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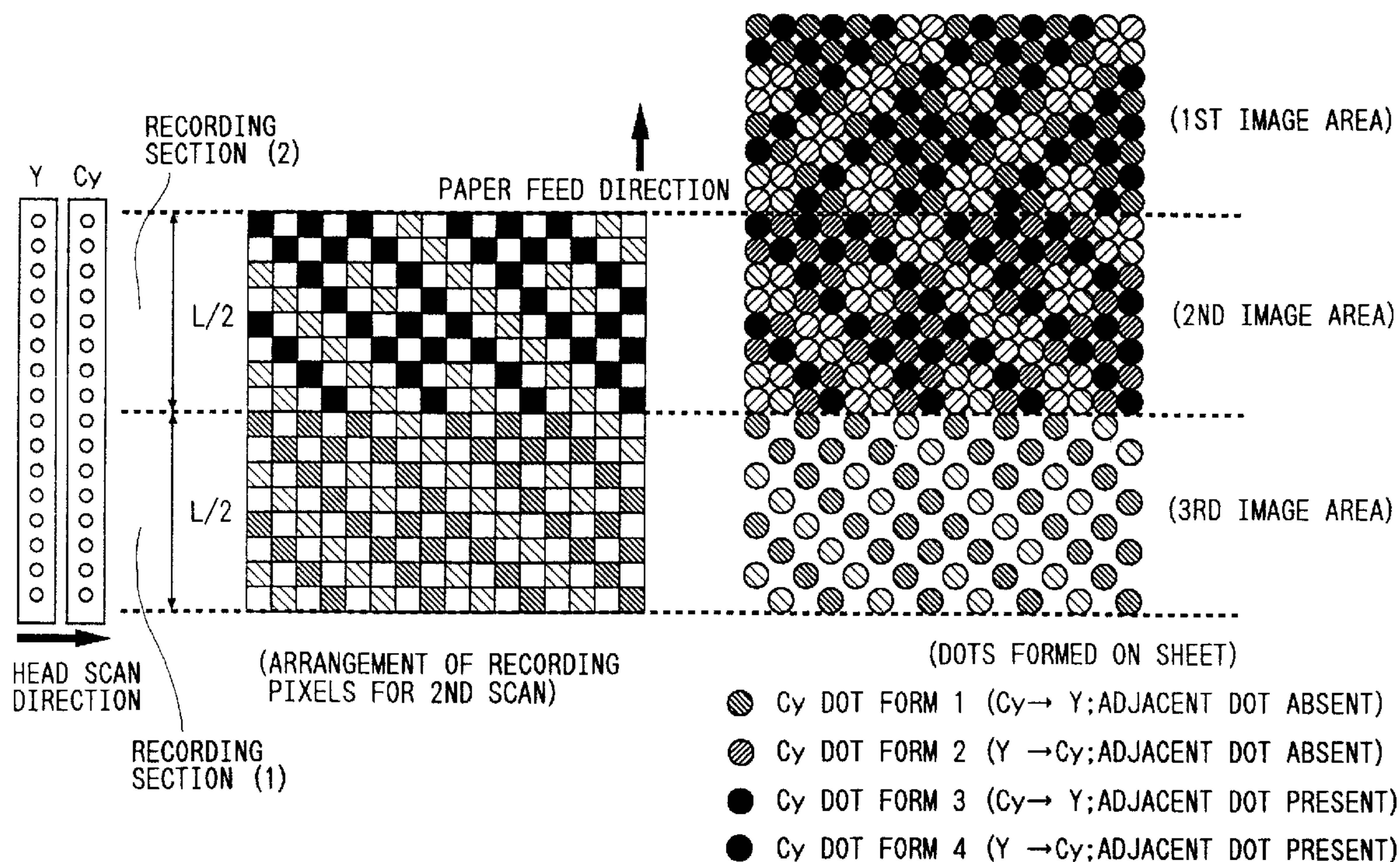
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(54) Titre : METHODE ET APPAREIL D'ENREGISTREMENT A JET D'ENCRE

(54) Title: INK JET RECORDING METHOD AND APPARATUS



(57) Abrégé/Abstract:

A recording section of each of recording heads of different recording colors is divided into a plurality of sub-sections, and the recording heads are moved back and forth relative to a recording medium to conduct a main scan in each run, and thinned images are sequentially recorded on the same area of the recording medium by using different recording sections of the recording heads in a plurality of main scans. The numbers of dots recorded in the main scans are equal without regard to the image data to prevent ununiformity of density due to reach accuracy and amount of discharge and regular ununiformity of color due to a sequence of ink injection.

1 ABSTRACT OF THE DISCLOSURE

 A recording section of each of recording heads
of different recording colors is divided into a
plurality of sub-sections, and the recording heads
5 are moved back and forth relative to a recording
medium to conduct a main scan in each run, and thinned
images are sequentially recorded on the same area of
the recording medium by using different recording
sections of the recording heads in a plurality of
10 main scans. The numbers of dots recorded in the main
scans are equal without regard to the image data to
prevent ununiformity of density due to reach accuracy
and amount of discharge and regular ununiformity of
color due to a sequence of ink injection.

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1 Ink Jet Recording Method and Apparatus

BACKGROUND OF THE INVENTIONField of the Invention

5 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.

10 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
15 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
20 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 a recording speed, a recording head (multi-head) having a plurality of recording elements integrated therein
25 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.

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1 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
5 image. As to the uniformity, even a slight variation
among nozzle units due to a difference among multi-
head manufacturing processes affects to an amount of
ink discharged from the nozzle and a direction of
discharge in printing and it finally appears as
10 ununiformity 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 light multi-
15 nozzles 92. 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
20 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
25 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.

1 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 over-
lap more than required, or a white band appears as
5 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.

10 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 Fig. 25 and 26 but
15 half of the print area (four-pixel unit area) is com-
pleted 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
20 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.
25 The above recording method is hereinafter referred
to as a divisional recording method.

In accordance with this recording method,

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1 the affect of the nozzle inherency 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
5 stripes and the white stripes shown in Fig. 26B
are not very prominent. As a result, the ununiformity
of density is also significantly relaxed compared to
that of Fig. 26, as shown in Fig. 27C.

In such recording method, the image data is
10 divided for the first scan and the second scan in
accordance with a predetermined arrangement so that
they complement each other. The image data arrange-
ment (thinned pattern) is usually a checker pattern
(or zigzag pattern) for each vertical and horizontal
15 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
20 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
25 is recorded by using the lower four nozzles (Fig. 28A).
In the second scan, hte sheet is fed by four pixels
(1/2 of the head length) and the reverse checker

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1 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).

5 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.

10 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.

This printing method is disclosed in USP
15 4,967,203 and Japanese Laid-Open Patent Application
No. 60-107975 and it is effective to solve the
problems of the ununiformity of density and the
connecting lines.

Although the above method can reduce the
20 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
25 inks of different colors are overlapped and put
adjacently.

Fig. 29 shows a printing method (hereinafter

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1 referred to as an L/n sheet feed printing method,
where n is the number of divisions) by the prior art
head division.

5 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
10 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
15 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
20 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
25 the record area. The same steps are repeated. In
Fig. 29, the indicia in the parentheses in the second
and third scan indicate the previously printed ones.

1 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
5 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
10 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
15 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
20 checker pattern so that the Cy-Y overlapped dots are
formed in the checker pattern on the recording
medium. Then, the 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).

25 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

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1 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
5 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
10 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.

15 Then, the 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
20 image area comes into the recording section (1).

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
25 deeply in the depthwise direction of the sheet than the
early printed dot and it spreads around the early
printed dot. The same is true when a dot reaches on

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1 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
5 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
10 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.

15 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 discharge positions in the third
20 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
25 (2). As a result, dots reach in the recording
section (1) adjacently to the reverse checker dots
recorded in the second scan to complete the printing.

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1 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
5 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.

10 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
15 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
20 recording scans are different, the numbers of Cy dots
which are injected to the areas having the Cy or Y
dots formed adjacently thereto to form indefinite
shape dots are different between the two image areas,
and hence a difference in hue appears. In the present
25 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

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1 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,
5 the improper ununiformity of color takes place 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.

10 Further, in the prior art L/n sheet feed
printing method, substantially 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
15 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
20 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
25 of injection of the inks in the color mixed areas is
different between the forth scan and the back scan.
Accordingly, there is few case of the color printing

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1 which has been put into the 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 Application
5 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
10 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.
15 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
20 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 creat the ununiformity of color as
25 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

1 given image area. Accordingly, this method cannot be simply applied and it has not been put in practical use.

5 SUMMARY OF THE INVENTION

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

10 It is another object of the present invention to provide ink jet recording method and apparatus which prevent the ununiformity of density, the ununiformity of color and the occurrence of a connecting line and enable to record a high quality color image.

15 It is still another object of the present invention to provide ink jet recording method and apparatus which prevent the occurrence of the ununiformity of color in a color mixed record area in the reciprocal scan divisional recording and enable to record a high quality color image.

20 It is still another object of the present invention to provide ink jet recording method and apparatus which prevent the occurrence of the regular ununiformity of color due to a difference in sequence of ink injection in the reciprocal recording.

25 It is still another object of the present invention to provide ink jet recording method and apparatus which sequentially record thinned images in

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1 the same area of a recording medium by using different
blocks of recording means through a plurality of main
scans in forth and back runs of the recording means,
and enable substantially uniform number of dots to be
5 recorded in each main scan.

The above and other objects of the present
invention will be apparent from the following
description taken in connection with the accompanying
drawings.

10

BRIEF DESCRIPTION OF THE DRAWINGS

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

Fig. 2 shows discharge positions in a first
15 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
20 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 embodiment,

Fig. 7 illustrates another thinning method,

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

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1 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,

15 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 a third embodiment,

 Fig. 19 shows the area gradation pattern 1 and a thinned pattern 2 in the third embodiment,

25 Fig. 20 shows an area gradation pattern 2 and the thinned pattern 1 in the third embodiment,

 Fig. 21 shows the area gradation pattern 2

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1 and the thinned pattern 2 in the third embodiment,

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

5 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,

10 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 ununiformity of density,

15 Figs. 27A to 27C illustrate the reduction of the ununiformity of density by an L/n sheet feed printing method,

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

20 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,

25 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

1 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.

5

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
10 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
15 drawing, numeral 701 denotes an ink cartridge which
comprises an ink tank filled with one of four color
inks, black (BK), cyan (Cy), mazenta (M) and yellow
(Y), and a multi-head 702 for those colors. Multi-
nozzles arranged on the multi-heads, an viewed along
20 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
25 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

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1 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
5 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 embodi-
ment, a recording head of each of the ink jet
cartridges discharges ink droplets when a status
10 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 over-
printed in a sequence of black ink, cyan ink, mazaenta
ink and yellow ink. A half-tone color is attained by
15 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)
20 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
25 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

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1 apparatus in accordance with a program stored in the
ROM. Numeral 202 denotes a driver for driving a
carriage motor 205 to drive the carriage 706 in an
X-direction (main scan) in accordance with a signal
5 from the control unit 201, numeral 203 denotes a driver
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,
10 numeral 204 denotes a driver 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.

15 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
20 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
25 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

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1 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.

5 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-
10 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
15 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
20 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
25 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)

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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
5 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
10 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
15 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
20 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 se-
quentially record on the image areas on the recording
medium P divided by the half width ($L/2$) of the
25 recording head so that the recording of the entire
image data is completed. Indica in parentheses in the
second nad third scans in Fig. 1 indicate previously

1 printed ones.

In the present embodiment, in order to unify the number of injected dots in each recording scan, the ink jet recording head having a double recording
5 density 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
10 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
15 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.
20 Accordingly, as described above, whatever 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
25 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

- 1 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
5 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. Conse-
10 quently, the hues of the first image area and the
second image area are equal although the sequences of
the thinned printing are opposite.

An effect of the present embodiment is now
specifically explained. To simplify the explanation,
15 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
20 art. Since the recording density of the recording head
is double of that of the image data, the recording
pixels of the same data always comprise adjacent
 $2 \times 2 = 4$ pixels, as shown in Fig. 5. Fig. 6 shows a
thinned pattern of an image having the recording
25 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

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1 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
5 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.
10 As a result, in the recording pixel on the recording
medium at which the Cy and Y image data are over-
lapped, 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
15 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).

20 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
25 (2) for the first image area, and by the light nozzles
of the recording section (1) for the second image
area, in the sequence of Y-M-Cy-Bk. The Cy dot

1 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
5 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
10 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.

15 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
20 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
25 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

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1 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
5 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
10 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
15 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
20 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
25 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

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1 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
5 ununiformity of color is done in the reciprocal scan.

In the present invention, the feature of the
L/n 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
10 discharge is maintained and inks of different colors
are properly overprinted or adjacently 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
15 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
20 patterns, 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
25 section (2) are complementary to each other and the
numbers of dots when the image data is recorded in
division are equal.

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1 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
5 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. Con-
versely, where it is desired to reduce the ink
10 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
15 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.

20 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
25 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

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1 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
5 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,
10 a general control method relating to the reciprocal
recording such as a correction method of regist
data of the recording head, for the forth run scan
and the back run scan, relating to a spacing between
recording heads and a print start position, and a
15 correction of the sequence of drive, for the forth
run scan and the back run scan, relating to the time
division drive of the multi-nozzle recording head,
is omitted.

[Second Embodiment]

20 Figs. 11 to 17 show a recording method in a
second embodiment of the present invention.

In the present embodiment, the recording
section (L) of the recording head is divided into four
sections, 25 % of the recording pixels is recorded in
25 the first scan of each recording head, the sheet is
then fed by L/4 width, another 25 % of the recording
pixels is printed in the second scan, the sheet is

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1 fed by $L/4$ width, further 25 % is printed in the
third scan, the sheet is fed by $L/4$ width, and the
remaining 25 % is printed in the fourth scan to
complete the printing.

5 In Figs. 12 to 17, the discharge port line
which is not actually visible is shown as a vertical
perspective view for a sake of illustration. The
image data and the recording heads are identical to
those of the first embodiment. Fig. 11 illustrates a
10 method of 25 % thinning in the present embodiment.
4x8-pixel thinned pattern is used for each scan.

Specific explanation is made with reference
to Figs. 12 to 17. In the first scan, the 25 % thinned
pattern is printed in the first image area by the
15 four nozzles in the recording section (1) of the
recording head. In the 25 % thinning, the area
corresponding to the $(4n-3)$ th scan position shown in
Fig. 11 is printed so that dots are formed on the
sheet in the recording pixel arrangement shown in
20 Fig. 12. Then, the sheet is fed by $L/4$ width so that
the first image area recorded by the recording
section (1) is moved to the recording section (2).
In the second scan, the second image area and the
first image area are printed by the recording section
25 (1) and the recording section (2), respectively, in
the backward head scan by the thinned pattern of the
 $(4n-2)$ th scan shown in Fig. 11. Fig. 13 shows the

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1 recording in the second scan. Then, the sheet is fed
by $L/4$ width so that the first image area is moved to the
recording section (3) and the second image area is moved
to the recording section (2). In the following third
5 scan, the printing is made by the recording sections
(1), (2) and (3) as shown in Fig. 14. In the third
scan, the recording is made by the thinned pattern of
the $(4n-1)$ th scan shown in Fig. 11. Then, the sheet is
fed by $L/4$ width and the recording is made by the thinned
10 pattern of the $4n$ -th scan of Fig. 11, as shown in Fig.
15. Then, the recording is made as shown in Figs. 16
and 17. The printing is completed by the subsequent
similar sheet feed and head scan operations.

Noticing the dot formation in the first to
15 third image areas of Fig. 17 in which the recording
has been completed, each pixel of the original image
data is formed 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
20 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
25 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

1 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 ununiformity of
5 density due to the reach precision such as landing
deviation and the amount of discharge is maintained
while the occurrence of the regular ununiformity of
color which otherwise is caused in printing half-tone
color by printing inks of different colors in overlap
10 or adjacently is prevented. Thus, a high quality
color image recording is attained by the reciprocal
printing.

[Third Embodiment]

A third embodiment of the present invention
15 is now explained.

In the present embodiment, 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
20 recording apparatus of the present embodiment. In the
present embodiment, 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
25 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

1 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
5 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 combi-
10 nations of the area gradation pattern and the thinned
pattern. 64 gradations are expressed by $8 \times 8 = 64$ 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
15 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
20 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 which the recording
head is divided into two sections, and the image areas
25 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

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1 gradation level changes, a difference of 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
5 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
10 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
15 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 ununiformity of color in the image is affected by
the combination of the gradation pattern and the
20 thinned pattern, the thinned pattern is selected in
accordance with the gradation pattern in the present
embodiment.

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

In the present embodiment, the reciprocal color

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1 printing which is free from the ununiformity of color
is attained while the recording density of the
recording apparatus is utilized at a maximum level.

5 In the present embodiment, the dots of the
gradation pattern is developed by the ink jet
recording apparatus. Alternatively, it 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
10 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
15 of the ink jet recording apparatus may be prepared to
avoid the interference and fixed.

In accordance with the present embodiment, the
recording means is moved back and forth relative to
the recording medium to conduct the main scan for
20 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
25 equal without regard to the image data. Accordingly,
the ununiformity of density due to the reach accuracy
of the recording means and the amount of discharge is

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1 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 ununiformity of color due to the difference in the sequence of ink injection in the forth and back run scans is prevented.

In the present invention, the ink jet recording apparatus which utilizes thermal energy to form flying droplets to record data has been described. Representative construction and principle thereof are disclosed in USP 4,723,129 and USP 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

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1 pulsive, the growth and shrinkage of the air bubbles
are effected instantly so that highly responsive
liquid (ink) discharge is attained.

A preferable pulsive drive signal is one
5 disclosed in USP 4,463,359 or USP 4,345,262. When the
condition disclosed in the above-mentioned USP 4,313,124
relating to the temperature rise rate of the thermal
action plane is met, more excellent recording is
attained.

10 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 USP's, or a construction in which the
15 thermal action element is arranged in a curved area
as disclosed in USP 4,558,333 or USP 4,459,600.

Alternatively, a construction in which a slit
common to a plurality of electro-thermal transducers
is used as discharge ports of the electro-thermal
20 transducer as disclosed in Japanese Laid-Open Patent
Application No. 59-123670, or a construction in which
openings for absorbing pressured liquid of thermal
energy are associated with discharge ports as disclosed
in Japanese Laid-Open Patent Application No. 59-138461
25 may be used.

In a full line type recording head having a
length corresponding to a maximum width of a recording

1 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
5 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
10 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
15 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 trans-
ducer or other heating element or a combination
20 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
25 as black.

In the embodiments of the present invention,
the ink is used as the liquid. Ink which is solidified

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1 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 in the ink jet recording system it is
5 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
10 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
15 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
20 sheet recesses or via-holes in a liquid or solid
state, as disclosed in Japanese Laid-Open Patent
Application No. 54-56847 or Japanese Laid-Open Patent
Application No. 60-71260. In the present invention, the
film boiling system mentioned above is most effective
25 to those inks.

The recording apparatus in the present invention
may be a word processor, an image output terminal of an

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1 information handling system such as a computer, either
integral or separate, a copying apparatus combined with
a reader, or a facsimile apparatus having transmitting
and receiving functions.

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CLAIMS:

1. An ink jet recording method for reciprocally moving recording means for recording, said recording means having a plurality of recording element lines for discharging respective different color ink droplets, said recording means being moved relative to a recording medium in a main scan direction, to record a color image corresponding to image data on the recording medium, and for moving said recording medium relative to said recording in a sub-scan direction different from said main scan direction, comprising:

a first step of recording an image corresponding a first thinned pattern for each color to a predetermined area of the recording medium by using a first recording section of said recording means in a forward movement in main scan direction of said recording means;

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

a third step of recording an image corresponding to a second thinned pattern for each color to said predetermined area of said recording medium by using a second recording section of said recording means in a backward movement in the main scan direction of said recording means,

wherein said first thinned pattern and said second thinned pattern are complementary to each other and are set such that a number of dots recorded in each of said first step and said third step are substantially equal without regard to the image data.

