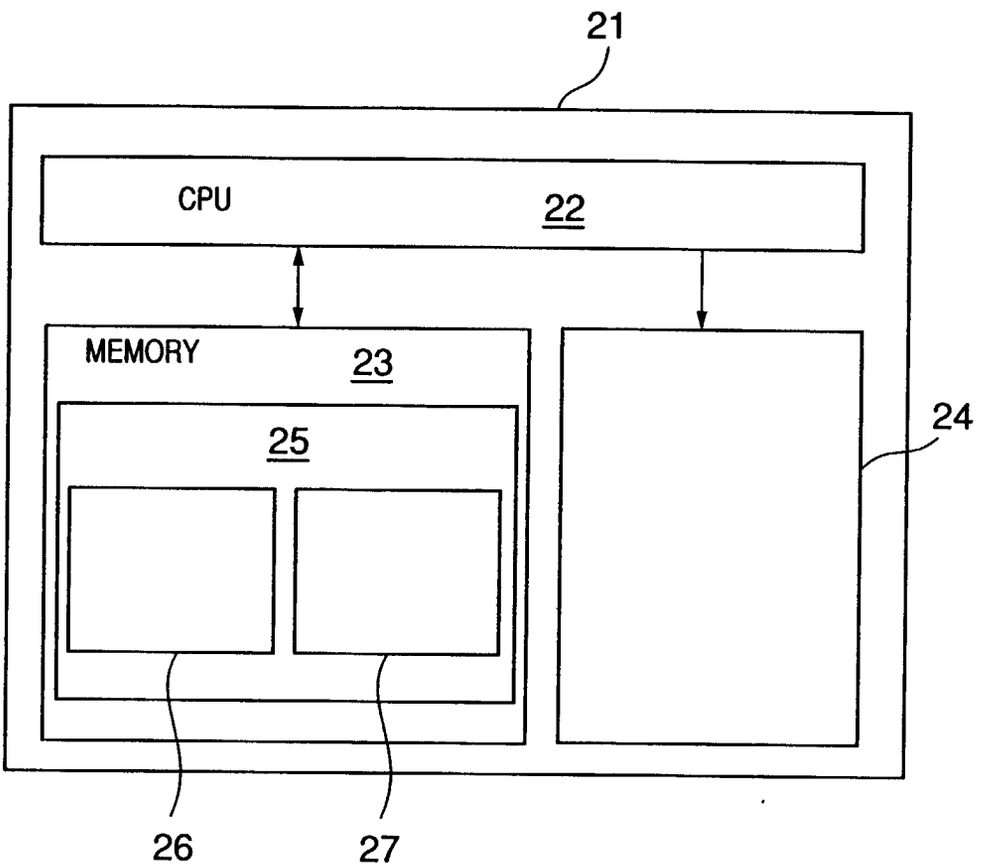

FIG.4A

LINE NO.		1 PITCH FEED 1ST	2ND	3RD	m × n LINES RECORDED
1	NOZZLE N1 ①				①
2		①			①
3			①		①
4				①	①
5	NOZZLE N2 ②				②
6		②			②
7			②		②
8				②	②
9	NOZZLE N3 ③				③
10		③			③
11			③		③
12				③	③
13	NOZZLE N4 ④				④
14		④			④
15			④		④
16				④	④
17	NOZZLE N5 ⑤				⑤
18		⑤			⑤
19			⑤		⑤
20				⑤	⑤

