Title: SWATH PRINTER AND METHOD FOR APPLYING AN INK IMAGE TO A RECEIVING MEDIUM USING A SWATH PRINTER

Abstract: A swath printer is provided comprising a print head, the print head being moveable along a scan direction for applying an ink image to the receiving medium. Transport means can move the receiving medium and the print head with respect to each other in a transport direction that is substantially orthogonal to the scan direction. A first sensor is arranged to detect a position of a first reference pattern present on the receiving medium in a first area thereof, and a second sensor is arranged to detect a position of a second reference pattern present on the receiving medium in a second area thereof. A controller is provided to control the printer on the basis of the detected positions of said reference patterns during use of the printer.
Swath printer and method for applying an ink image to a receiving medium using a swath printer

FIELD OF THE INVENTION

The invention relates to the field of printers. In particular the invention relates to the field of swath printers, such as inkjet printers. Furthermore, the present invention relates to a method of applying an ink image to a receiving medium using a swath printer.

BACKGROUND OF THE INVENTION

Swath-type printers and methods applying an ink image to a receiving medium using a swath printer are known in the art. Such printers may comprise a carriage for holding a print head, which carriage is moveable along a carriage scan-axis for applying an ink image to a strip of receiving material. The receiving material, such as a paper sheet, can be stepwise advanced in the direction of advance, which extends in a direction substantially orthogonal to the carriage scan-axis. During the printing of an image, the carriage is driven back and forth along the scan-axis to print the successive swaths with the print head. Transporting means are provided for stepwise advancing of the receiving material between each successive swath.

A known problem with swath-type printers is the accurate positioning of the stepwise advancing of the receiving material effected by the transporting means. The need for precise positioning of the receiving material is increased when the printer is a high-resolution printer used for printing graphics with high resolution.

United States patent US 4,916,638 describes a media advance-system for swath-type printers for precise positioning of the receiving material for successive swath-printing. The media advance-system is provided with a dual photodiode sensor, which is mounted on the print head. This print head is provided with nozzles, which nozzles are positioned along a line that extends in the direction of advance of the receiving material. The print head is used to print lines in the margin of the receiving material using the first and Nth nozzle of the print head. These lines in the margin can be detected with the
dual photodiode sensor. In order to obtain a defined stepwise advancing of the receiving material, the following method is used: First, the sensor is positioned over a line in the margin printed by the first nozzle, and the resulting difference signal of the two photodiodes of the sensor is saved as a reference value. Subsequently, the receiving material is advanced until the same value of the difference signal is obtained from the line image of the marginal line drawn by the Nth nozzle. Finally, the receiving material is advanced over a predetermined amount to position the receiving material for the next successive swath to be printed.

A concern of the method of US 4,916,638 is that after each advancing step of the receiving material, a calibration step is required for positioning the receiving material before the next successive swath can be printed. A further concern is that advancement of the receiving material is relatively slow in order to obtain the same value of the difference signal and not to overshoot this position. Still a further concern is that it is not possible to detect whether or not the receiving material is skewed with respect to the print head.

An different solution for the identified problem of swath-type printers is proposed in JP 11301883, in which a printer is described that is provided with a sensor system that is arranged to detect the skew of a recording medium caused by a paper feed miss in advance by detecting the skew of the recording medium when it is fed via the presence or absence of a time difference when two sensors arranged on a paper feeder at a fixed interval detect the feeding of the recording medium. The printer of JP 11301883 comprises two paper tip sensors that are able to detect the presence of the leading edge of the recording medium. The difference of the arrival time of the right and left ends of the recording medium is measured by the sensors. Any difference in the arrival time of the paper edge is indicative of the amount in which the paper is skewed.

A concern of the solution proposed in JP 11301883 is that the sensor system can only detect whether or not the recording medium is fed to the printer in a skewed orientation. The sensor system cannot detect an error in the stepwise advancement or transport, i.e. movement between the recording medium and the print head of the printer, of the recording medium during the printing process. This makes the system of JP 11301883 unsuitable for printing relatively long pieces of recording medium.
SUMMARY OF THE INVENTION

It would therefore be desirable to provide a method of applying an ink image to a receiving medium using a swath printer and to provide a swath printer which can detect errors in the movement between the receiving medium and a print head of the printer, both with respect to an error in the stepwise movement and with respect to an error which leads to a skewed orientation of the receiving medium with respect to the print head of the printer. It would further be desirable to provide at least a good alternative to the available swath printers and to the available method of applying an ink image to a receiving medium using a swath printer.