2. An ink jet recording method according to claim 1, wherein a recording density of said recording means is double of a recording density of said image data, each pixel of the image data is recorded by a plurality of recording dots, and a same number of the recording dots of each said pixel are recorded in the forward movement and the backward movement.

3. An ink jet recording 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 said second thinned pattern has a dot arrangement by which remaining said dots not recorded by the first thinned pattern are recorded.

4. An ink jet recording method according to claim 2 wherein said recording means includes a plurality of recording heads each having a plurality of ink discharge ports for discharging inks of different colors.
5. An ink jet recording method according to claim 1 wherein said recording means includes a plurality of recording heads each having a plurality of ink discharge ports for discharging inks of different colors.
6. An ink jet recording method according to claim 1 wherein said image data is formed in accordance with an area gradation method of a predetermined dot arrangement, and said first and second thinned patterns are dot arrangement patterns asynchronous with the dot arrangement of the area gradation method.
7. An ink jet recording method according to claim 6 wherein said area gradation method is a dither method.
8. An ink jet recording method according to claim 1 wherein said recording means causes a status change in an ink by thermal energy to discharge the ink from the discharge port.
9. An ink jet recording apparatus for recording a color image corresponding to image data to a recording medium by using recording means for recording, said recording means having a plurality of recording element lines for discharging respective different color ink droplets, comprising:
 - first move means for reciprocally moving said recording means relative to said recording medium in a main scan direction;
 - drive means for driving said recording means in accordance with the image

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data and a first thinned pattern in a forward movement in the main scan direction of said recording means by said first move means and driving said recording means in accordance with the image data and a second thinned pattern in a backward movement in the main scan direction of said recording means by said first move means;

said first and second thinned patterns being complementary to each other; and

second move means for moving said recording medium relative to said recording means in a sub-scan direction after each the forward movement of said recording means and the backward movement of said recording means;

said drive means recording an image in accordance with the image data and the first thinned pattern to a predetermined area on said recording medium by using a first recording section of said recording means in the forward movement of said recording means by said first move means, and recording an image in accordance with the image data and the second thinned pattern to said predetermined area on said recording medium by using a second recording section of said recording means in the backward movement of said recording means by said first move means after the sub-scan by said second move means;

said first and second thinned patterns being set such that the numbers of dots recorded in the forward movement of said recording means and the backward movement of said recording means are substantially equal without regard to the image data.

10. An ink jet recording apparatus according to claim 9 wherein a recording density of said recording means is double of a recording density of said image data, each pixel of the image data is recorded by a plurality of recording dots, and a same number of the recording dots of each said pixel are recorded for each of the forward movement and the backward movement.

11. An ink jet recording apparatus according to claim 10 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 remaining said dots not recorded by the first thinned pattern are recorded.

12. An ink jet recording apparatus according to claim 10 wherein said recording means includes a plurality of recording heads each having a plurality of ink discharge ports for discharging inks of different colors.

13. An ink jet recording apparatus according to claim 9 wherein said recording means includes a plurality of recording heads each having a plurality of ink discharge ports for discharging inks of different colors.

14. An ink jet recording apparatus according to claim 9 wherein said image data is formed in accordance with an area gradation method of a predetermined dot arrangement, and said first and second thinned patterns are dot arrangement patterns asynchronous with the dot arrangement of the area gradation method.

15. An ink jet recording apparatus according to claim 14 wherein said area gradation method is a dither method.

16. An ink jet recording apparatus according to claim 9 wherein said recording means causes a status change in an ink by thermal energy to discharge the ink from the discharge port.

17. An ink jet recording method for performing a relative movement of a recording means for recording, said recording means having a plurality of recording element lines for discharging respective different color ink droplets, relative to a recording medium in a main scan direction, said recording means recording a color image corresponding to an image data on the recording medium during the relative movement, and thereafter performing a relative movement of said recording medium relative to said recording means in a sub-scan direction that is different from said main scan direction, said method comprising:

a first step of providing a set of thinned patterns which are complementary

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to each other, said thinned patterns corresponding to an area gradation pattern for processing said image data;

a second step of recording on a predetermined area of said recording medium a first thinned image corresponding to said image data which is processed based on the area gradation pattern, using a given one of the set of thinned patterns which was provided in said first step, during a first relative movement of said recording means in the main scan direction; and

a third step of recording on the predetermined area of said recording medium a second thinned image corresponding to said image data which is processed based on the area gradation pattern, using another given one of the set of thinned patterns which was provided in said first step, during a second relative movement of said recording means in the main scan direction, said second thinned image being complementary to said first thinned image,

wherein said given thinned pattern and said another given thinned pattern are complementary to each other and are set such that a number of dots recorded in each of said second step and said third step are substantially equal without regard to the image data.

18. A method according to claim 17, wherein in said first step, said set of thinned patterns is selected from a plurality of thinned patterns that renders less of a difference between a first number of dots recorded during the first relative movement and a second number of dots recorded during the second relative movement with regard to every gradation level reproducible by the area gradation pattern.

19. A method according to claim 17, wherein in said second step, the first thinned image is recorded using a first recording section of said recording means, and in said third step, the second thinned image is recorded using a second recording section of the recording means.

20. A method according to claim 19, further comprising a step of moving said recording medium relative to said recording means in a sub-scan direction by a

distance that corresponds to the first recording section before starting recording of the second thinned image following recording of the first thinned image.

21. A method according to claim 17, wherein the first relative movement and the second relative movement are in opposite directions.

22. A method according to claim 17, wherein the area gradation pattern is based upon a dither method.

23. A method according to any of claims 17 to 22, wherein said recording means has a plurality of recording heads each of which is equipped with a plurality of recording elements, wherein said recording heads respectively discharge different color inks.

24. A method according to claim 23, wherein said recording element causes a change in a state of the ink by applying thermal energy to said ink, thereby discharging ink droplets from a discharge port.

25. A method according to any of claims 17 to 22, wherein said recording element causes a change in a state of the ink by applying thermal energy to said ink, thereby discharging ink droplets from a discharge port.

26. An ink jet recording apparatus for recording a color image on a recording medium using a recording means for recording, said recording means having a plurality of recording element lines for discharging respective different color ink droplets, comprising:

input means for inputting a signal indicating an area gradation pattern for processing an image data;

providing means for providing a set of thinned patterns which are complementary to each other in response to the signal indicating an area gradation pattern inputted by said input means;

first move means for reciprocatingly moving said recording means relative

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to said recording medium in a main scan direction; and

drive means for driving said recording means in accordance with the image data which is processed based on the area gradation pattern and the set of thinned patterns provided by said providing means,

wherein said drive means drives said recording means, using a given one of the set of thinned patterns, during a first relative movement of said recording means by said first move means, and drives said recording means using another given one of the set of thinned patterns, during a second relative movement of said recording means by said first move means, whereby a first thinned image is recorded on a predetermined area of said recording medium during the first relative movement and a second thinned image complementary to the first thinned image is recorded on the predetermined area of said recording medium during the second relative movement,

and wherein said given thinned pattern and said another given thinned pattern are complementary to each other and are set such that a number of dots recorded for each of said first thinned image and said second thinned image are substantially equal without regard to the image data.

27. An apparatus according to claim 26, wherein said set of thinned patterns provided from a plurality of thinned patterns by said providing means is such as to render less of a difference between a first number of dots recorded during the first relative movement and a second number of number of dots recorded during the second relative movement with regard to every gradation level reproducible by the area gradation pattern.

28. An apparatus according to claim 26, wherein said drive means drives said recording means to record the first thinned image on the recording area of said recording medium by using a first recording section of said recording means and to record on the recording area of said recording medium the second thinned image by using a second recording section of said recording means.

29. An apparatus according to claim 28, further comprising second move

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means for moving said recording medium relative to said recording means in the sub-scan direction which is different from the main direction by a distance that corresponds to the first recording section before starting recording of the second thinned image following recording of the first thinned image.

30. An apparatus according to claim 26, wherein the first relative movement and the second relative movement in opposite directions.

31. An apparatus according to claim 26, wherein the area gradation pattern is based upon a dither method.

32. An apparatus according to any of claims 26 to 31, wherein said recording means has a plurality of recording heads each of which is equipped with a plurality of recording elements, wherein said recording heads respectively discharge different color inks.

33. An apparatus according to claim 32, wherein said recording element causes a change in a state of the ink by applying thermal energy to said ink, thereby discharging ink droplets from a discharge port.

34. An apparatus according to any of claims 26 to 31, wherein said recording element causes a change in a state of the by applying thermal energy to said ink, thereby discharging ink droplets from a discharge port.

35. An ink jet recording method for performing relative movement of a recording means for recording, said recording means having a plurality of recording element lines for discharging respective different color ink droplets, relative to a recording medium in a main scan direction, said recording means recording a color image corresponding to an image data on the recording medium during the relative movement, and thereafter performing a relative movement of said recording medium relative to said recording means in a sub-scan direction that is different from said main scan direction, said method comprising:

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a first step of selecting a set of thinned patterns which are complementary to each other, said thinned patterns corresponding to an area gradation pattern for processing said image data;

a second step of recording on a predetermined area of said recording medium a first thinned image corresponding to said image data which is processed based on the area gradation pattern, using a given one of the set of thinned patterns which was selected in said first step, during a first relative movement of said recording means in the main scan direction; and

a third step of recording on the predetermined area of said recording medium a second thinned image corresponding to said image data which is processed based on the area gradation pattern, using another given one of the set of thinned patterns which was selected in said first step, during a second relative movement of said recording means in the main scan direction, said second thinned image being complementary to said first thinned image,

wherein in said first step, said set of thinned patterns is selected from a plurality of thinned patterns to reduce a difference between a first number of dots recorded during the first relative movement and a second number of dots recorded during the second relative movement with regard to a gradation level reproducible by the area gradation pattern, without regard to the image data.

36. A method according to claim 35, wherein in said second step, the first thinned image is recorded using a first recording section of said recording means, and in said third step, the second thinned image is recorded using a second recording section of the recording means.

37. A method according to claim 36, further comprising a step of moving said recording medium relative to said recording means in the sub-scan direction by a distance that corresponds to the first recording section before starting recording of the second thinned image following recording of the first thinned image.

38. A method according to claim 35, wherein the first relative movement and the second relative movement are in opposite directions.

39. A method according to claim 35, wherein the area gradation pattern is based upon a dither method.

40. A method according to any of claims 35-39, wherein said recording means has a plurality of recording heads each of which is equipped with a plurality of recording elements, wherein said recording heads respectively discharge different color inks.

41. A method according to claim 40, wherein said recording element causes a change in a state of the ink by applying thermal energy to said ink, thereby discharging ink droplets from a discharge port.

42. A method according to any of claims 35 to 39, wherein said recording element causes a change in a state of the ink by applying thermal energy to said ink, thereby discharging ink droplets from a discharge port.

43. An ink jet recording apparatus for recording a color image on a recording medium using a recording means for recording, said recording means having a plurality of recording element lines for discharging respective different color ink droplets, comprising:

input means for inputting a signal indicating an area gradation pattern for processing an image data;

selection means for selecting a set of thinned patterns which are complementary to each other in response to the signal indicating an area gradation pattern inputted by said input means;

first move means for reciprocatingly moving said recording means relative to said recording medium in a main scan direction; and

drive means for driving said recording means in accordance with the image data which is processed based on the area gradation pattern and the set of thinned patterns selected by said selection means,

wherein said drive means drives said recording means, using a given one of the set of thinned patterns, during a first relative movement of said recording

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means by said first move means, and drives said recording means using another given one of the set of thinned patterns, during a second relative movement of said recording means by said first move means, whereby a first thinned image is recorded on a predetermined area of said recording medium during the first relative movement and a second thinned image complementary to the first thinned image is recorded on the predetermined area of said recording medium during the second relative movement and,

wherein said set of thinned patterns selected from a plurality of thinned patterns by said selection means is such as to reduce a difference between a first number of dots recorded during the first relative movement and a second number of number of dots recorded during the second relative movement with regard to a gradation level reproducible by the area gradation pattern, without regard to the image data.

44. An apparatus according to claim 43, wherein said drive means drives said recording means to record the first thinned image on the recording area of said recording medium by using a first recording section of said recording means and to record on the recording area of said recording medium the second thinned image by using a second recording section of said recording means.

45. An apparatus according to claim 44, further comprising second move means for moving said recording medium relative to said recording means in the sub-scan direction which is different from the main direction by a distance that corresponds to the first recording section before starting recording of the second thinned image following recording of the first thinned image.

46. An apparatus according to claim 43, wherein the first relative movement and the second relative movement in opposite directions.

47. An apparatus according to claim 43, wherein the area gradation pattern is based upon a dither method.

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48. An apparatus according to any of claims 43 to 47, wherein said recording means has a plurality of recording heads each of which is equipped with a plurality of recording elements, wherein said recording heads respectively discharge different color inks.

49. An apparatus according to claim 38, wherein said recording elements cause a change in a state of the ink by applying thermal energy to said ink, thereby discharging ink droplets from a discharge port.

50. An apparatus according to any of claims 43-47, wherein said recording element causes a change in a state of the ink by applying thermal energy to said ink, thereby discharging ink droplets from a discharge port.

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Toronto, Canada
Patent Agents