FIG.4B

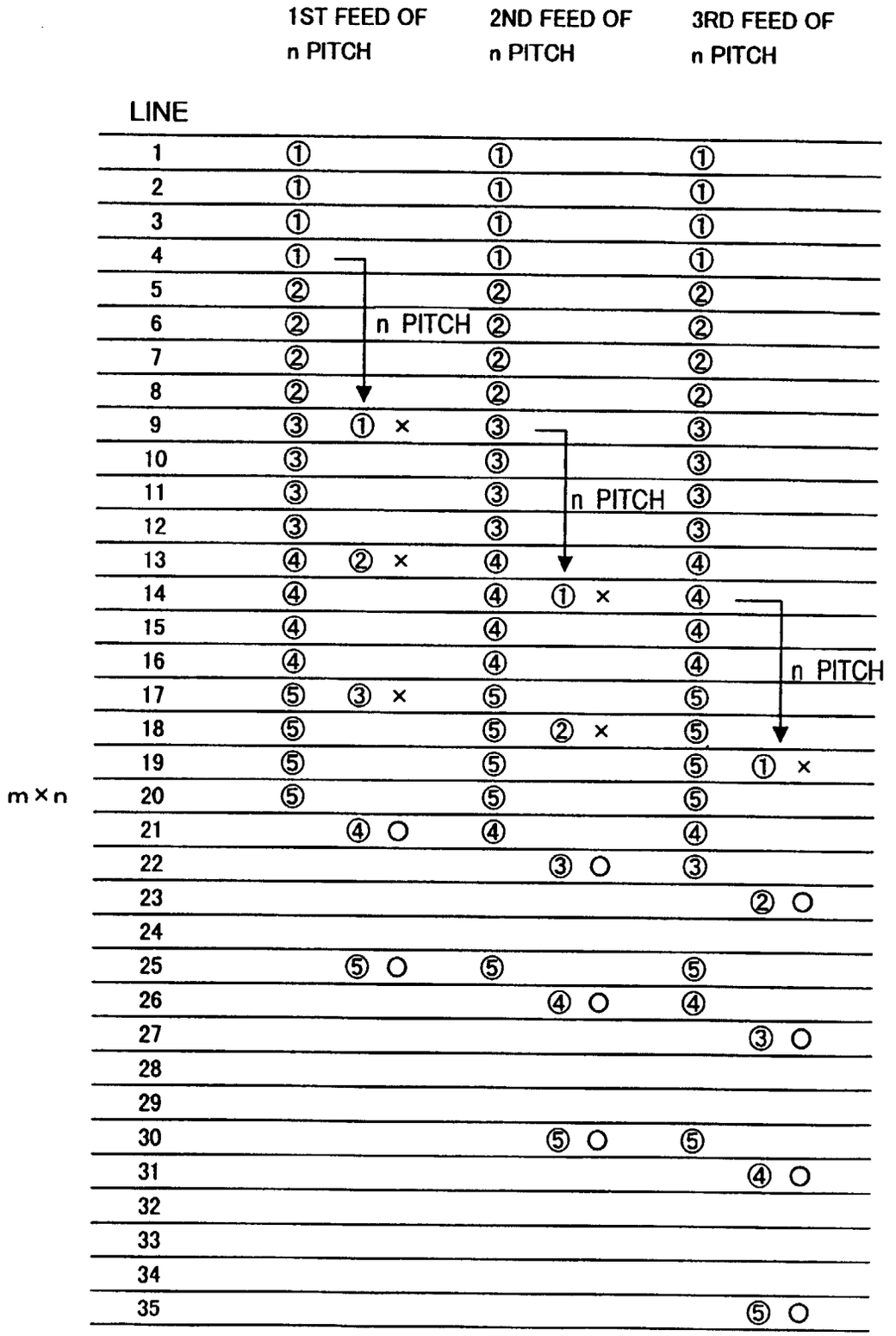
1ST FEED OF n PITCH
2ND FEED OF n PITCH
3RD FEED OF n PITCH
LINE
n PITCH
n PITCH
n PITCH
m × n