To better address one or more of these concerns, in a first aspect of the invention a method of applying an ink image to a receiving medium using a swath printer is provide the method comprising:

a) moving a print head along a scan direction to print a swath,
b) moving the receiving medium and the print head with respect to each other in a transport direction, which transport direction is substantially orthogonal to the scan direction,
c) detecting a position of a first reference pattern in a first area of the receiving medium,
d) detecting a position of a second reference pattern in a second area of the receiving medium,
e) determining a relative position between the receiving medium and the print head in the transport direction using said detected first and second positions, and
f) moving the print head along the scan direction to print a further swath taking into account the determined relative position between the receiving medium and the print head in the transport direction.

By detecting the position of a first reference pattern and a second reference pattern on two distinct areas of the receiving medium, it has become possible to determine or calculate the position of the receiving medium at the position of both reference patterns and consequently one can determine an overall relative position between the receiving medium and the print head. In particular it is possible to determine whether or not the receiving medium and the print head are in a skewed orientation with respect to each other as two distinct positions of two reference patterns have been detected.
In an embodiment step e) is effected by determining deviations in said detected positions of the first and second reference patterns from a desired position thereof. This increases the accuracy of the method.

In an embodiment the print head is moved along the scan direction to print the further swath while applying a correction to correct for said detected deviations. In this manner detected errors in the positioning between the receiving medium and the print head can be corrected directly after their detection and can it be ensured that subsequent swaths will connect correctly to previous swaths, so as to form a continuous image without printing errors, or at least without printing errors that are detectable by the human eye.

In an embodiment step f) further comprises moving the receiving medium and the print head with respect to each other in a direction that is substantially orthogonal to the scan direction during printing of the further swath, so that errors in the movement of the receiving medium and the print head with respect to each other in the transport direction can be corrected.

In an embodiment step f) further comprises moving the receiving medium and the print head with respect to each other in a direction that is angled with respect to the transport direction during printing of the further swath, so that errors in the movement of the receiving medium and the print head with respect to each other resulting in a skewed orientation can be corrected. Such correction may comprise rotating the receiving medium around a central axis and/or rotating the print head around a central axis, both in a plane that is substantially parallel to the plane wherein the receiving medium is located.

In an embodiment the print head comprises a plurality of ejectors arranged to eject droplets of ink on the receiving medium, and step f) further comprises adjusting a volume of the droplets of ink during printing of the further swath.

In an embodiment step f) further comprises adjusting the volume of the droplets of ink is adjusted for those ejectors that print a border of an input bitmap adjoining an input bitmap printed in a previous swath, so that a proper connection between the subsequent print swaths can be made and ink image without errors is printed. In particular, when the
detected error would result in a white line in the image, the volume of the droplets can
be increased. In case the detected error would lead to a dark line to be printed, the
volume of the droplets may be decreased. Adjusting the volume of the ejected droplets
may also include disabling one or more ejectors.

In an embodiment step f) further comprises adjusting the ink image to be printed for the
detected deviations.

In an embodiment the method further comprises shifting a remaining part of the input
bitmap to be printed by an amount substantially equal to said detected deviations, so
that a correct image with the correct dimensions will be printed.

In an embodiment said reference patterns are provided in an area of the receiving
medium that forms a margin in transport direction thereof. By providing reference
patterns in a marginal area of the receiving medium the relative position of the receiving
medium and the carriage with respect to each other can be determined during use of
the printer, i.e. after printing each subsequent swath. This allows for a dynamic
determination of said relative position and consequently allows for a dynamic error
correction. It is noted here that such patterns could be patterns that are for example
printed by the printer itself, patterns that are pre-printed on the receiving medium and
also patterns that are present in the fabric of the receiving medium.

In another aspect of the invention a swath printer is provided that comprises a print
head, the print head being moveable along a scan direction for applying an ink image to
the receiving medium, transport means for moving the receiving medium and the print
head with respect to each other in a transport direction that is substantially orthogonal to
the scan direction, a first sensor arranged to detect a position of a first reference pattern
present on the receiving medium in a first area thereof, a second sensor arranged to
detect a position of a second reference pattern present on the receiving medium in a
second area thereof, and a controller arranged to control the printer on the basis of the
detected positions of said reference patterns during use of the printer.

Such a swath printer, and its preferred embodiments as defined in the appended claims,
exhibits the same advantages as the method referred to above and is consequently able
to determine or calculate the position of the receiving medium at the position of both
reference patterns and consequently to determine an overall relative position between the receiving medium and the print head. In particular it is able to determine whether or not the receiving medium and the print head are in a skewed orientation with respect to each other as two distinct positions of two reference patterns can be detected.