FIG. 1

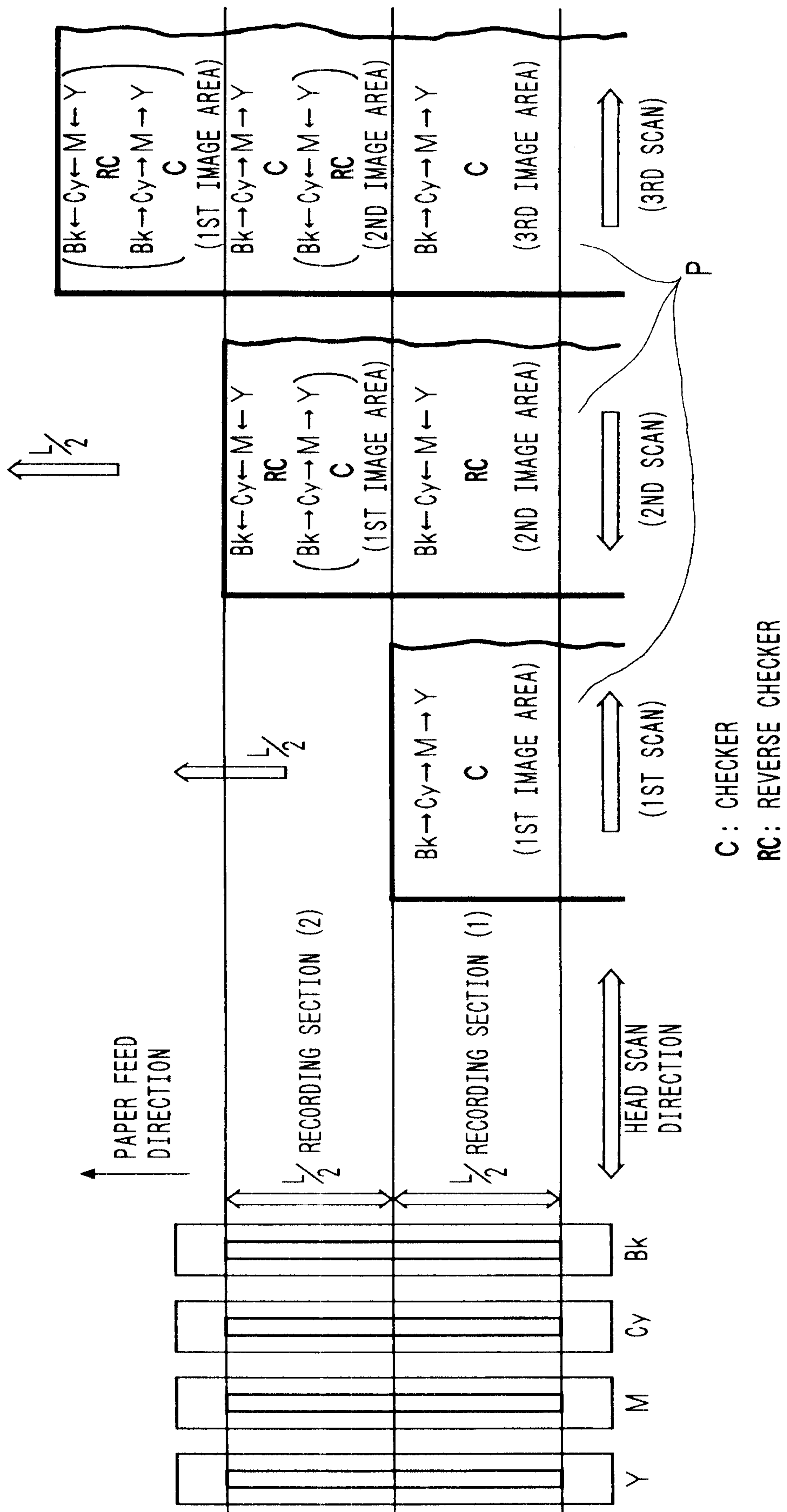


FIG. 2

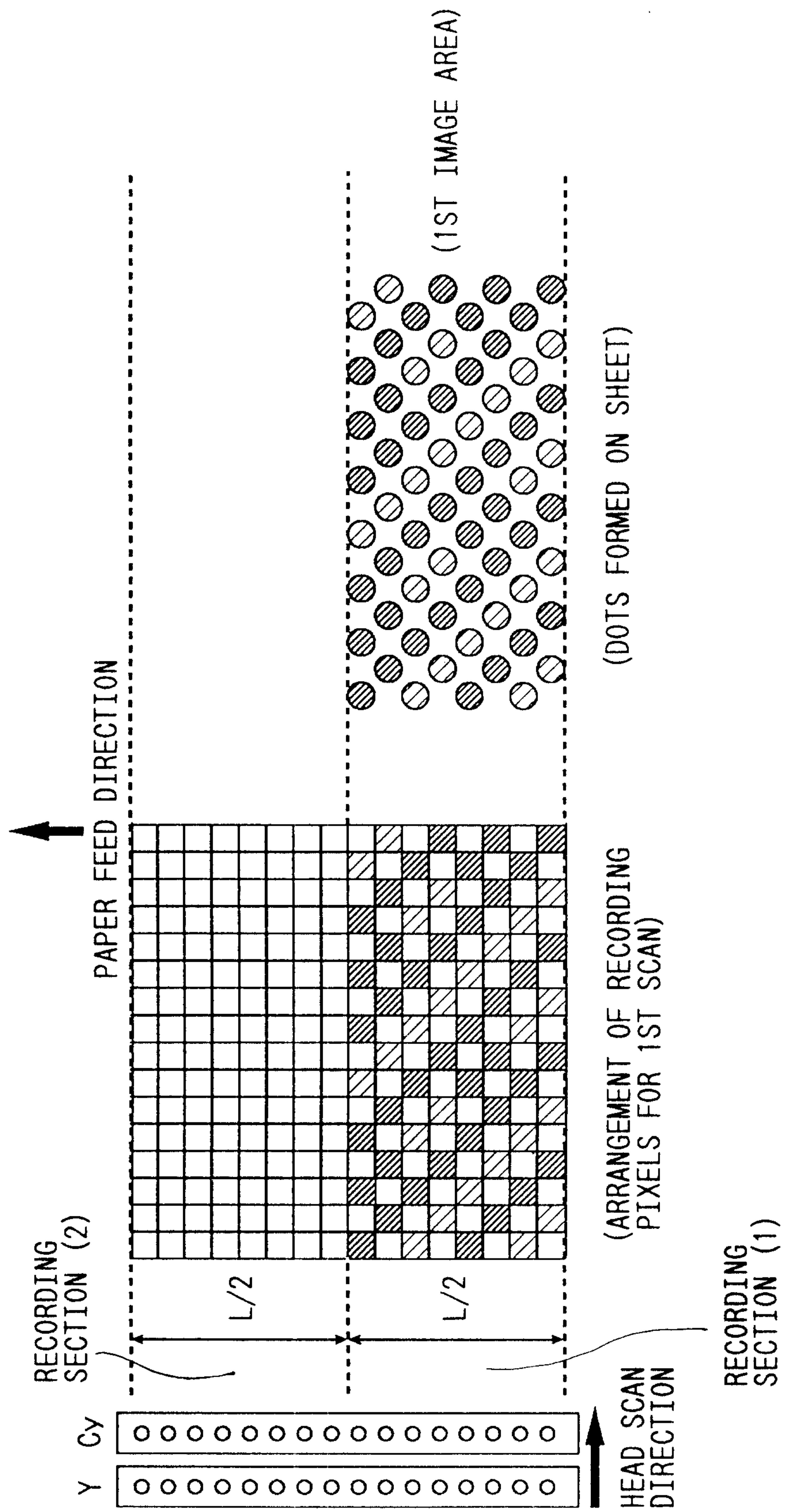


FIG. 3

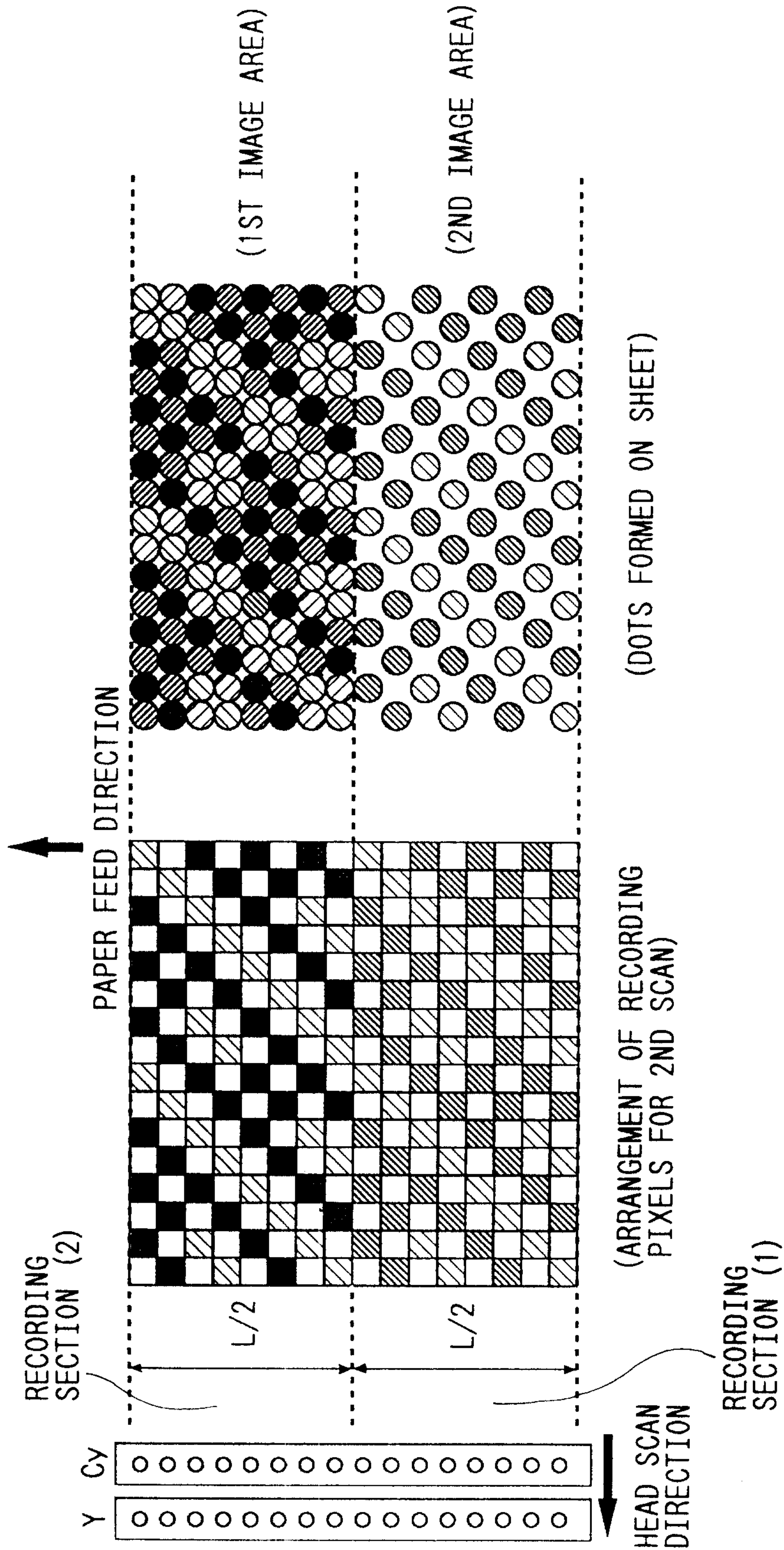
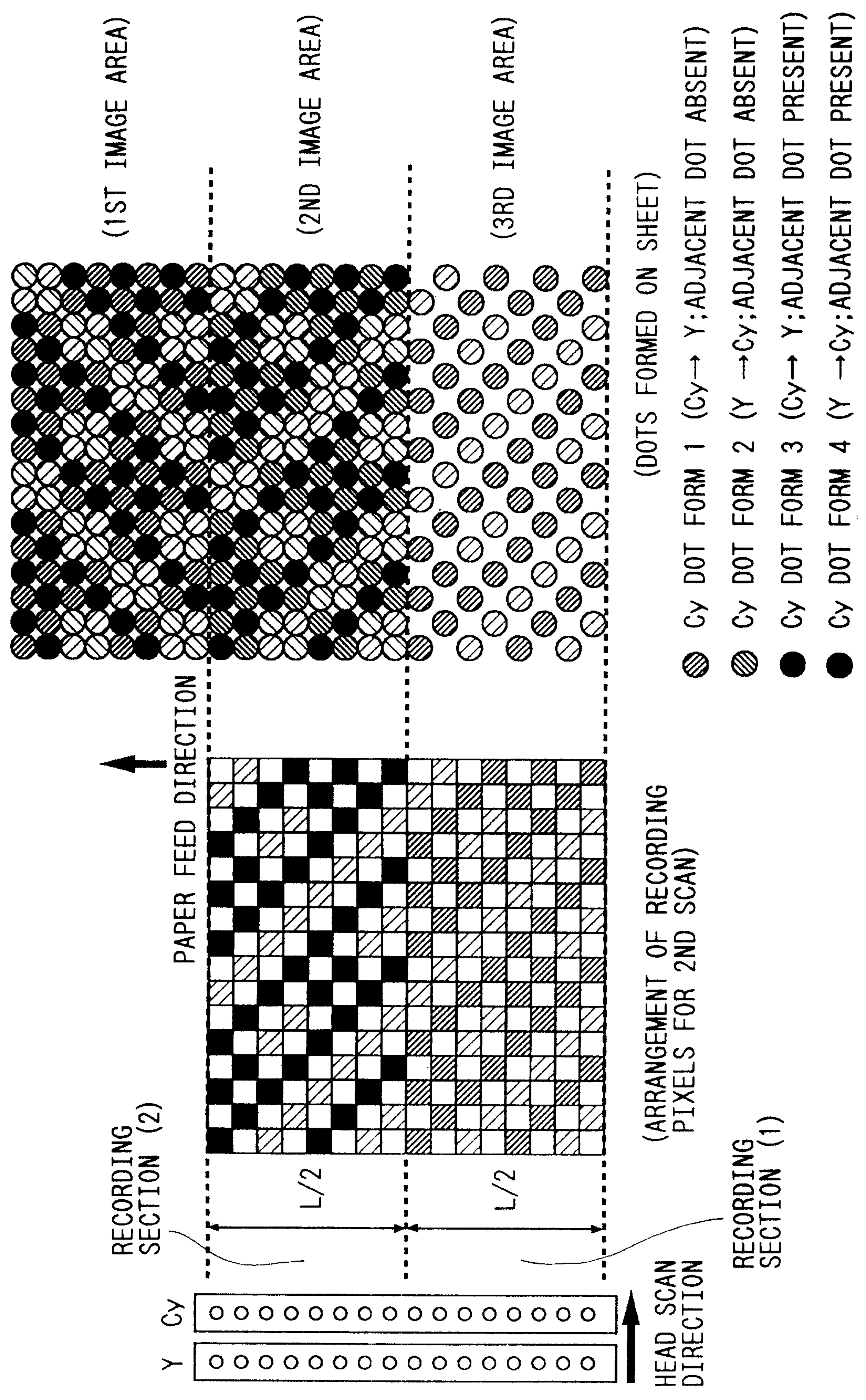