FIG.4C

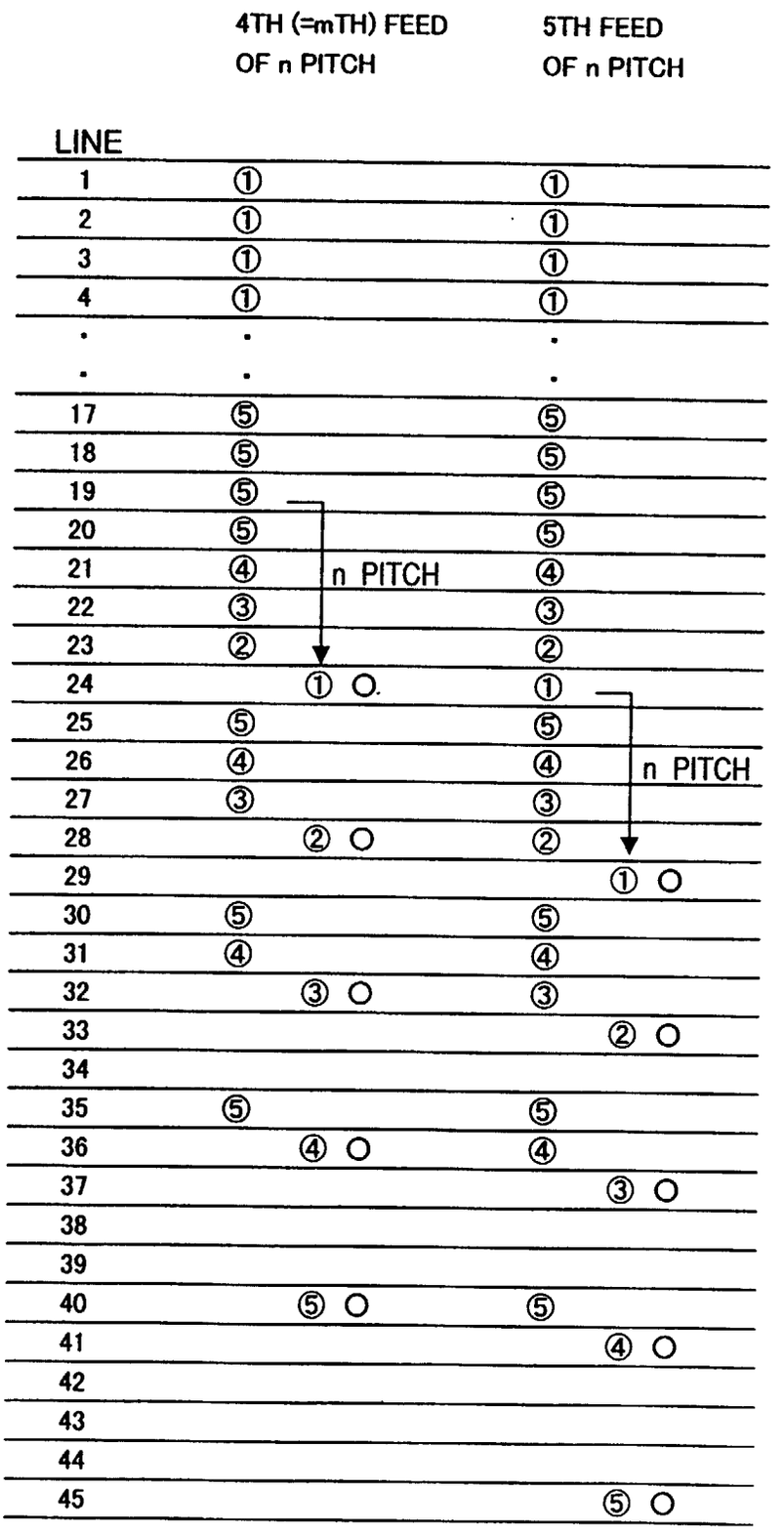
4TH (=mTH) FEED OF n PITCH
5TH FEED OF n PITCH
LINE
1 ① ①
2 ① ①
3 ① ①
4 ① ①
17 ⑤ ⑤
18 ⑤ ⑤
19 ⑤ ⑤
20 ⑤ ⑤
21 ④ n PITCH ④
22 ③ ③
23 ② ②
24 ① ○ ①
25 ⑤ ⑤
26 ④ ④ n PITCH
27 ③ ③
28 ② ○ ②
29 ① ○
30 ⑤ ⑤
31 ④ ④
32 ③ ○ ③
33 ② ○
34
35 ⑤ ⑤
36 ④ ○ ④
37 ③ ○
38
39
40 ⑤ ○ ⑤
41 ④ ○
42
43
44
45 ⑤ ○

FIG.5A

LINE NO.		1 PITCH FEED 1ST	2ND	3RD	m×n LINES RECORDED
1	NOZZLE N1 ①				①
2		①			①
3			①		①
4				①	①
5	NOZZLE N2 ②				②
6		②			②
7			②		②
8				②	②
9	NOZZLE N3 ③				③
10		③			③
11			③		③
12				③	③
13	NOZZLE N4 ④				④
14		④			④
15			④		④
16				④	④
17	NOZZLE N5 ⑤				⑤
18		⑤			⑤
19			⑤		⑤
20				⑤	⑤
21	NOZZLE N6 ⑥				⑥
22		⑥			⑥
23			⑥		⑥
24				⑥	⑥
25	NOZZLE N7 ⑦				⑦
26		⑦			⑦
27			⑦		⑦
m×n 28				⑦	⑦