FIG. 4



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FIG. 5

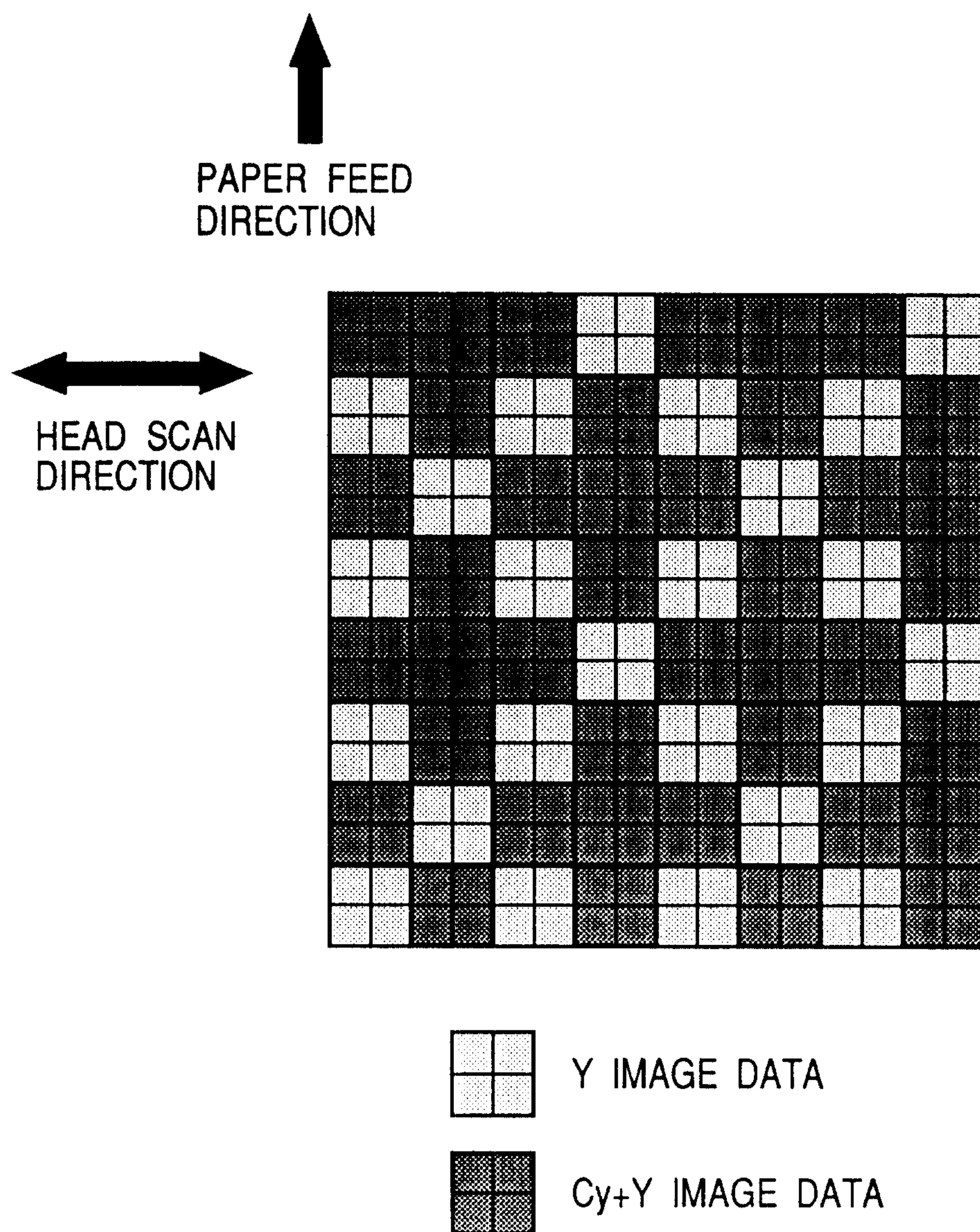


FIG. 6

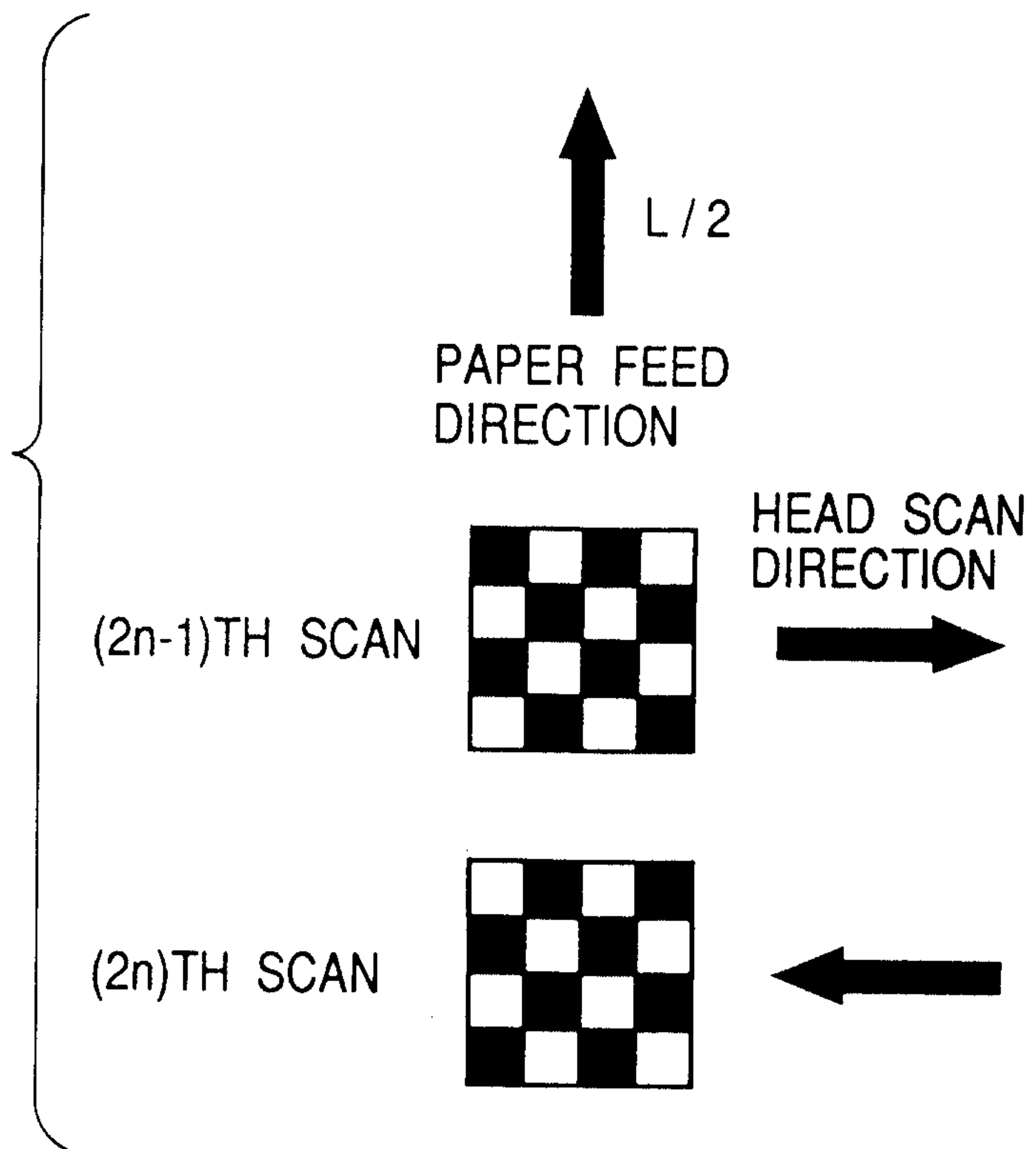


FIG. 7

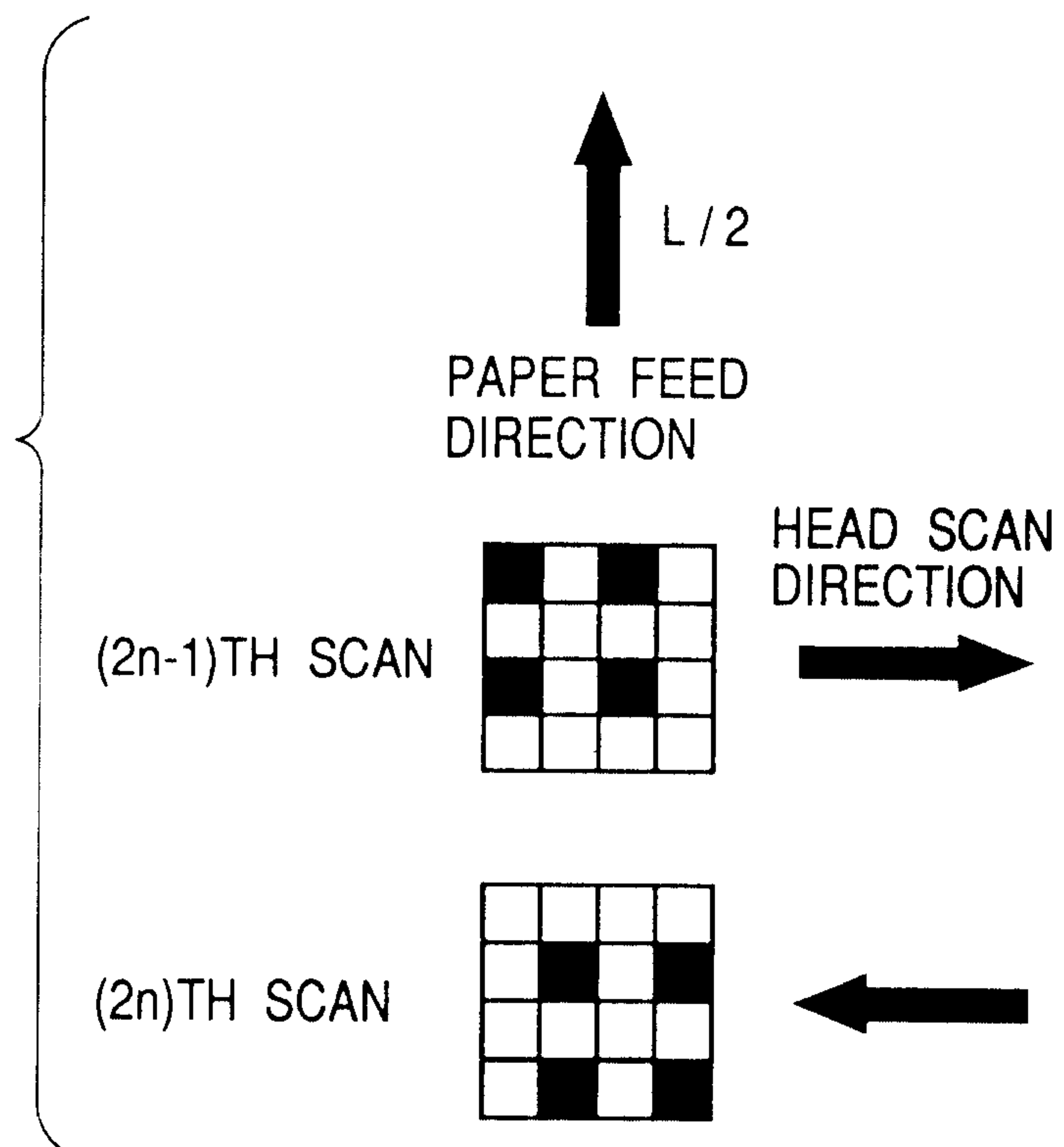
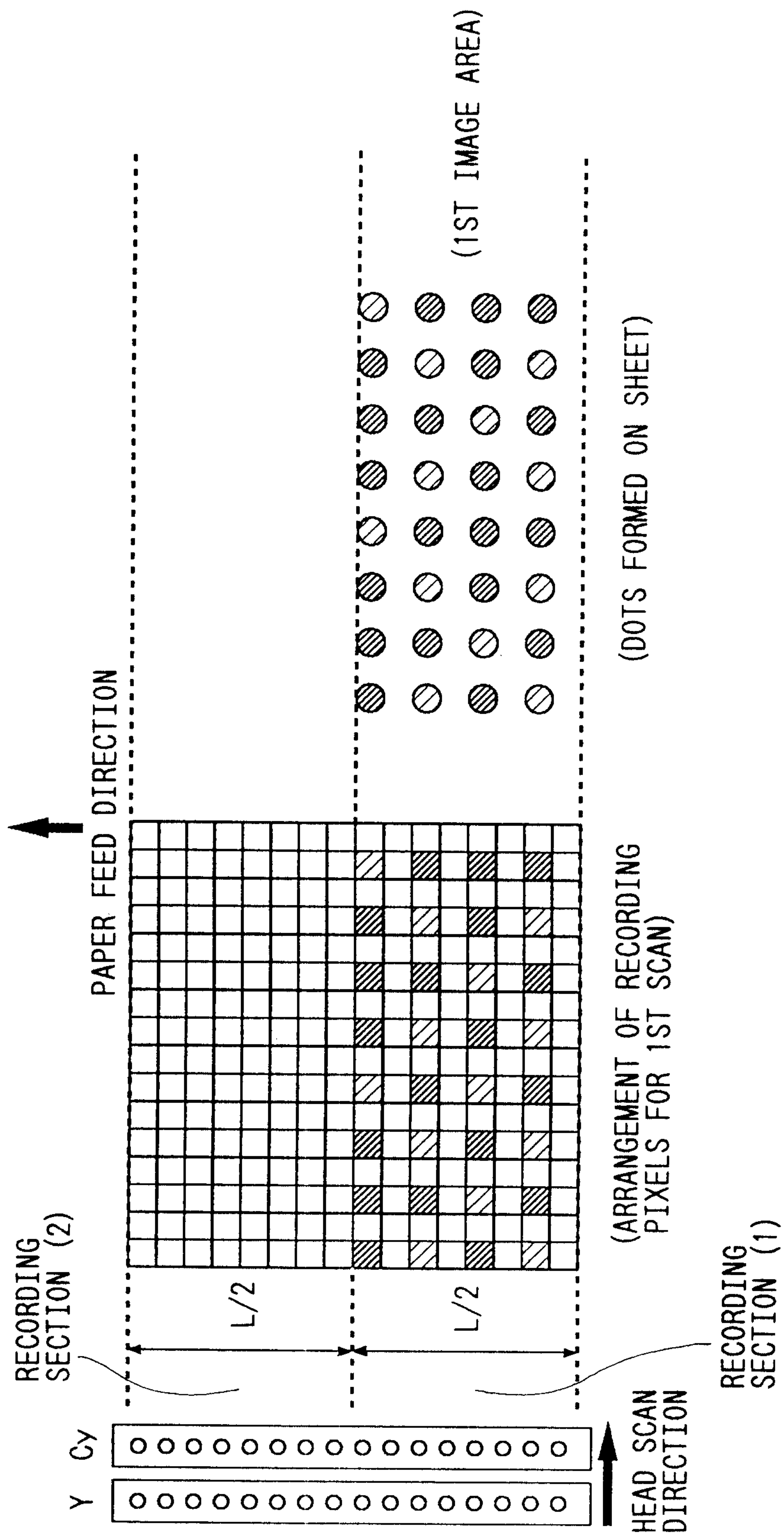


FIG. 8



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FIG. 11

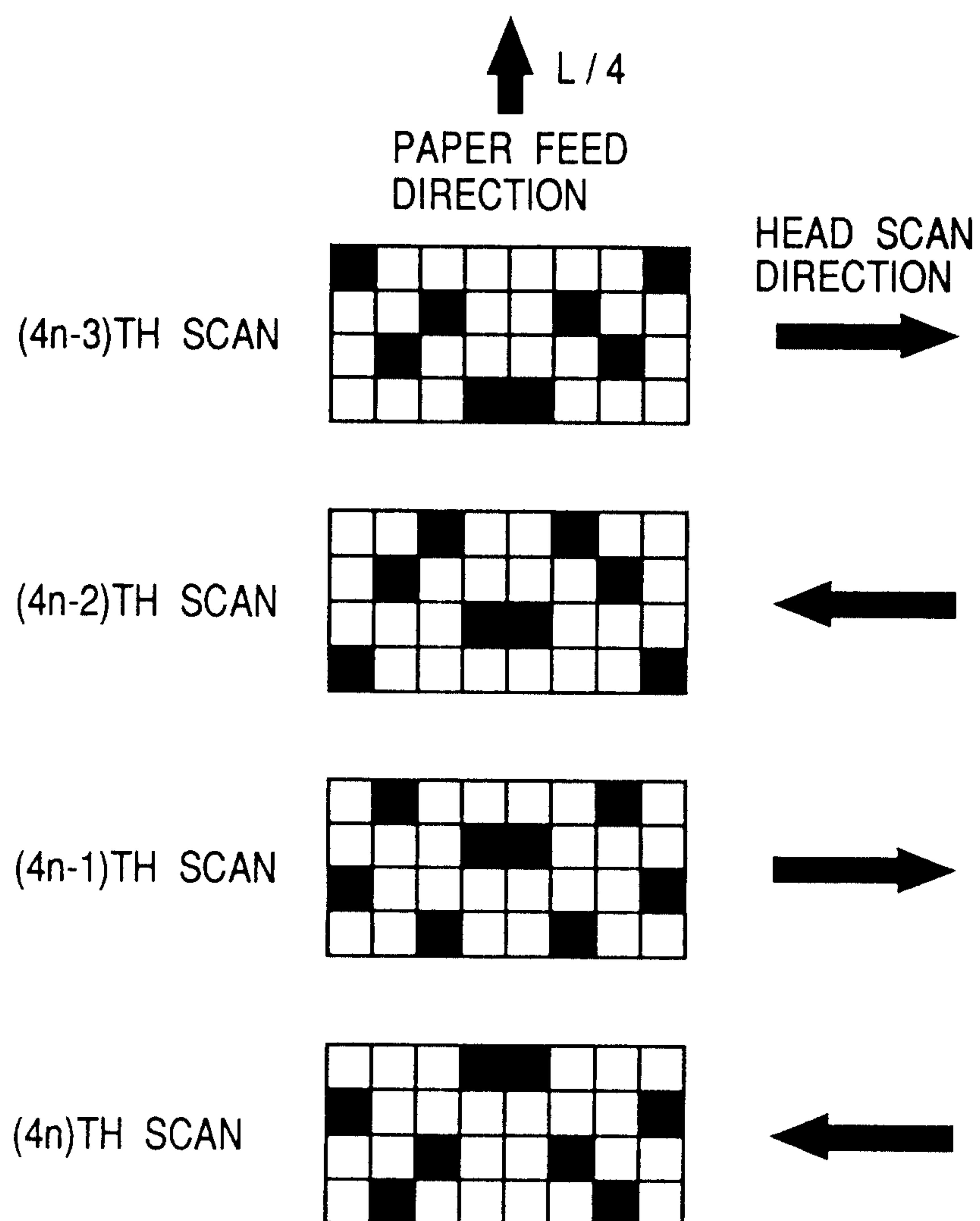


FIG. 12

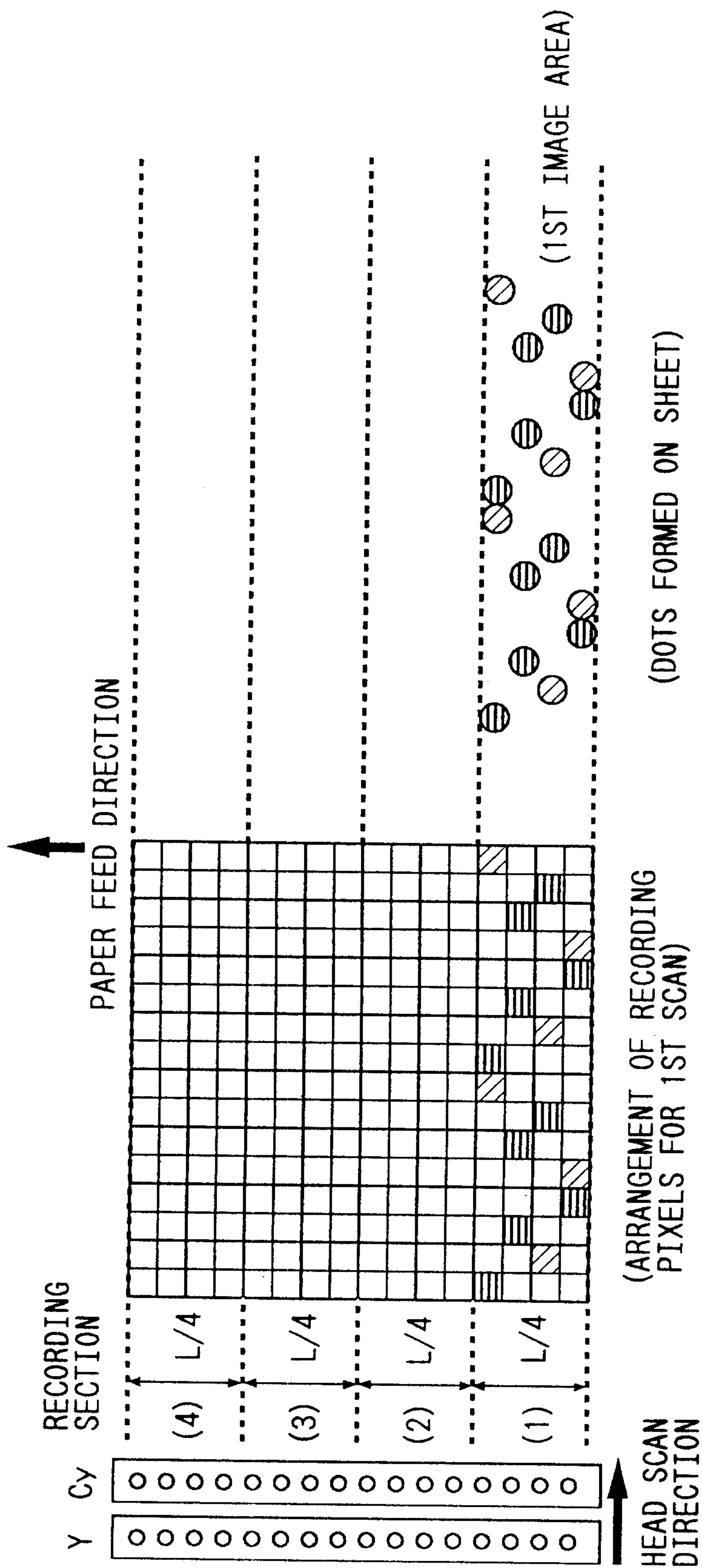


FIG. 13

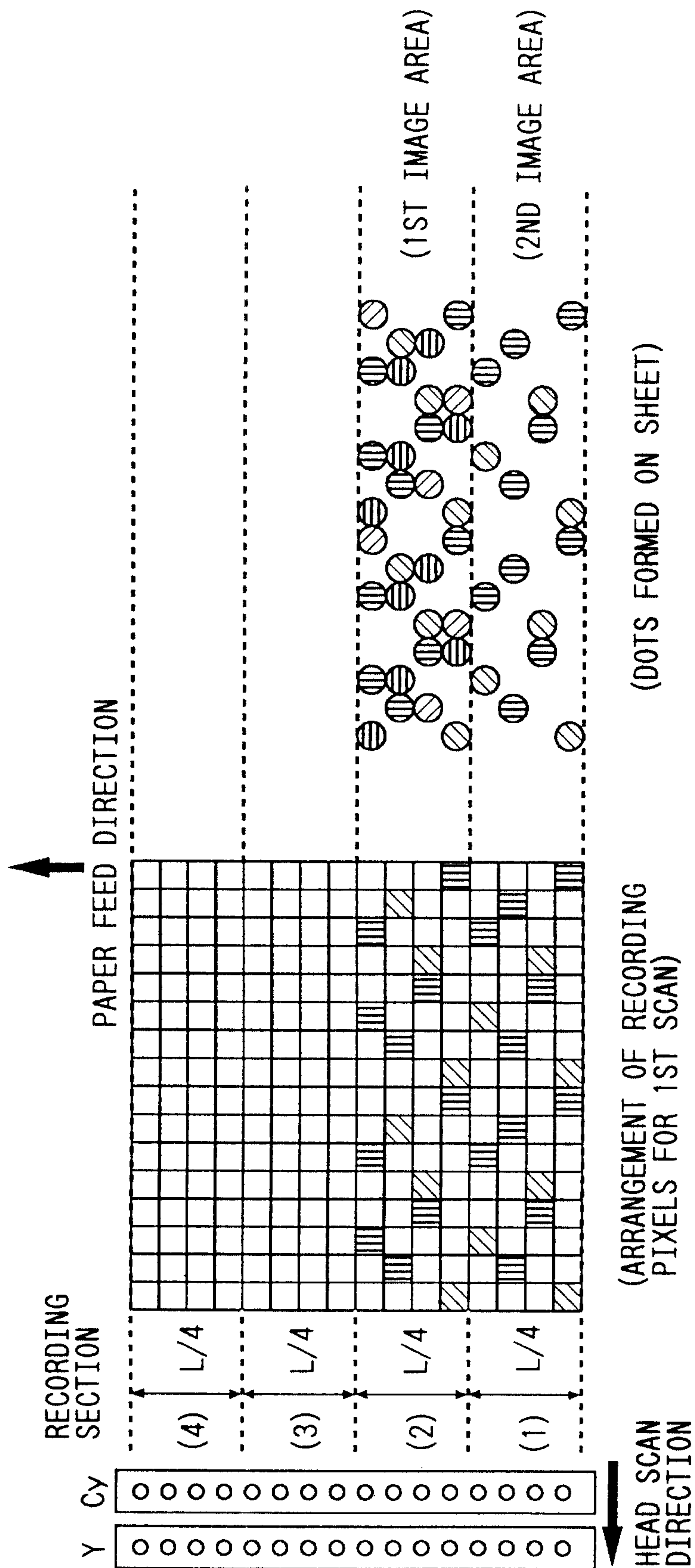
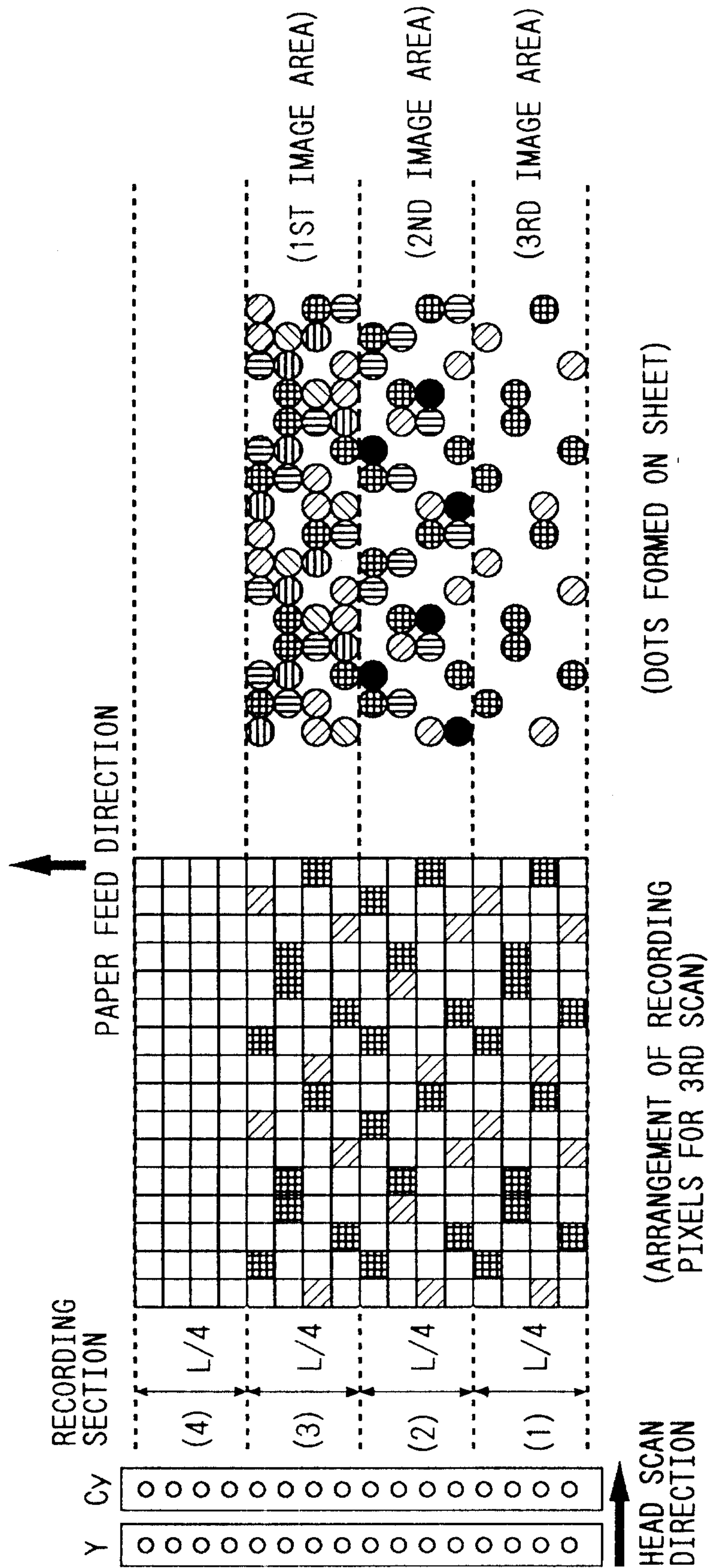
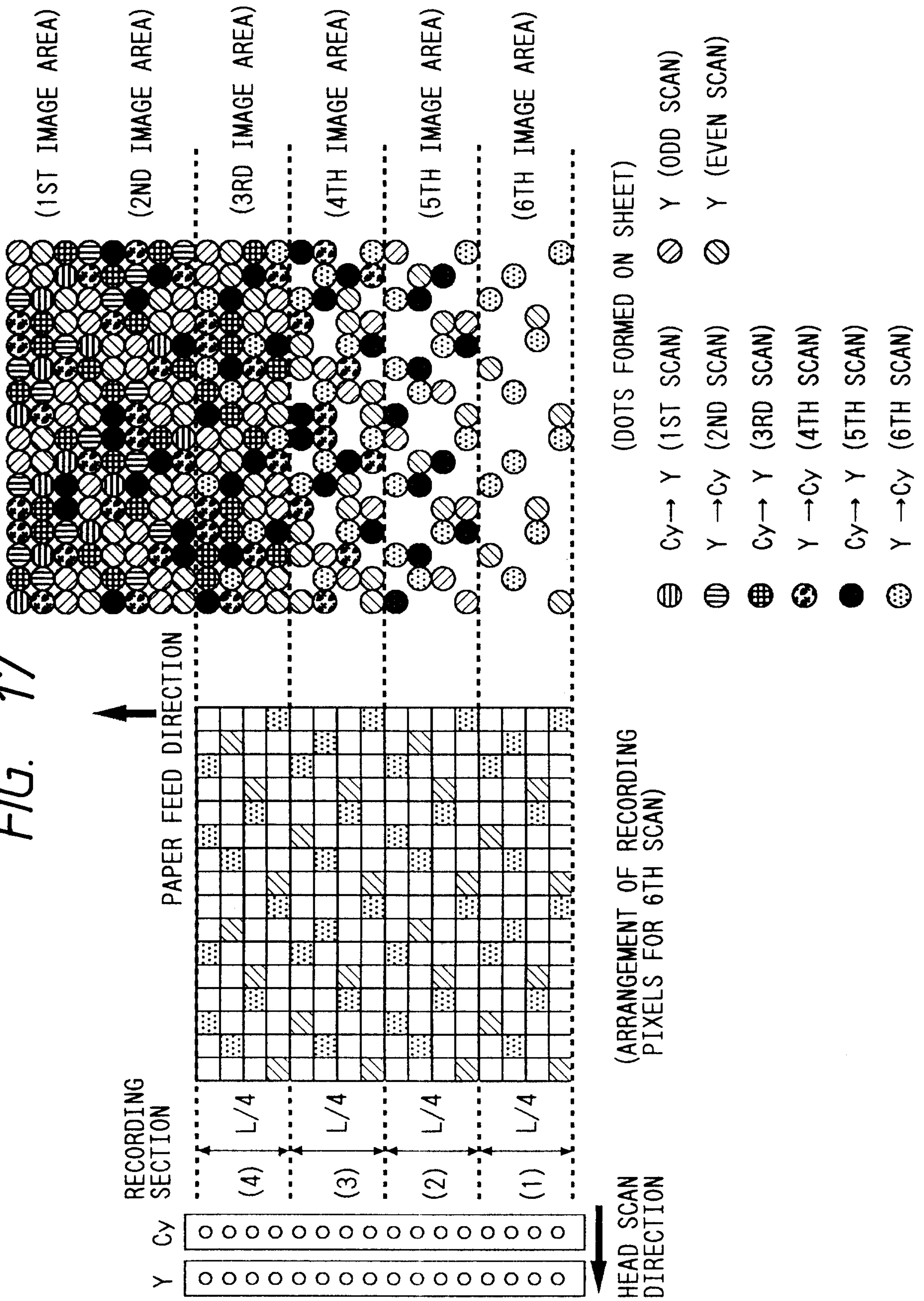


FIG. 14



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FIG. 17



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FIG. 18

1	53	9	61	19	39	27	47
37	17	45	25	55	3	63	11
49	5	57	13	35	23	43	31
21	33	29	41	7	51	15	59
28	48	20	40	10	62	2	54
64	12	56	4	46	26	38	18
44	32	36	24	58	14	50	6
16	60	8	52	30	42	22	34

↑
PAPER FEED
DIRECTION

S (2n-1)TH SCAN
HEAD SCAN DIRECTION →

S (2n)TH SCAN
HEAD SCAN DIRECTION ←

AREA GRADATION PATTERN 1
AND THINNING PATTERN 1

FIG. 19

1	53	9	61	19	39	27	47
37	17	45	25	55	3	63	11
49	5	57	13	35	23	43	31
21	33	29	41	7	51	15	59
28	48	20	40	10	62	2	54
64	12	56	4	46	26	38	18
44	32	36	24	58	14	50	6
16	60	8	52	30	42	22	34

↑
PAPER FEED
DIRECTION

S (2n-1)TH SCAN
HEAD SCAN DIRECTION →

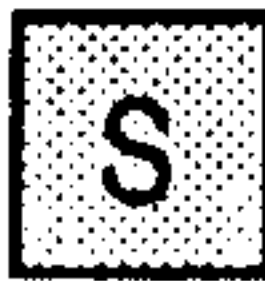
S (2n)TH SCAN
HEAD SCAN DIRECTION ←

AREA GRADATION PATTERN 1
AND THINNING PATTERN 2

FIG. 20

49	17	33	53	59	27	43	63
45	1	5	21	39	11	15	31
29	13	9	37	23	7	3	47
61	41	25	57	55	35	19	51
56	24	40	60	62	30	46	50
36	8	12	28	42	14	2	18
20	4	16	44	26	10	6	34
52	48	32	64	58	38	22	54


PAPER FEED
DIRECTION

 (2n-1)TH SCAN
HEAD SCAN DIRECTION 

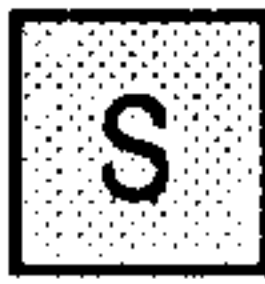
 (2n)TH SCAN
HEAD SCAN DIRECTION 

AREA GRADATION PATTERN 2
AND THINNING PATTERN 1

FIG. 21

49	17	33	53	59	27	43	63
45	1	5	21	39	11	15	31
29	13	9	37	23	7	3	47
61	41	25	57	55	35	19	51
56	24	40	60	62	30	46	50
36	8	12	28	42	14	2	18
20	4	16	44	26	10	6	34
52	48	32	64	58	38	22	54