FIG.5B

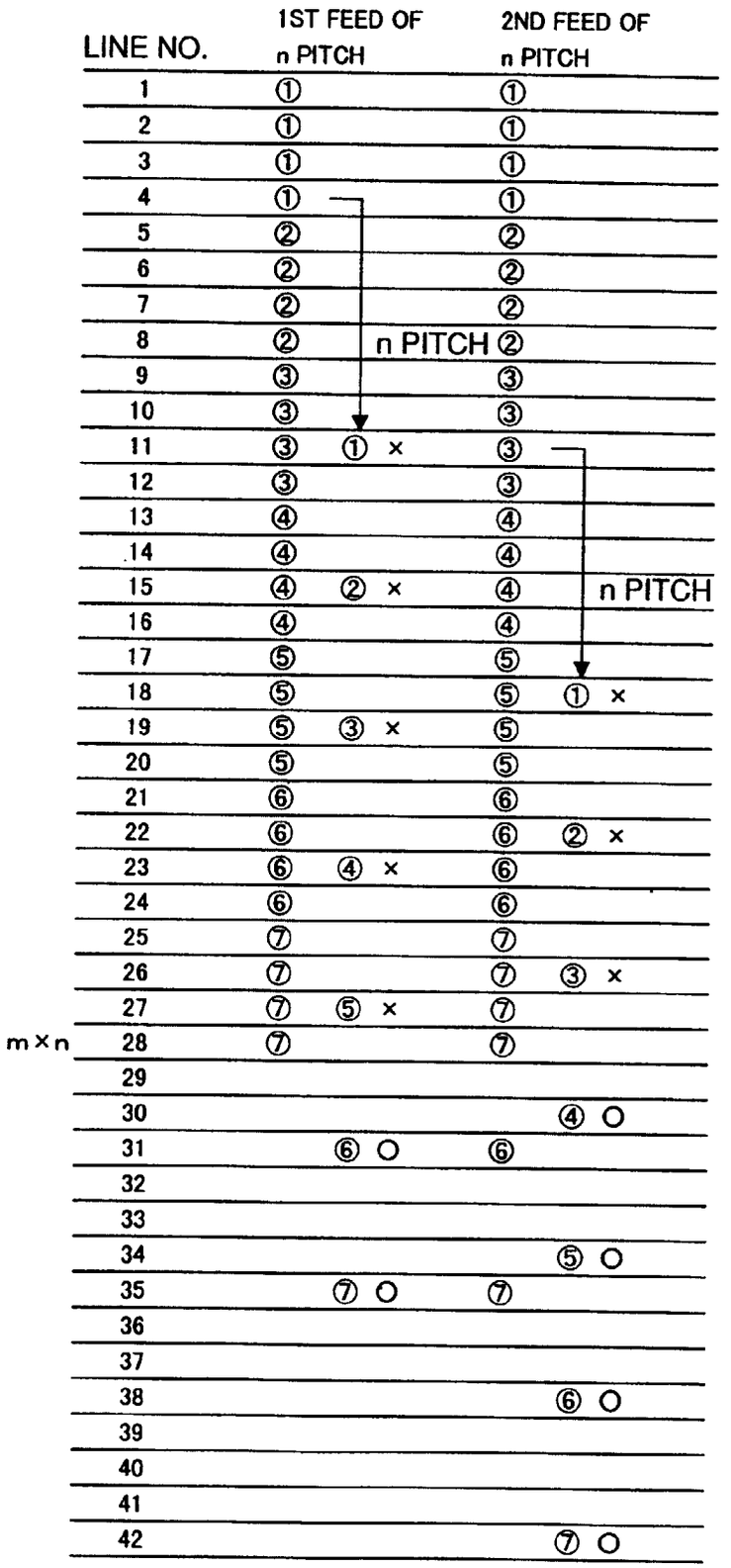
LINE NO.
1ST FEED OF n PITCH
2ND FEED OF n PITCH
n PITCH
n PITCH
m×n
1 ① ①
2 ① ①
3 ① ①
4 ① ①
5 ② ②
6 ② ②
7 ② ②
8 ② ② n PITCH
9 ③ ③
10 ③ ③
11 ③ ① × ③
12 ③ ③
13 ④ ④
14 ④ ④
15 ④ ② × ④ n PITCH
16 ④ ④
17 ⑤ ⑤
18 ⑤ ⑤ ① ×
19 ⑤ ③ × ⑤
20 ⑤ ⑤
21 ⑥ ⑥
22 ⑥ ⑥ ② ×
23 ⑥ ④ × ⑥
24 ⑥ ⑥
25 ⑦ ⑦
26 ⑦ ⑦ ③ ×
27 ⑦ ⑤ × ⑦
28 ⑦ ⑦
29
30 ④ ○
31 ⑥ ○ ⑥
32
33
34 ⑤ ○
35 ⑦ ○ ⑦
36
37
38 ⑥ ○
39
40
41
42 ⑦ ○