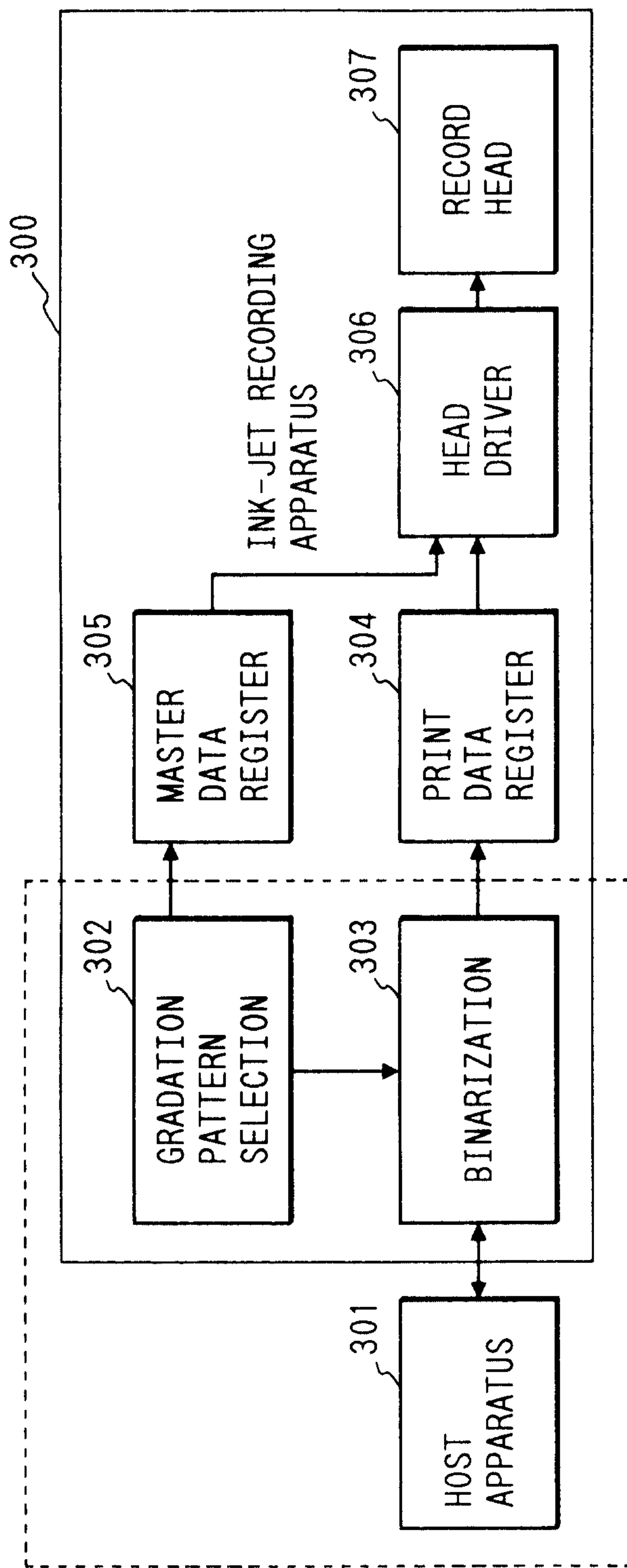

PAPER FEED
DIRECTION

 (2n-1)TH SCAN
HEAD SCAN DIRECTION 

 (2n)TH SCAN
HEAD SCAN DIRECTION 

AREA GRADATION PATTERN 2
AND THINNING PATTERN 2

FIG. 22



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FIG. 23A

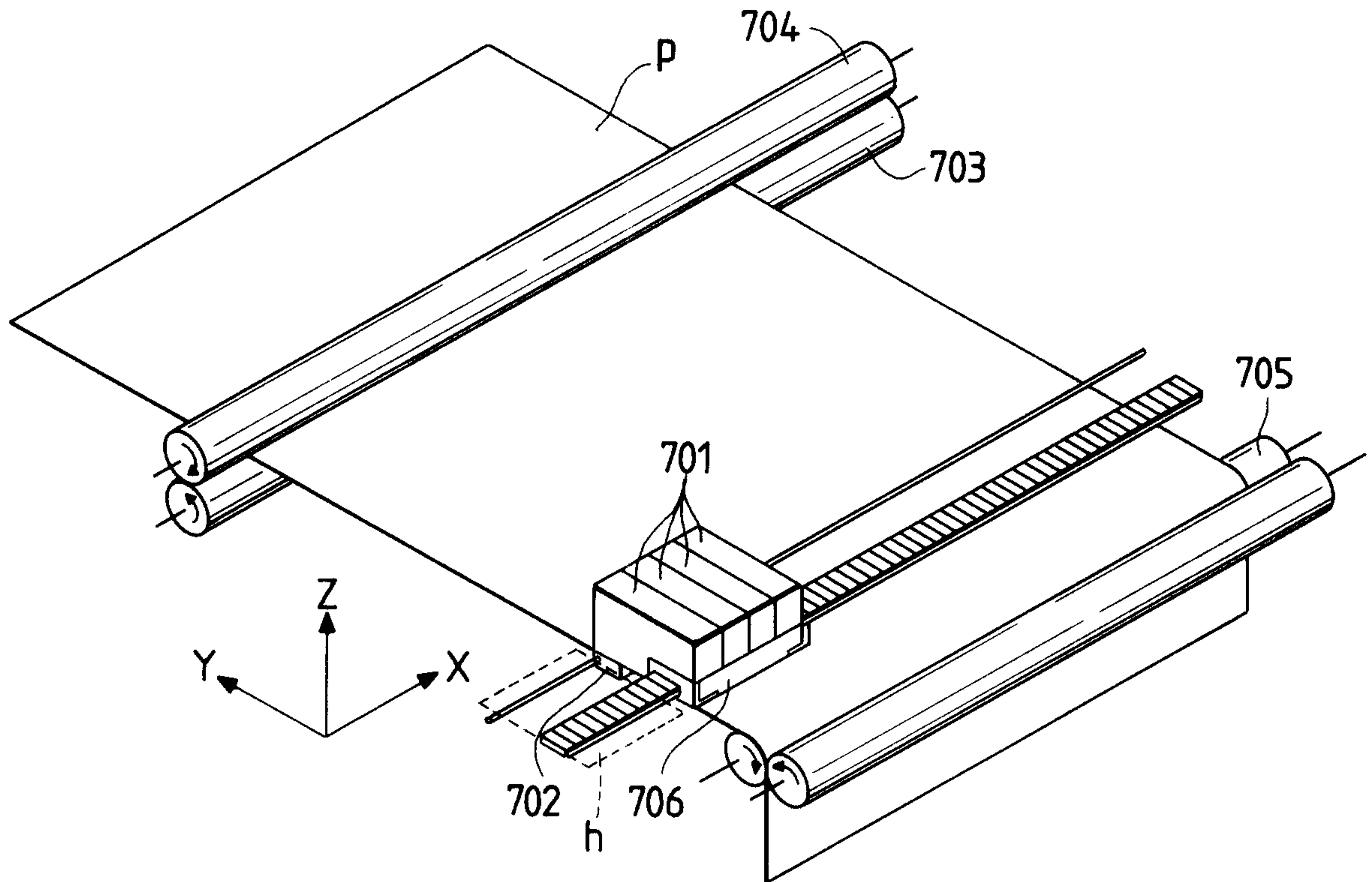


FIG. 23B

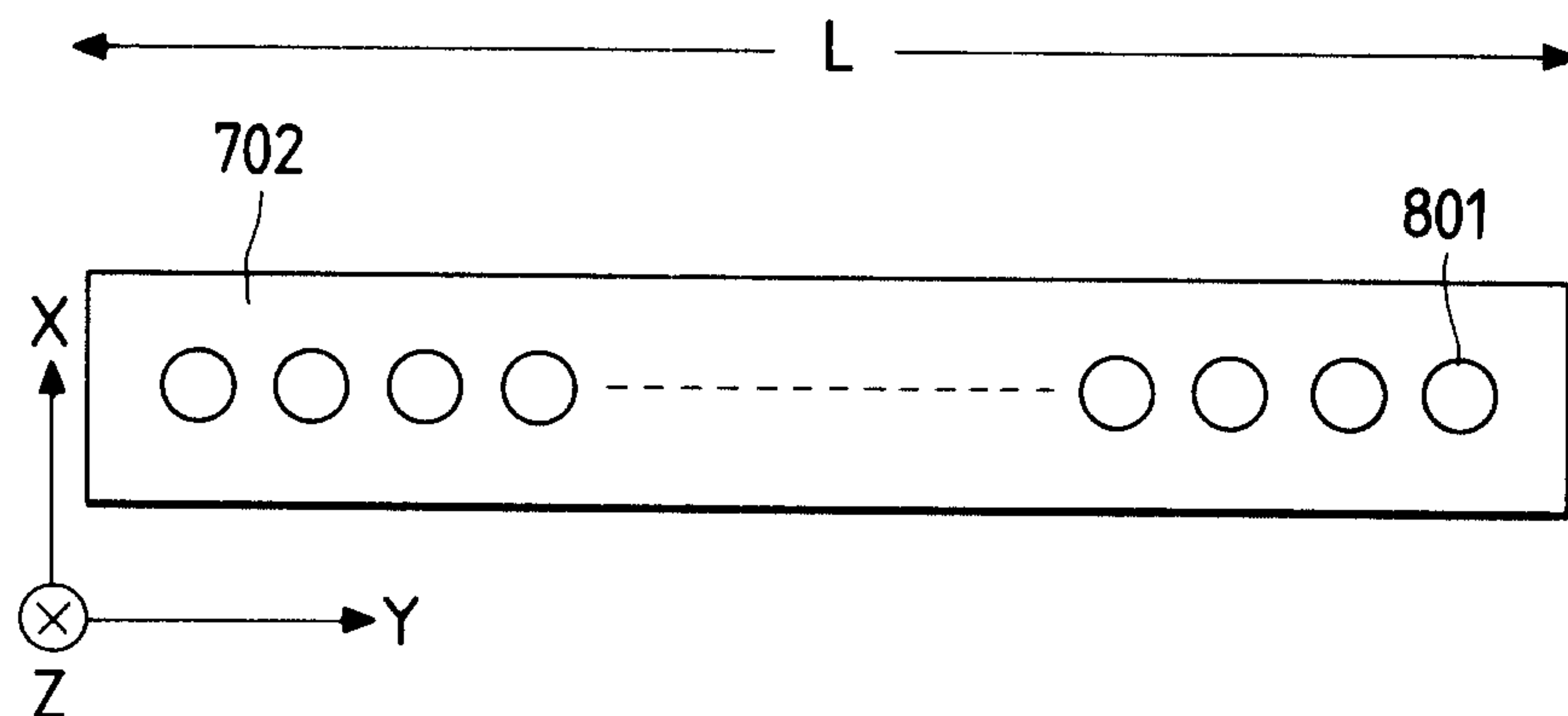


FIG. 24

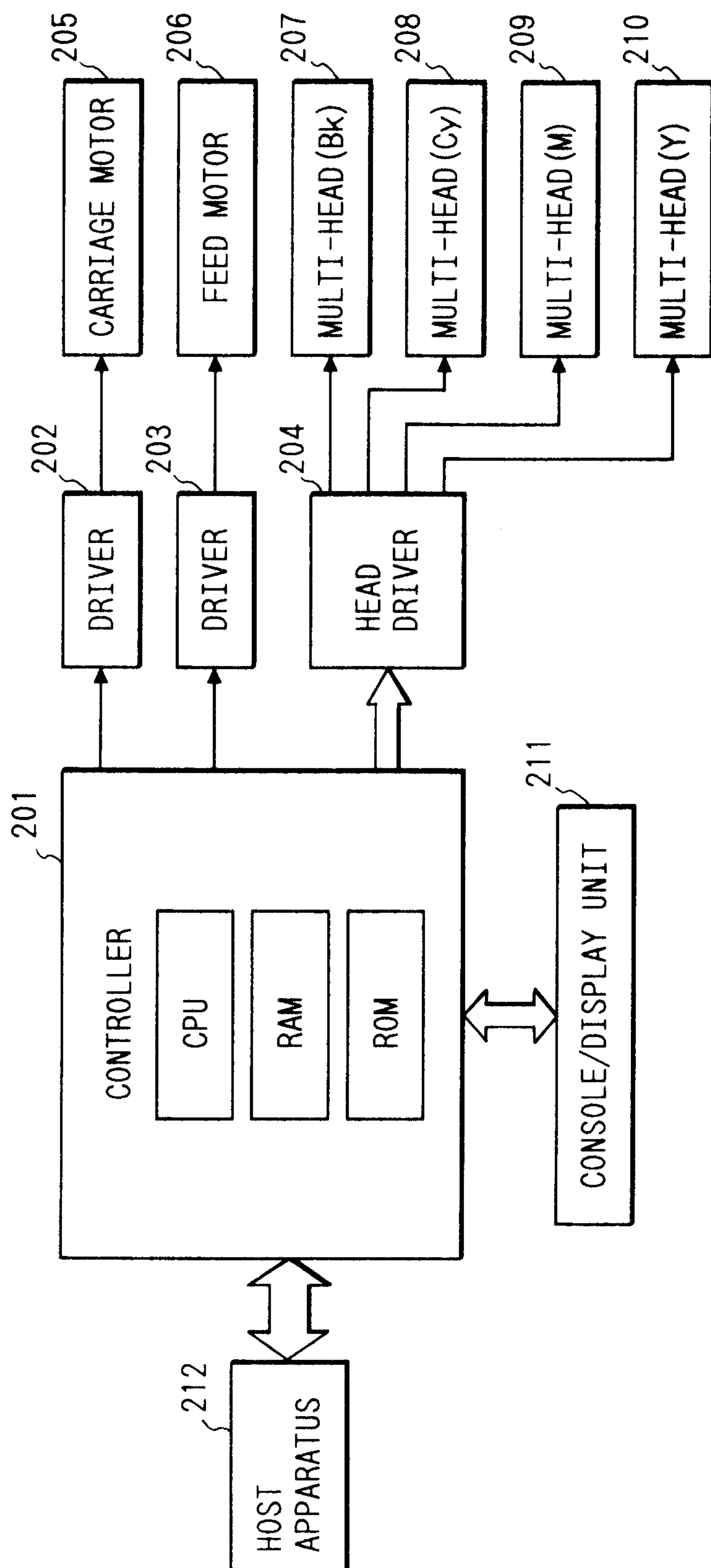


FIG. 25A

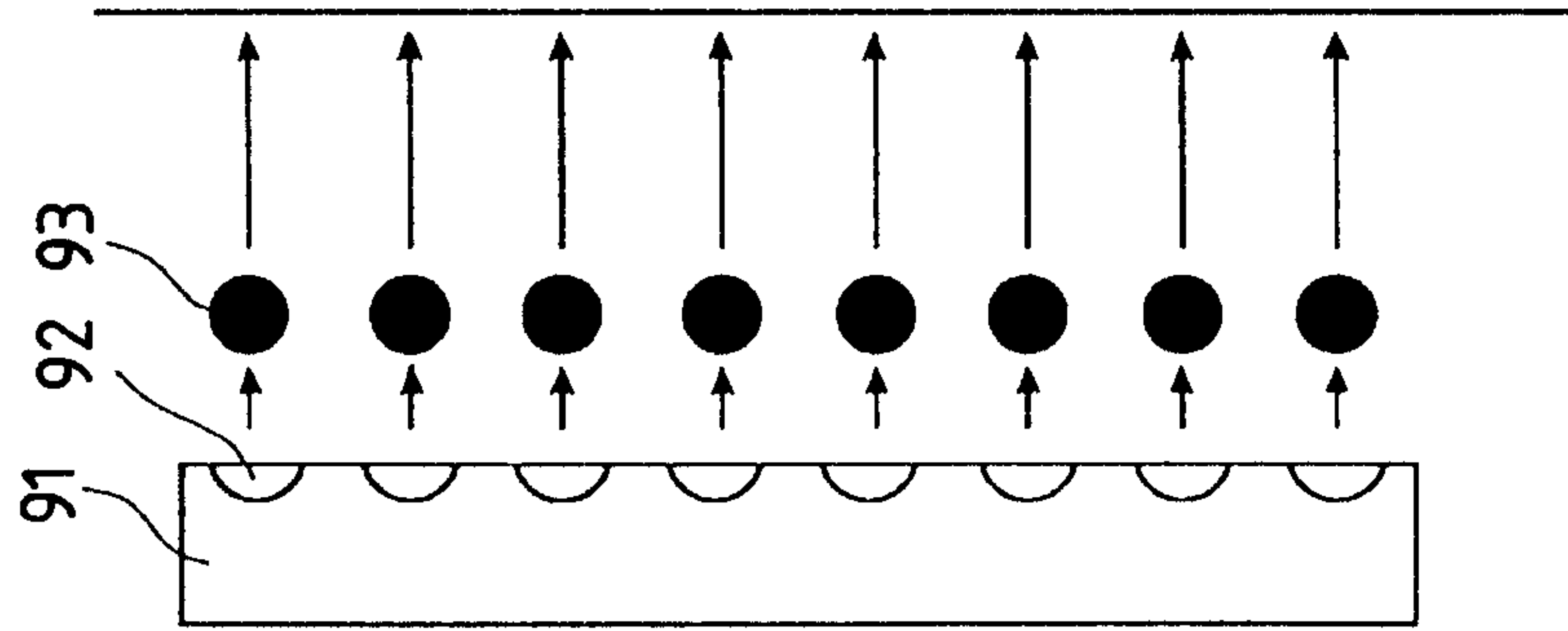


FIG. 25B

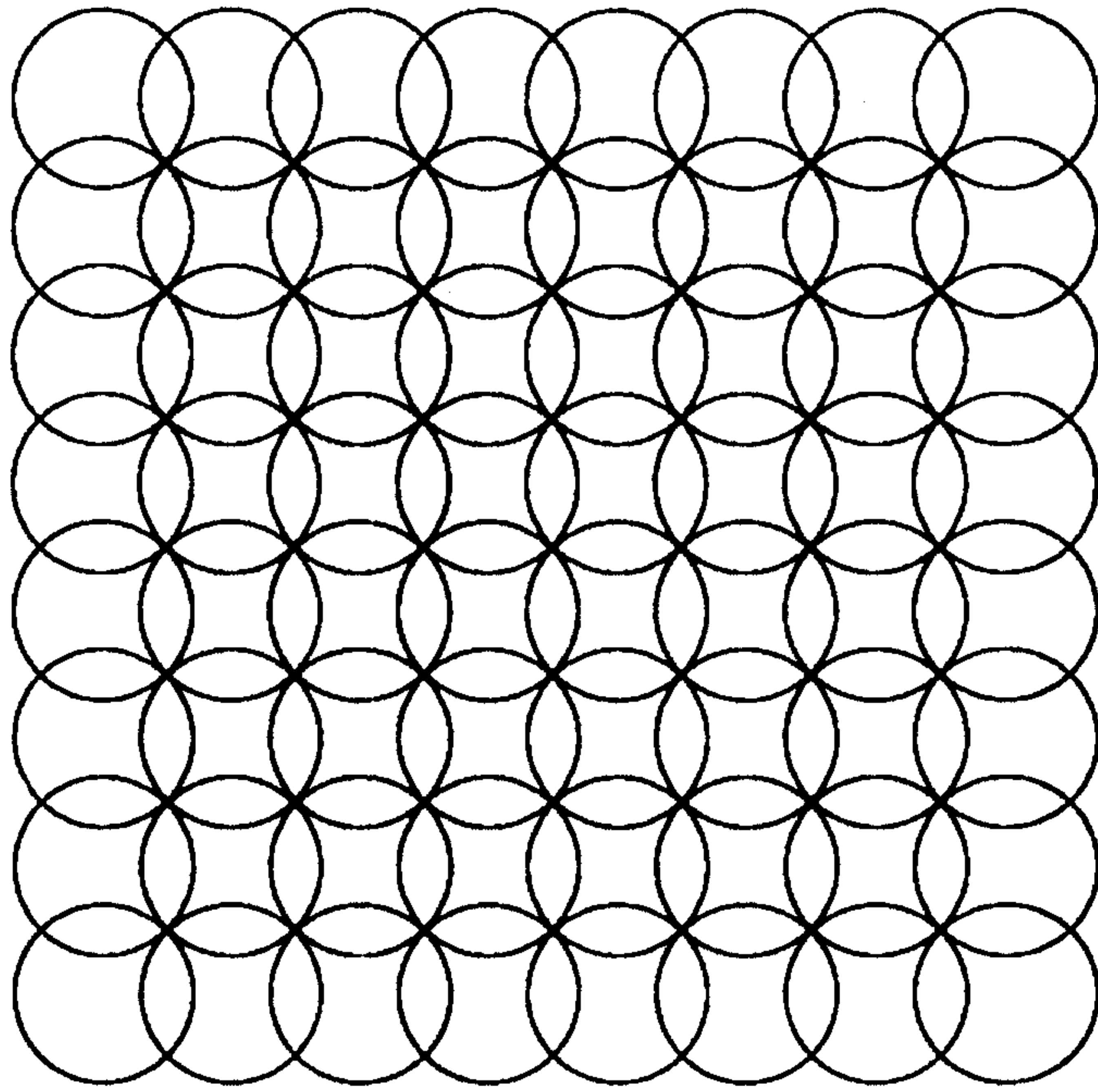
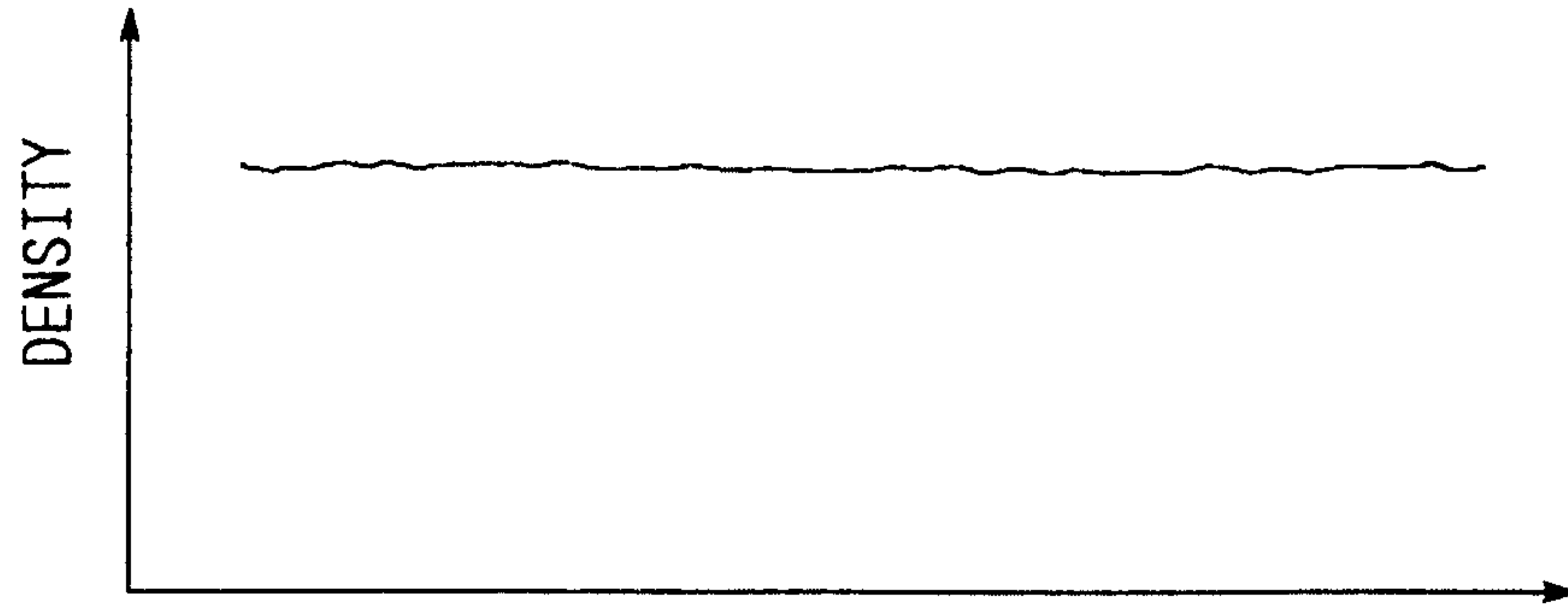


FIG. 25C



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FIG. 26A

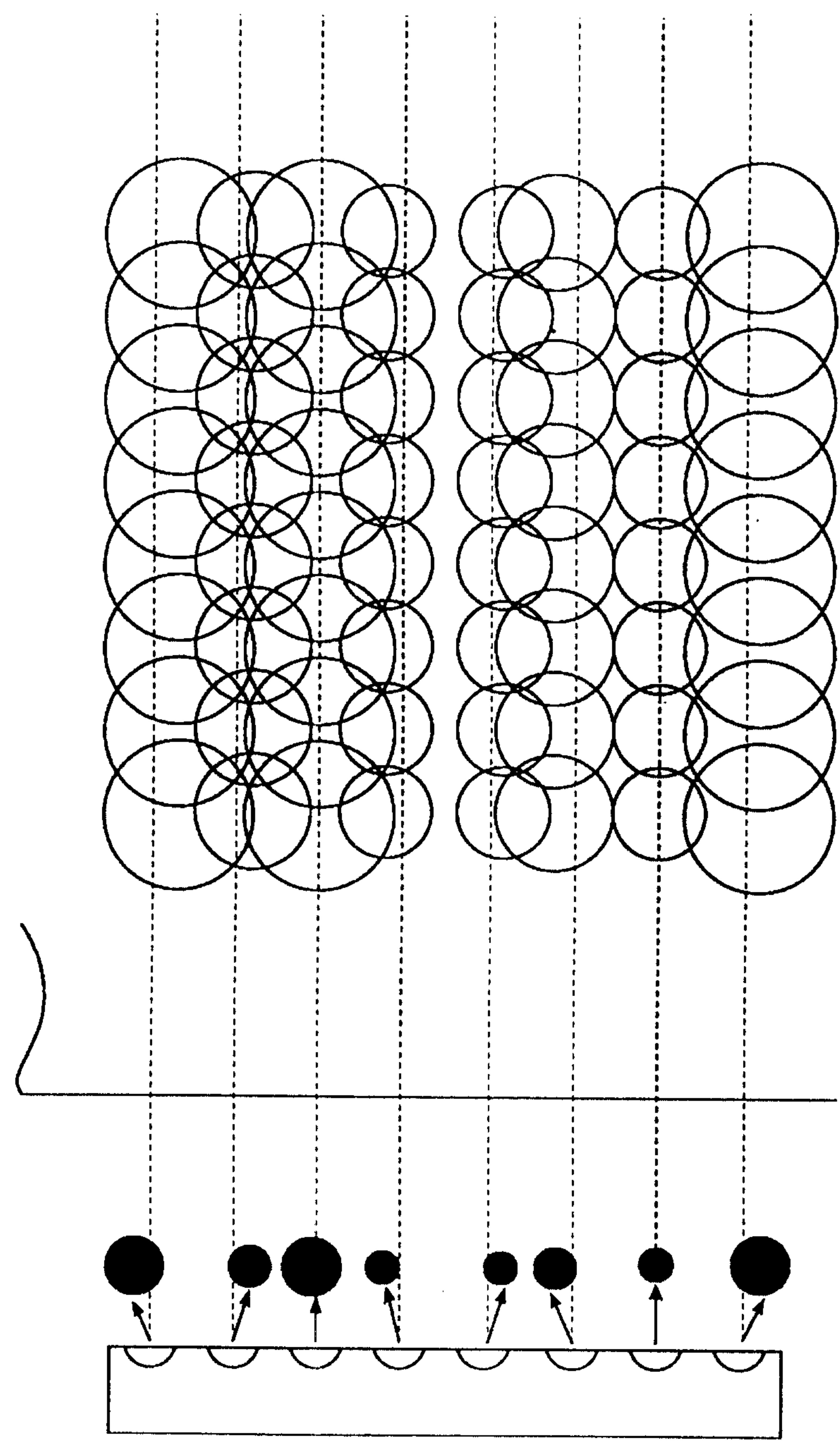
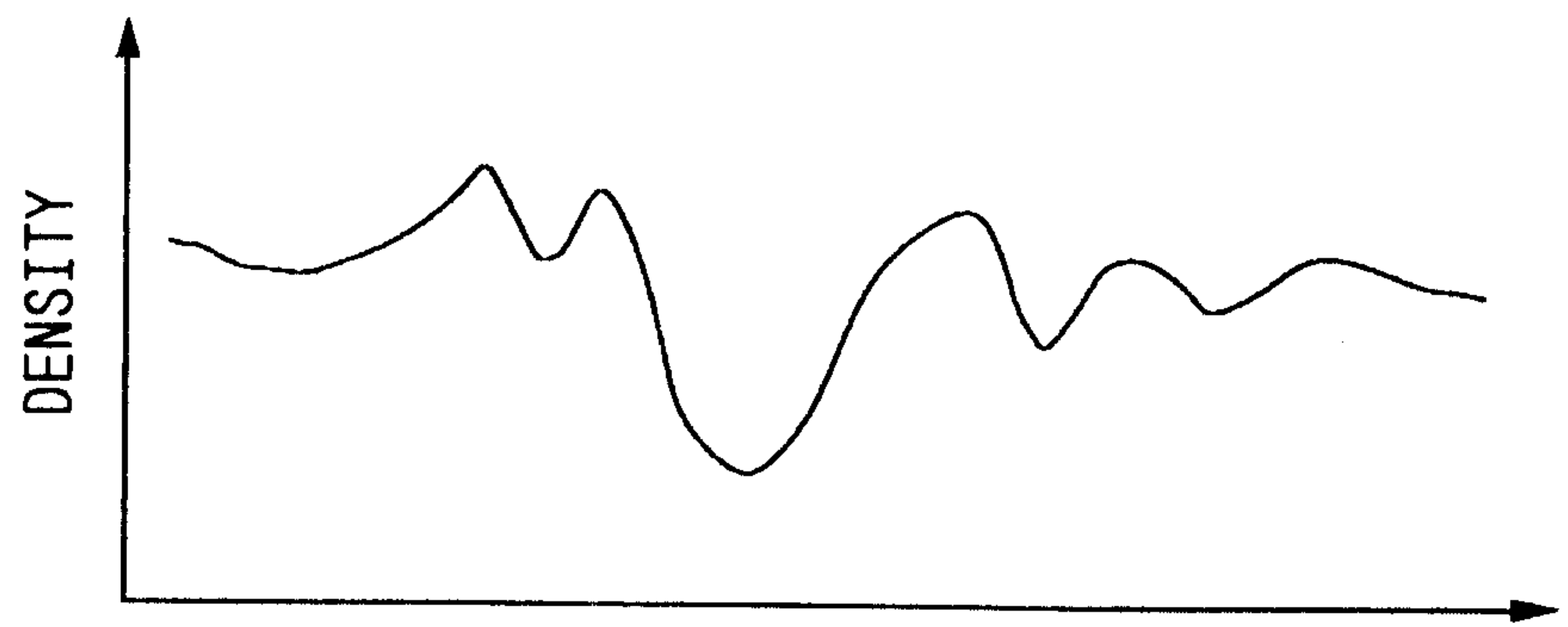


FIG. 26B

FIG. 26C



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FIG. 27A

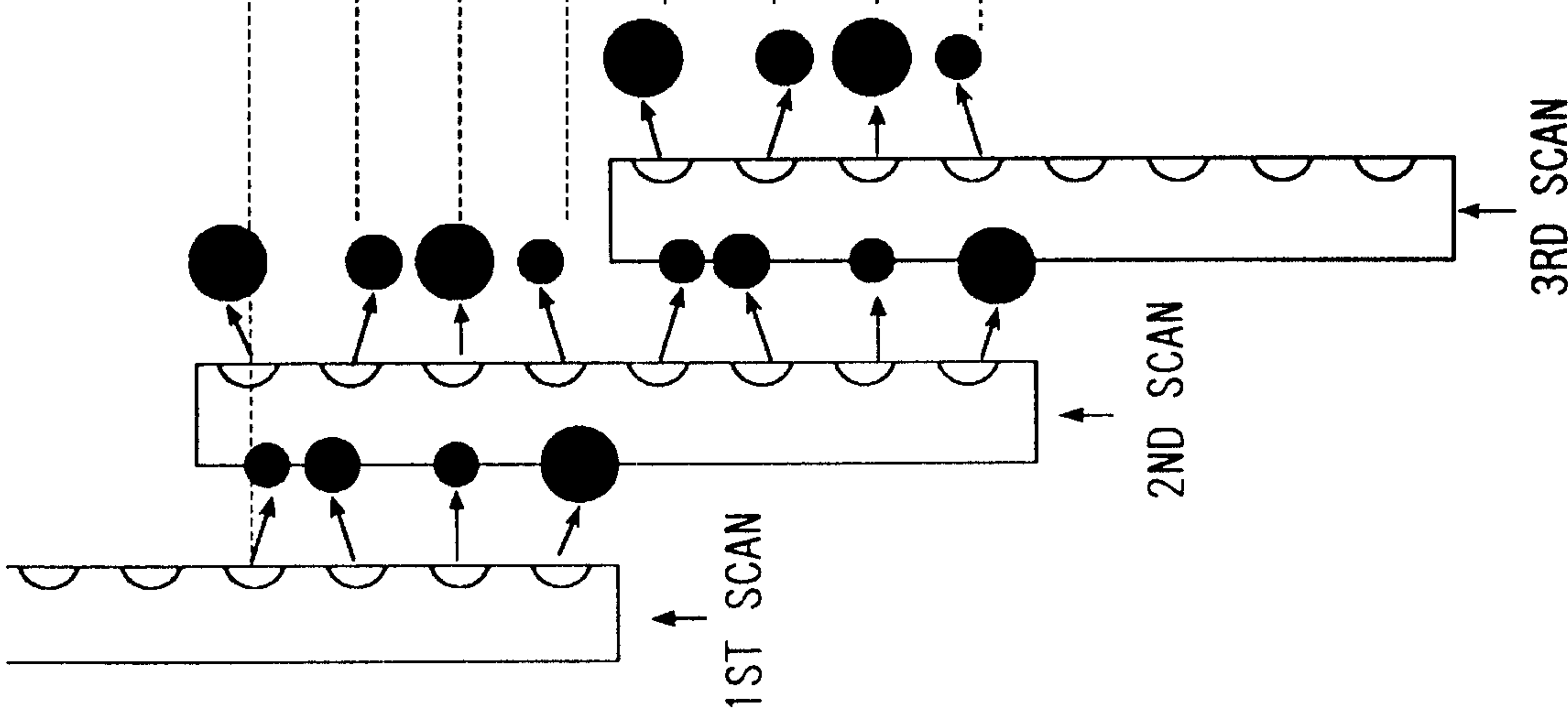


FIG. 27B

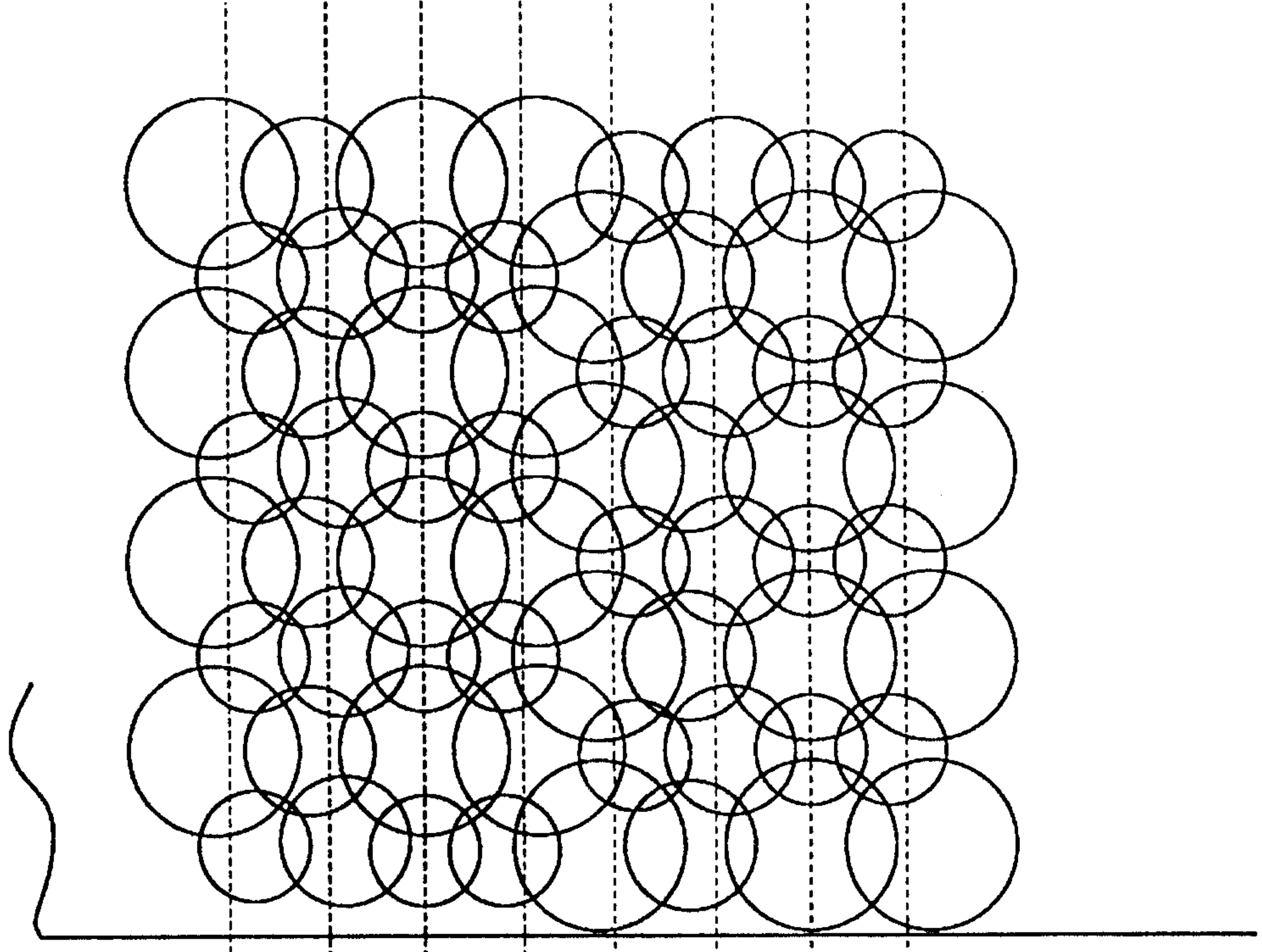
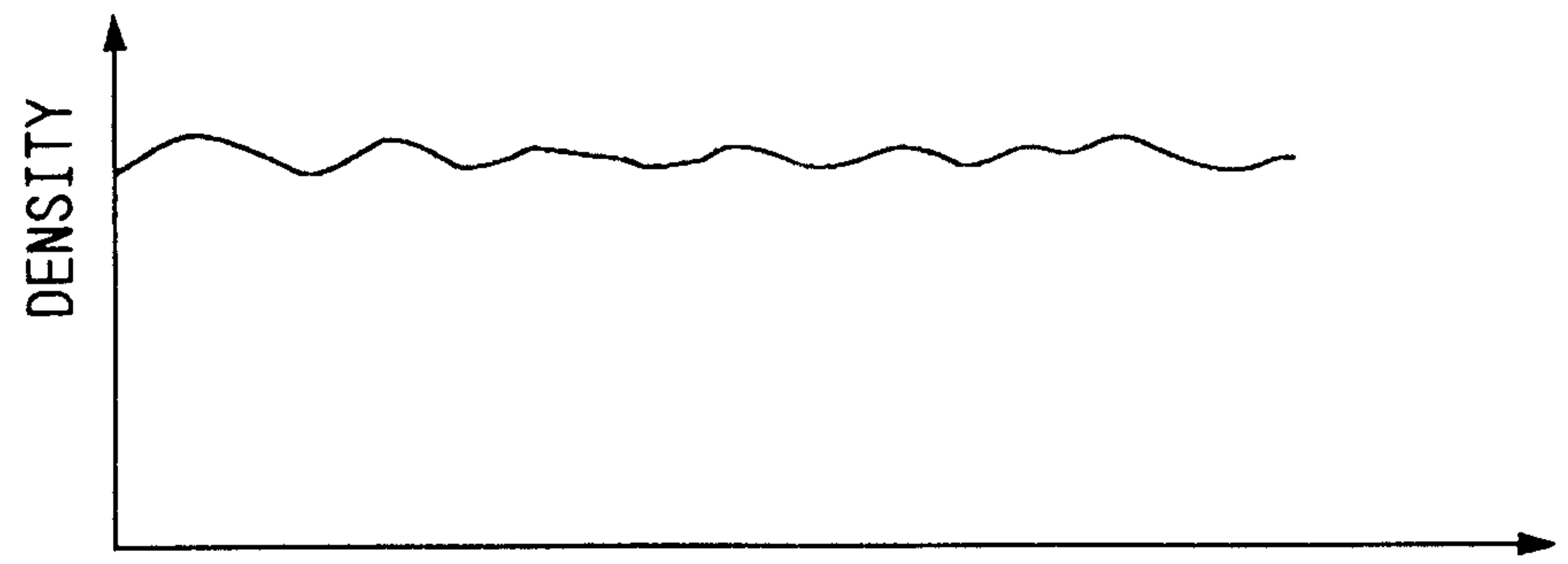


FIG. 27C



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FIG. 28A

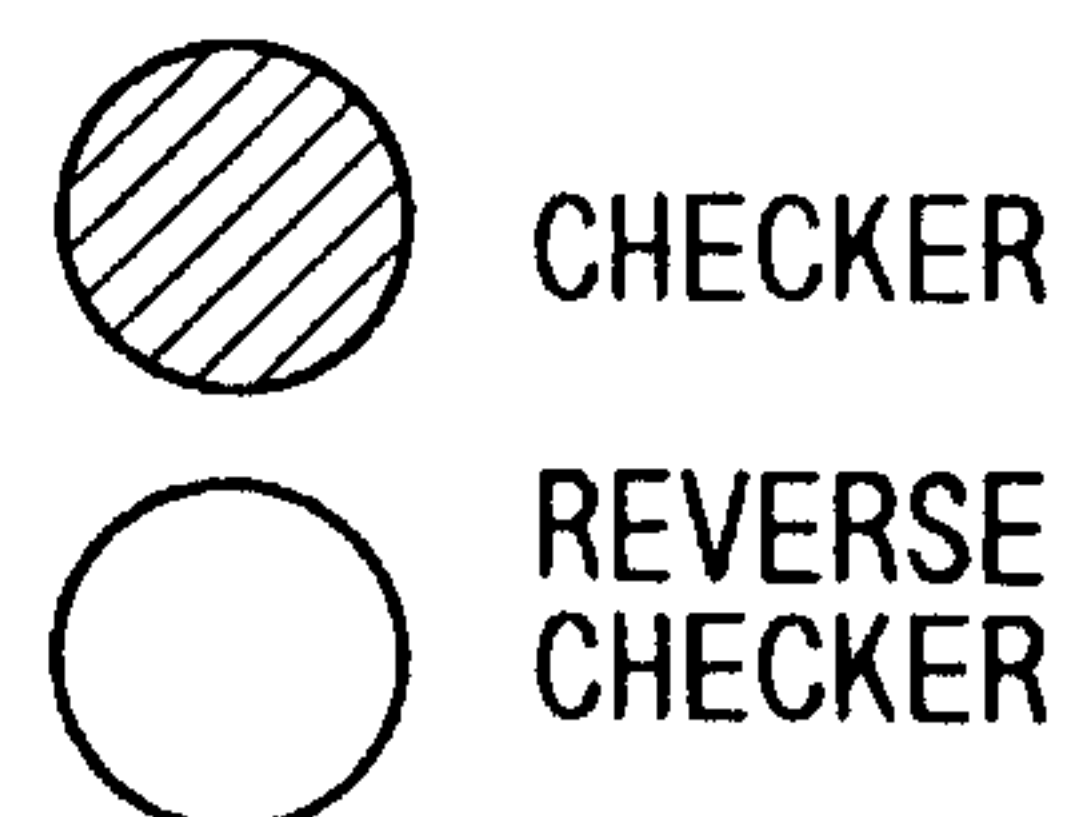
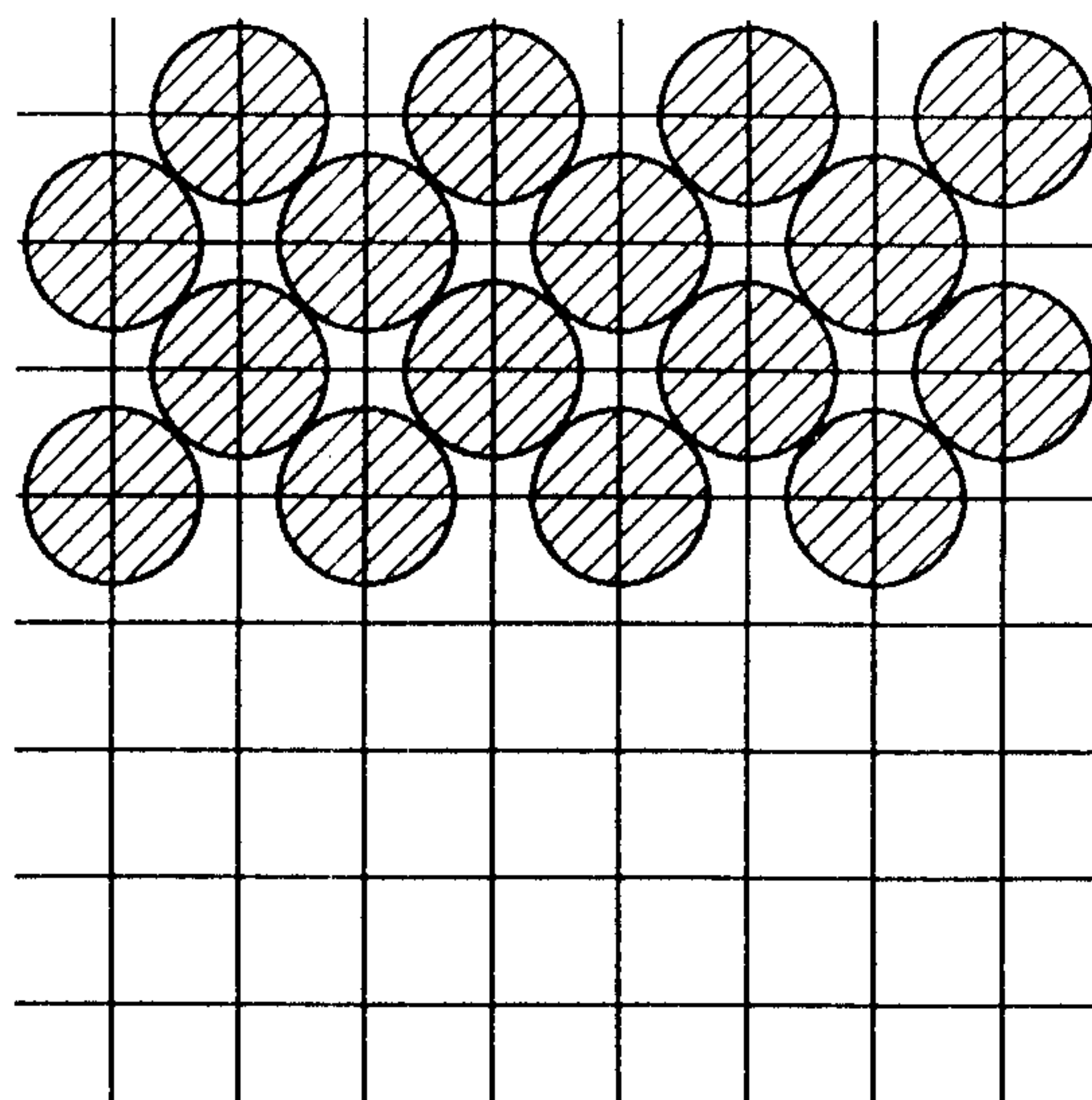
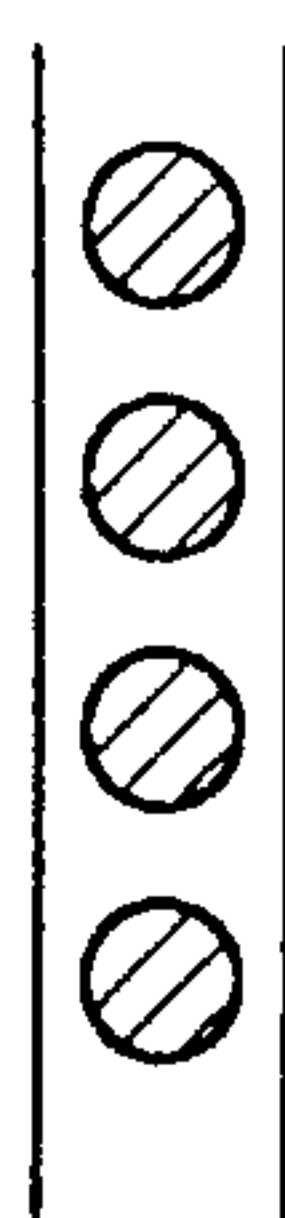