FIG.5C

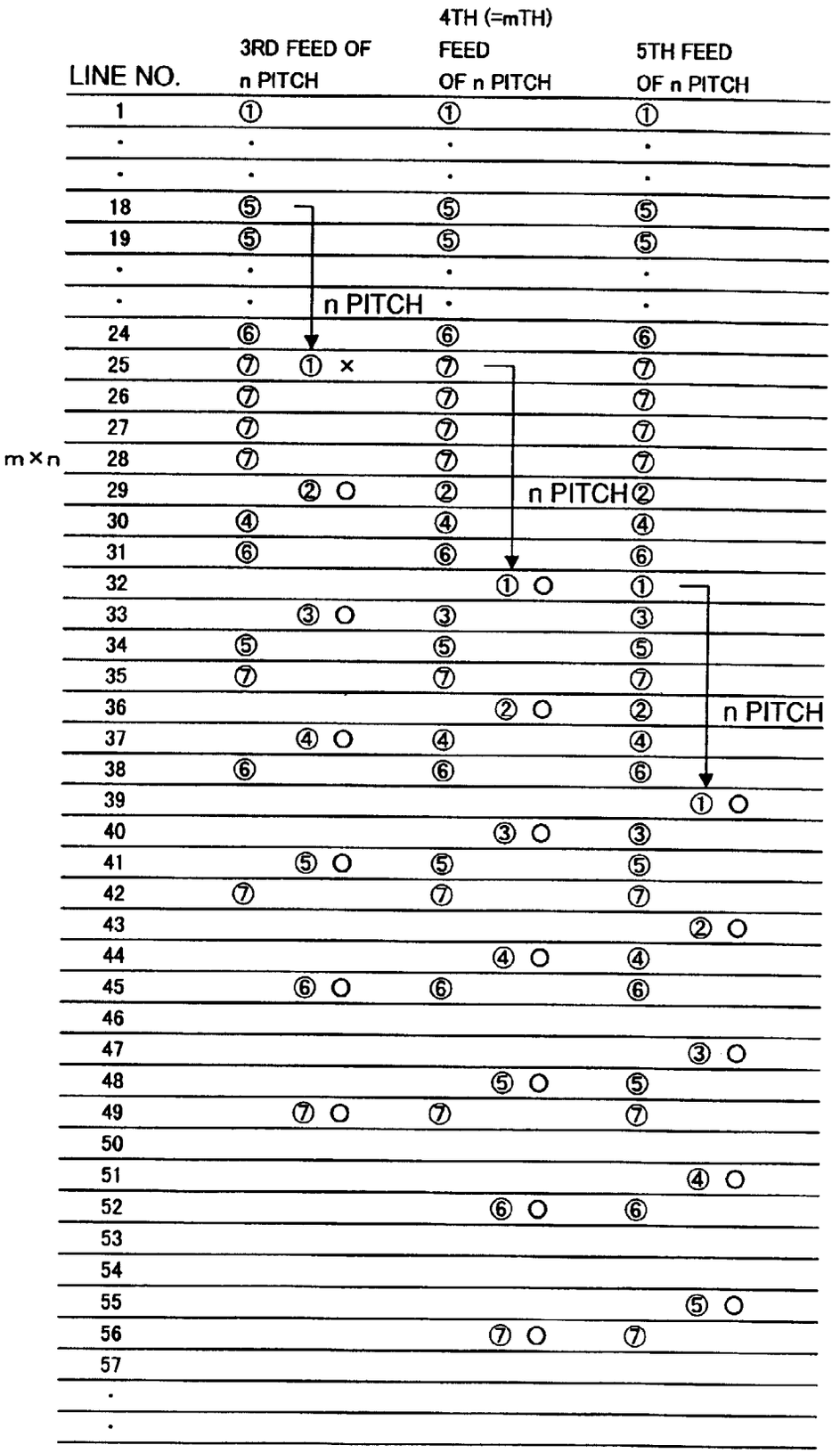
LINE NO.
3RD FEED OF n PITCH
4TH (=mTH) FEED OF n PITCH
5TH FEED OF n PITCH
n PITCH
n PITCH
n PITCH
m×n