FIG. 28B

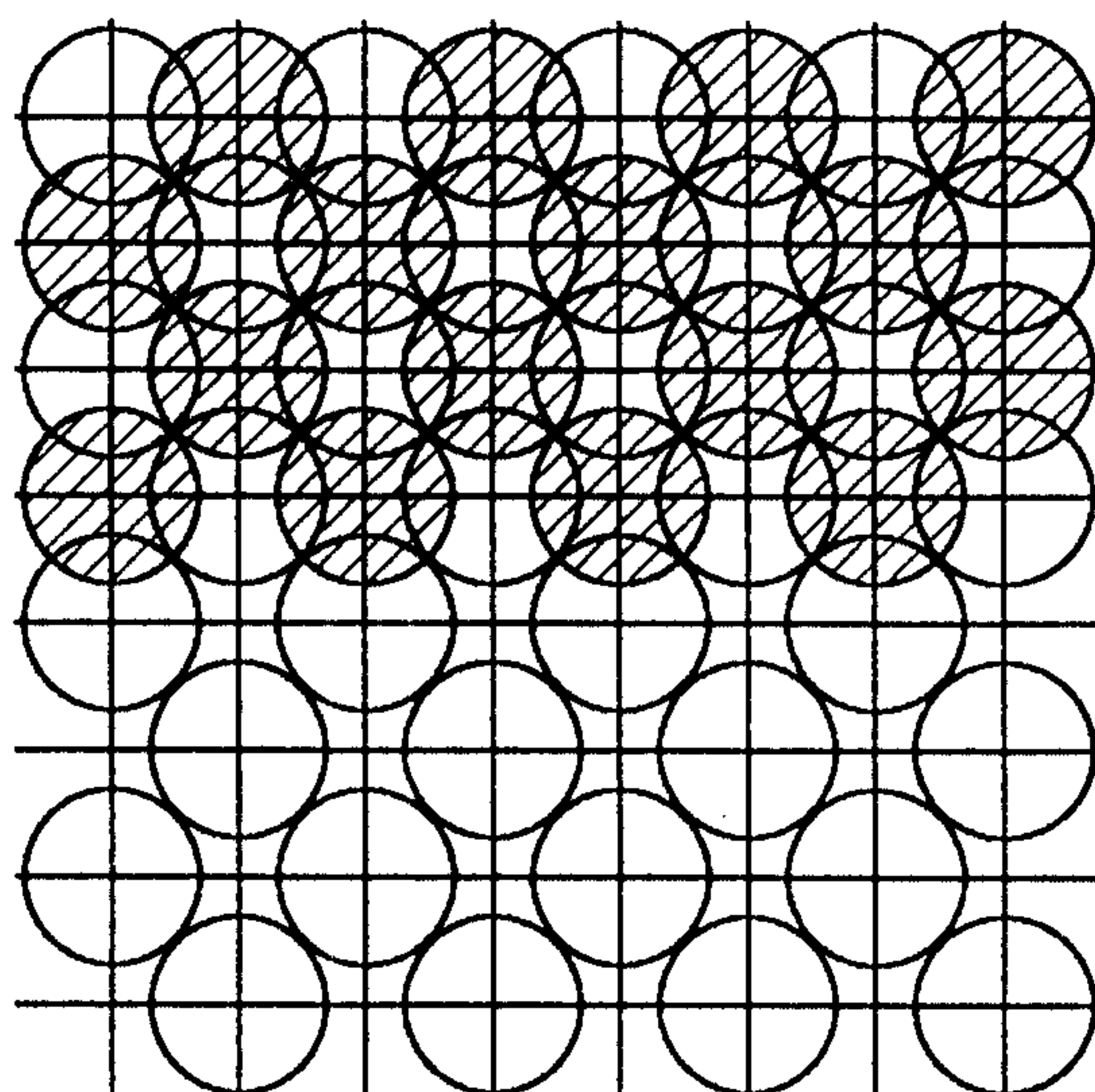


FIG. 28C

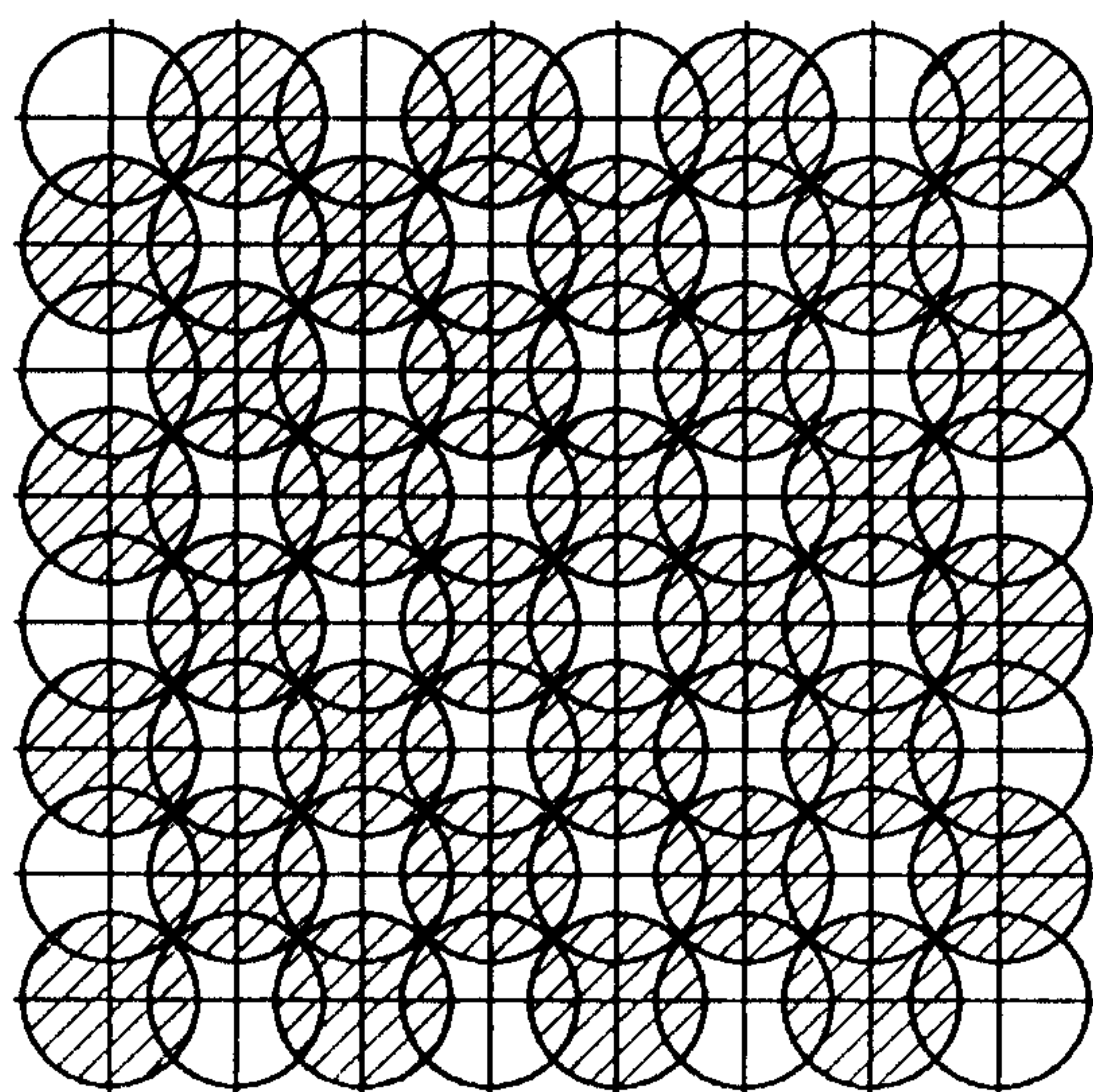
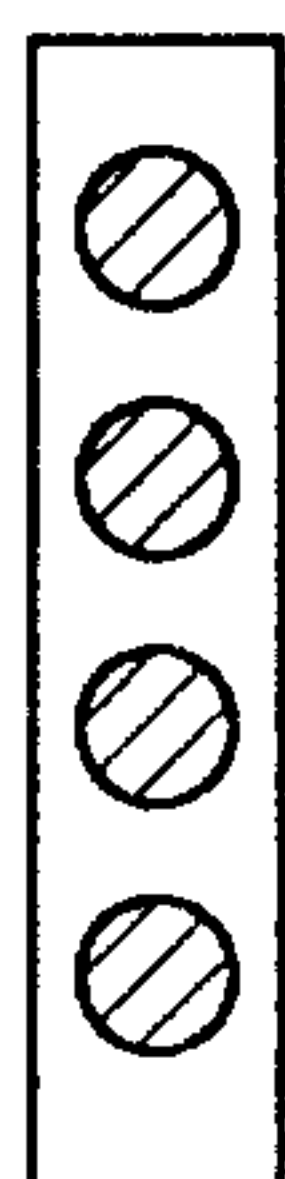


FIG. 29

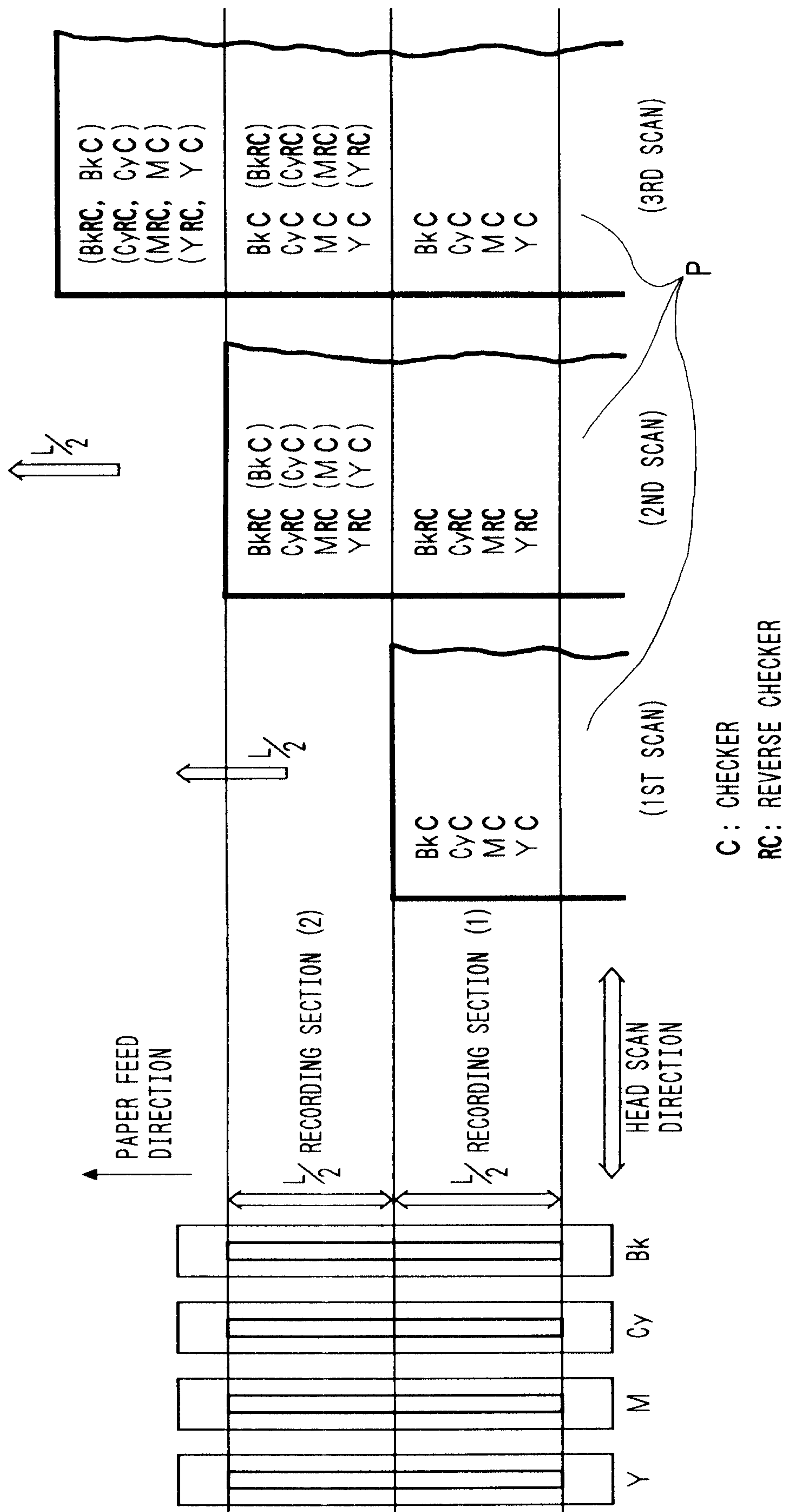


FIG. 30

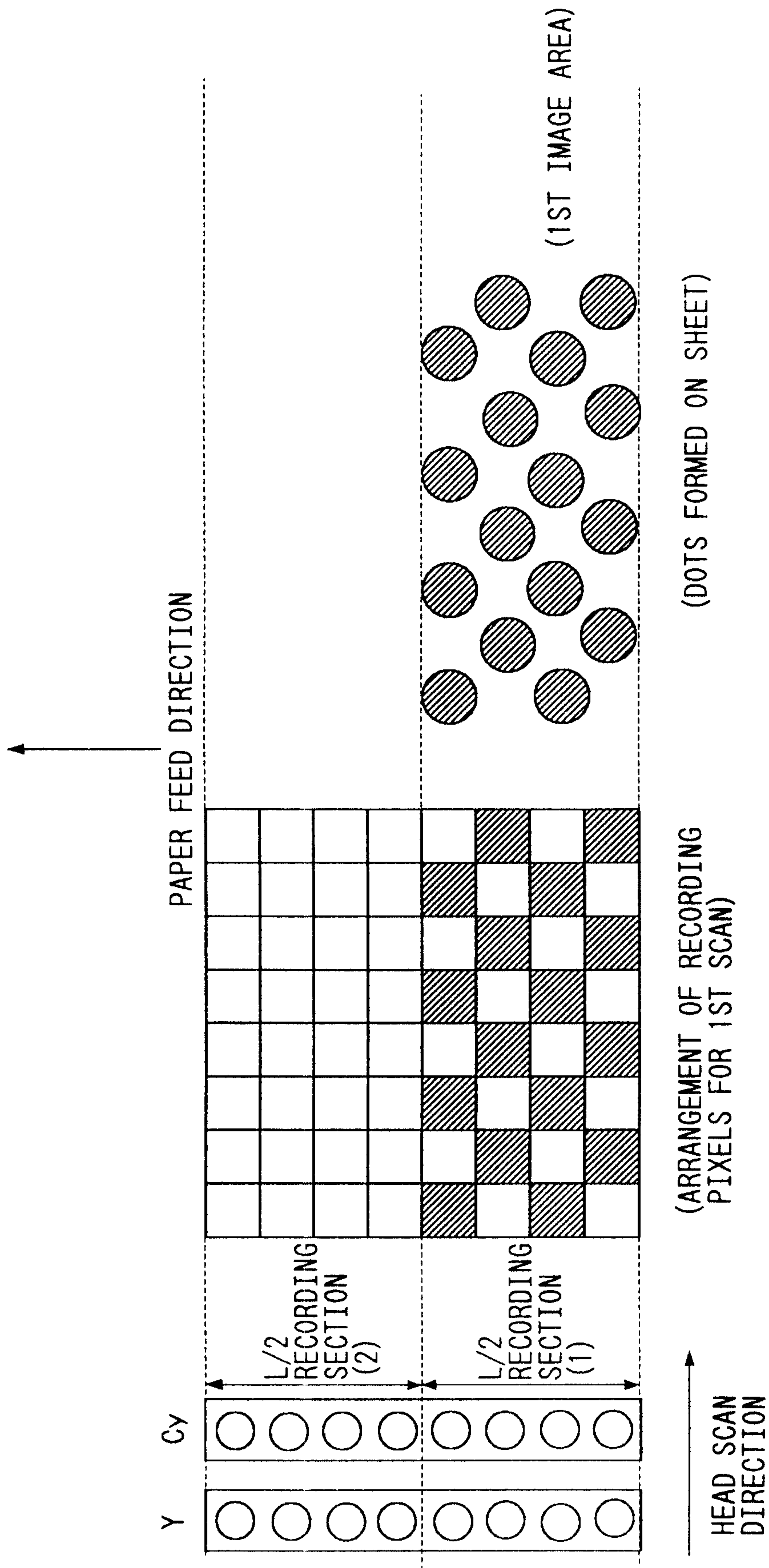
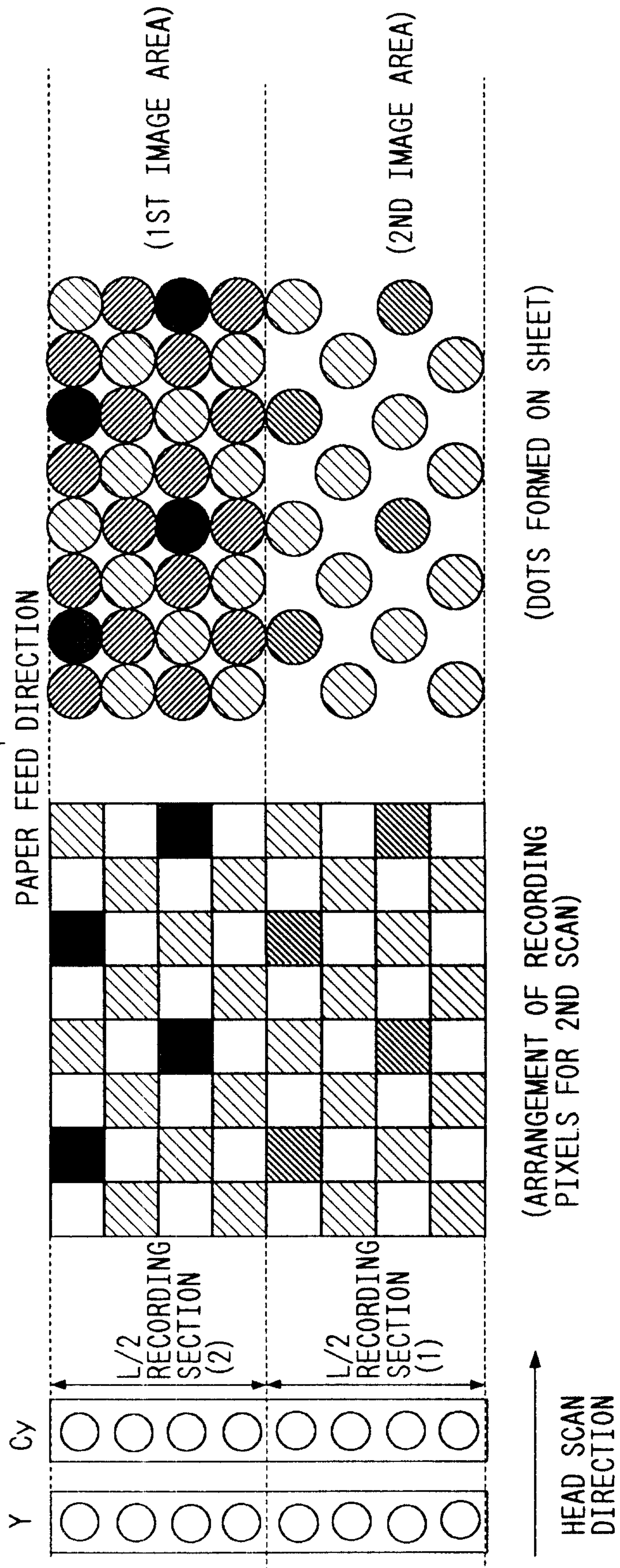


FIG. 31



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FIG. 32

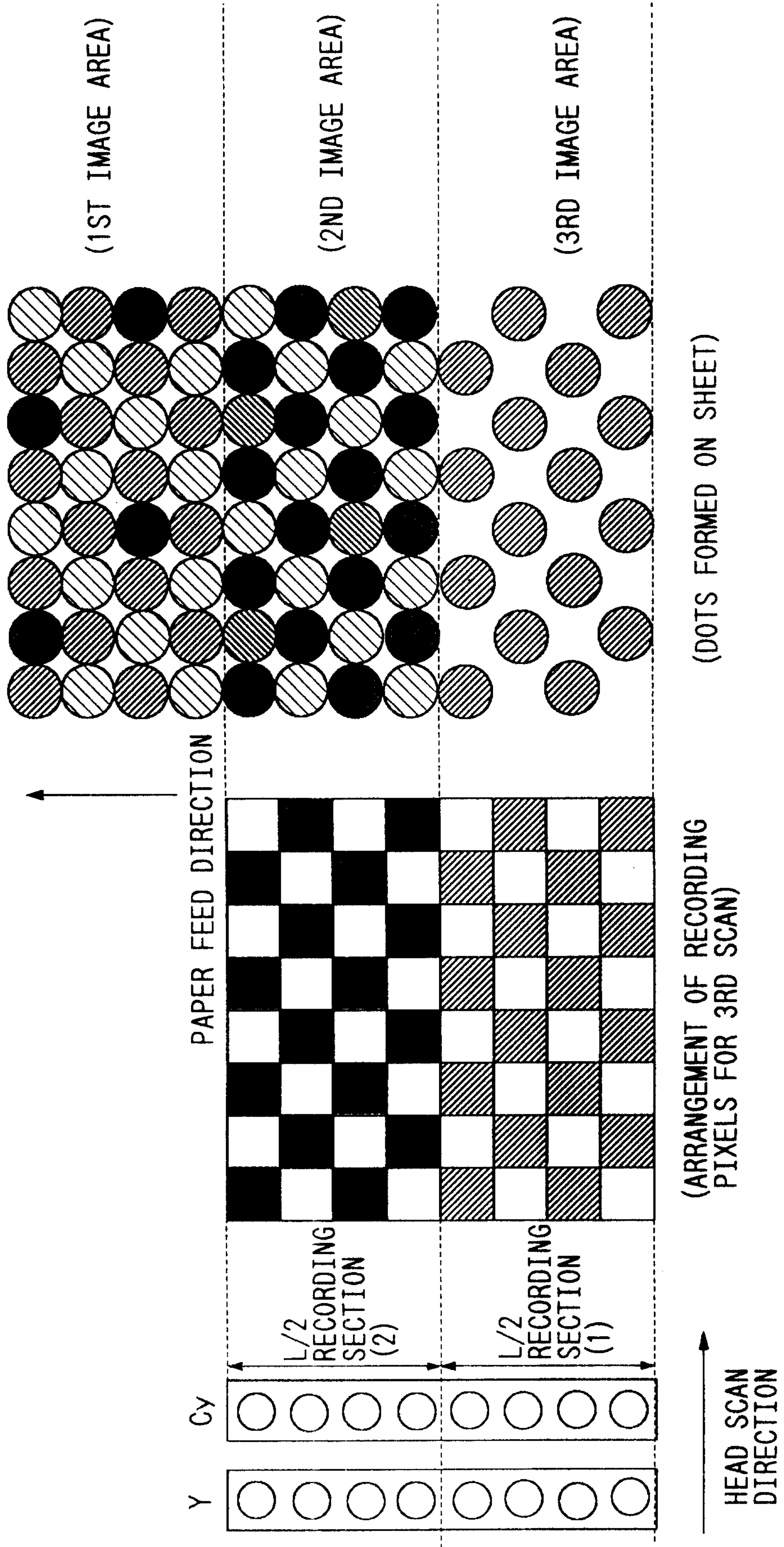


FIG. 33