FIG.6

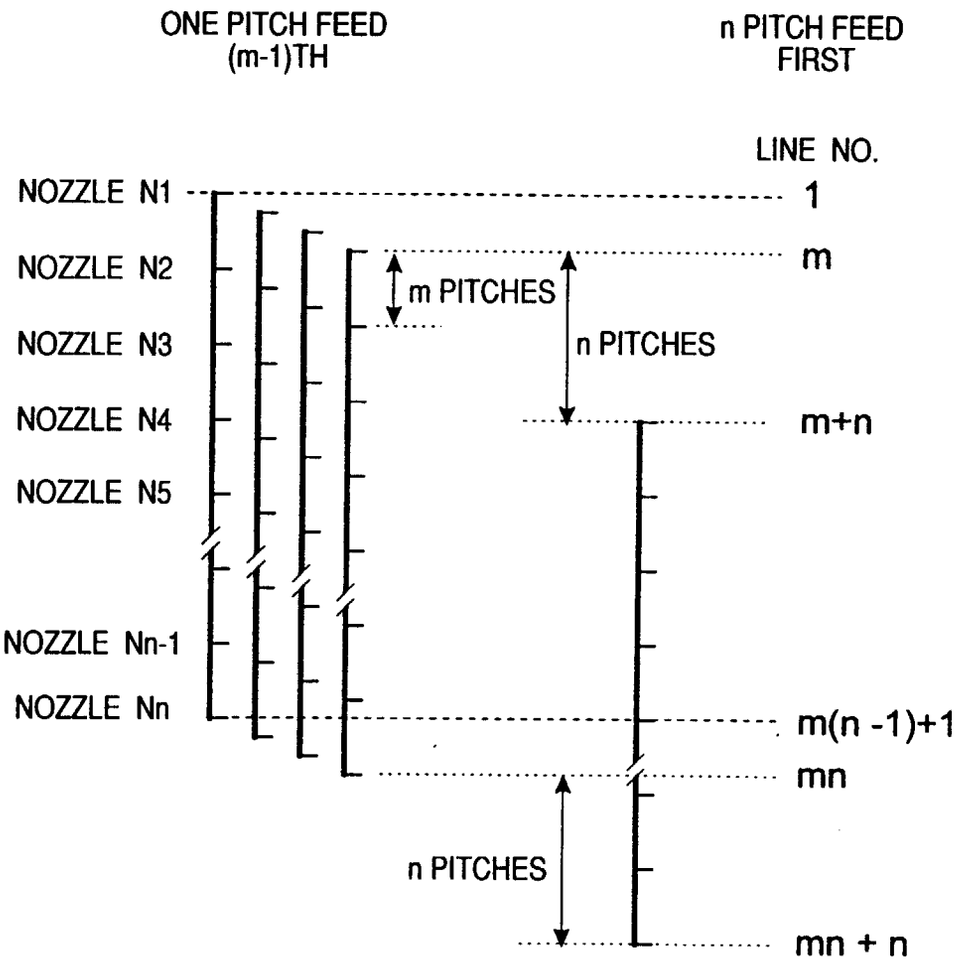
ONE PITCH FEED
(m-1)TH
n PITCH FEED
FIRST
LINE NO.
NOZZLE N1
NOZZLE N2
NOZZLE N3
NOZZLE N4
NOZZLE N5
NOZZLE Nn-1
NOZZLE Nn
1
m
m PITCHES
n PITCHES
m+n
m(n -1)+1
mn
n PITCHES
mn + n

FIG.7

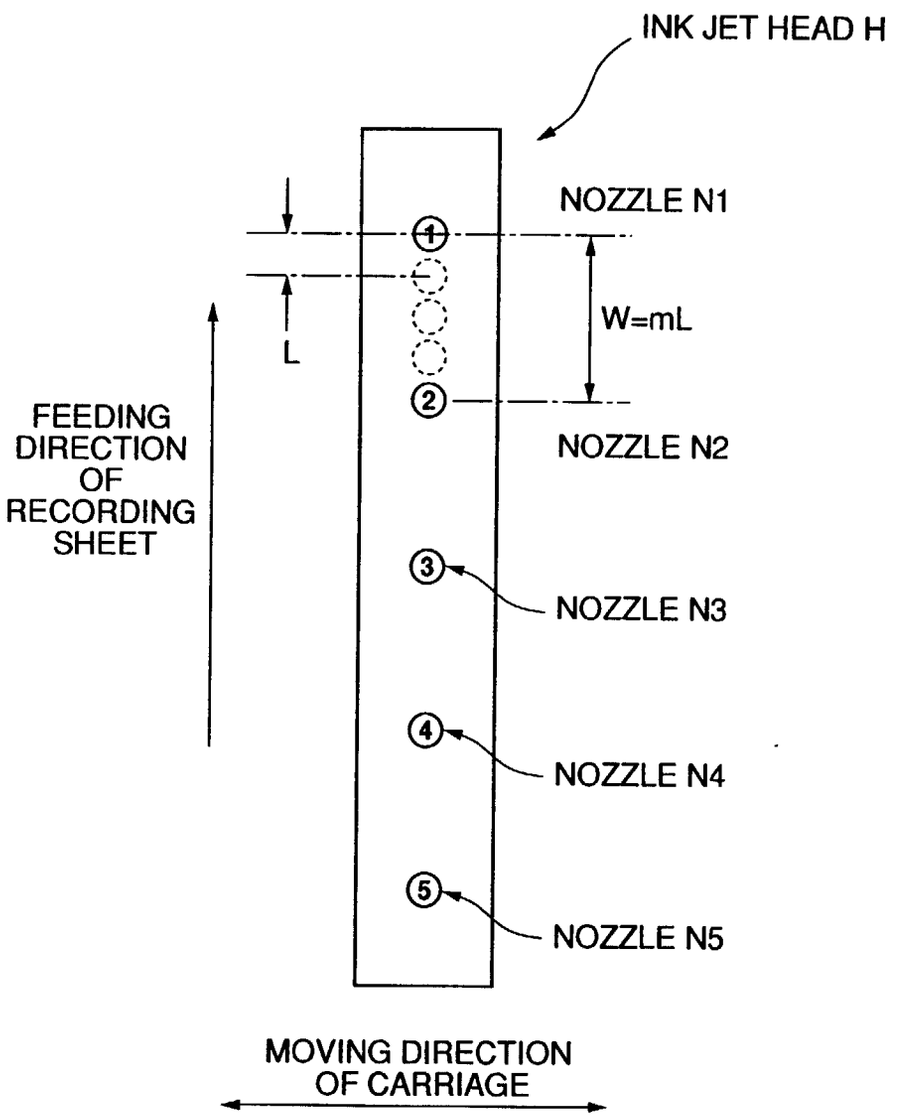
INK JET HEAD H
NOZZLE N1
W=mL
L
FEEDING DIRECTION OF RECORDING SHEET
NOZZLE N2
NOZZLE N3
NOZZLE N4
NOZZLE N5
MOVING DIRECTION OF CARRIAGE

FIG.8
PRIOR ART

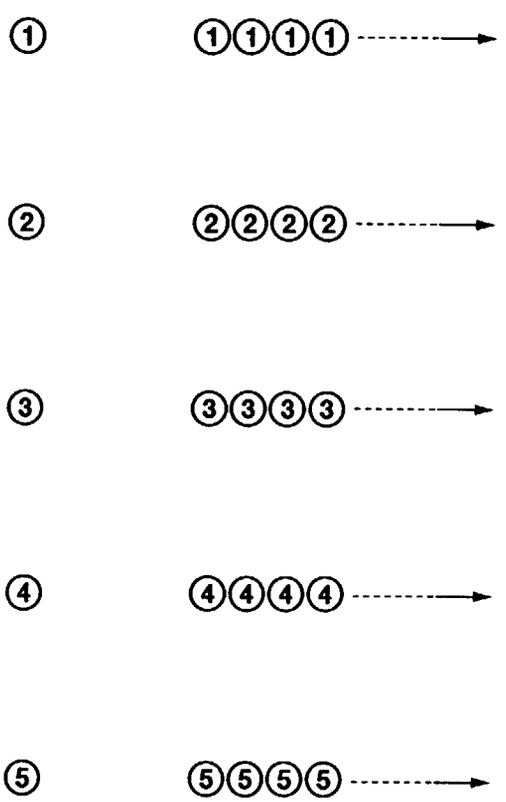

FIG.9
PRIOR ART

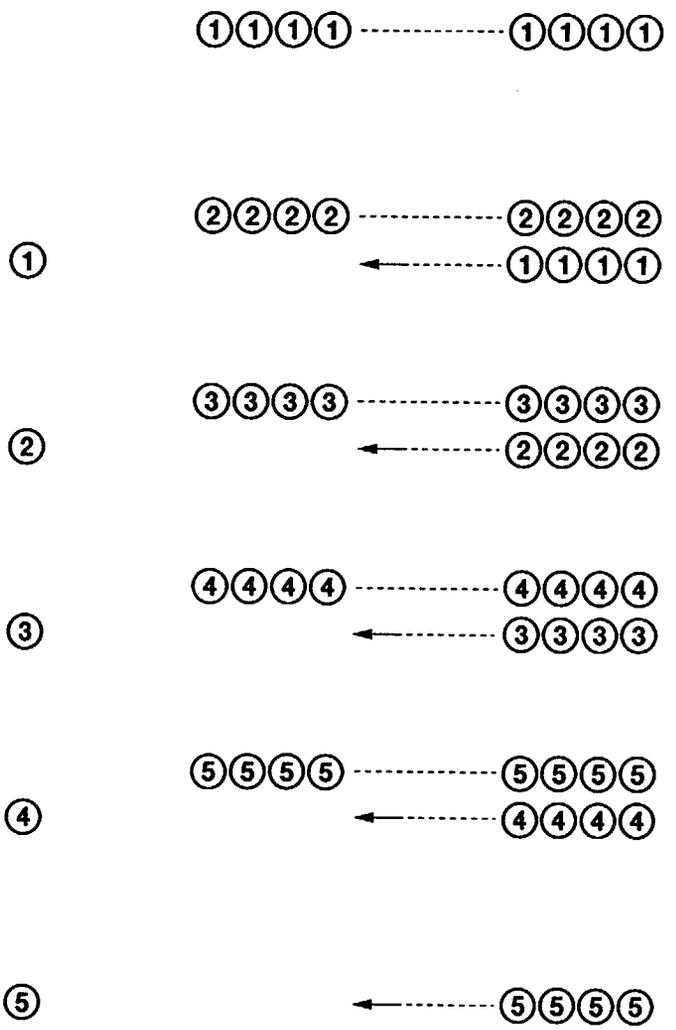

FIG.10
PRIOR ART

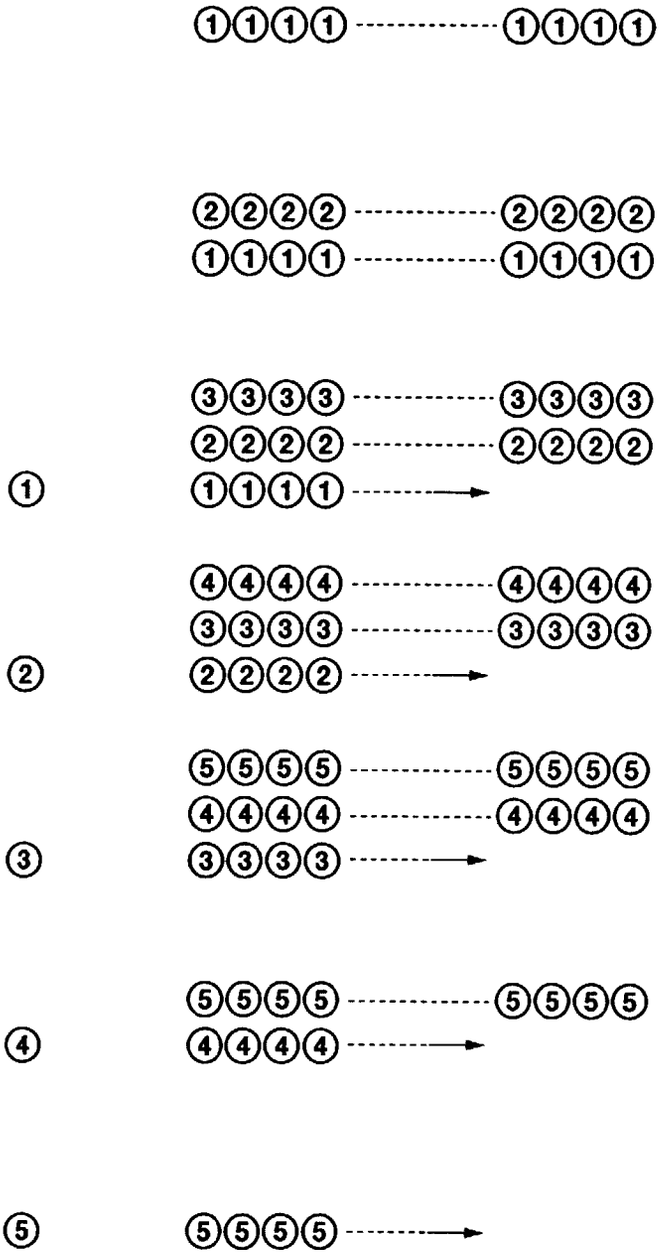

FIG.11
PRIOR ART