Furthermore, in an embodiment the reference parameters may be provided in a marginal area or margin of the receiving medium the relative position of the receiving medium and the print head with respect to each other can be determined during use of the printer, i.e. after printing each subsequent swath. This allows for a dynamic determination of said relative position and consequently allows for a dynamic error correction and will provide improved printing performance.

These and other aspects of the invention will be more readily appreciated as the same become better understood by reference to the following detailed description of a method of applying an ink image to a receiving medium using a swath printer and of such a swath printer, considered in connection with the accompanying drawing in which like reference symbols designate like parts.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 depicts a schematic setup of a swath printer;
Figure 2 depicts a simplified block diagram of the operation of the swath printer;
Figures 3A, 3B depict an image of dots printed using a known printing method;
Figures 4A-4C depict an image of dots printed using the printing method according to an embodiment of the invention, and
Figures 5A, 5B depict an alternate printer with a skewed orientation of the receiving medium and the carriage holding the print head.

DETAILED DESCRIPTION OF EMBODIMENTS

Figure 1 schematically depicts a typical setup of a swath type printer, such as an ink jet printer, comprising a multi-nozzle print head 14 is mounted on a carriage 16 which is guided on guide rails 18, on which the carriage 16 can travel back and forth back across a receiving medium 12, such as a sheet of paper) in a direction indicated with a double arrow B. By moving the carriage 16 that carries the print head 14 along the guide rails
18, an image swath (i.e. an image strip with several dot lines) can be printed on the receiving medium 12 with each pass of the print head 14. The direction of movement B is also called the scan direction or scan axis of the printer.

In the example of Figure 1, the receiving medium 12 is transported by means of a rotary unit 8 having a feed roller 10. However, it is also possible that the receiving medium 12 is for example placed on a substantially flat surface over which it is transported with respect to the print head 14, or over which the print head 14 carried by the carriage 16 is transported. Such configurations can for example be used when sheets of non-flexible material are used, or when non-standard shapes and/or sizes of sheets need to be printed. Hence, it is possible to move the receiving medium 12 and the print head 14 with respect to each other in a number of alternative ways.

To continue with the example of Figure 1, which is not intended to be limitative in any way, the rotary unit 8 and the feed roller 10 operate as a transport means for moving the receiving medium 12 and the print head 14 with respect to each other in a transport direction C by rotating the feed roller 10 in a direction A. When the feed roller 10 is rotated in the direction of the arrow A, a sheet of the recording medium 12 is advanced in the direction represented by the arrow C along a path 24. The direction C is the transport or sub-scanning direction of the printer and the direction B is the main scanning direction, i.e. the direction in which the print head 14 moves back and forth along the scan direction. A camera (not shown) may be mounted on the carriage 16 for imaging an area on the image receiving medium 12, which area extends in the sub-scanning direction C.

A controller (not shown) can control a drive motor connected to the transport means so as to advance the receiving medium or sheet 12 by a desired amount, once the carriage 16 carrying the print head 14 has performed a pass across the sheet 12. After an image swath has been printed, the sheet 12 is thus advanced by a length equal to a step value, so that the next image swath can be printed and connects to the previous image swath. During each printer swath an input bitmap is printed. The print head 14 may comprise four nozzle heads 20a – 20d as shown in the example, whereby for example one nozzle head is provided for each one of the basic colours, yellow, magenta, cyan and black. Ink for printing the image may be supplied from an ink container in a manner known per se to the skilled person. On that part of the print head 14 that faces the sheet
12, each nozzle head 20a - 20d comprises one or more linear arrays of ink ejectors or nozzles 22, which are arranged to eject droplets of ink on the sheet 12 in response to a driving signal from the controller (not shown).

The nozzle heads 20a - 20d are energised in accordance with digital image data of an image to be printed onto the sheet 12. Driving signals in accordance with the image data are provided to the print head 14 through a connector (not shown) mounted on the carriage 16 or through any other suitable way. Each ejector 22 can be energised separately so as to eject an ink droplet which will form an ink dot at a corresponding pixel position on the sheet 12. Thus, when the print head 14 performs a single pass over the sheet or receiving medium 12, each ejector 22 can be energised to draw a single dot line of the intended image. As a result, during each pass of the carriage 16, the print head 14 will print a swath of the image based on an input bitmap. Although only eight nozzles 22 are shown per nozzle head 20a - 20d in Figure 1, in practice, a different number of nozzles may be considered.

Figure 2 shows a simplified component diagram of a printer according to the invention. The printer may comprise the print head 14 with the nozzle heads 20a - 20d, the carriage 16, a camera 50 which may be mounted on the carriage 16, a controller 34 which is arranged to control the printer and its components such as the motor 30 so as to rotate the feed roller 10 for moving the receiving medium or sheets by a required length. As mentioned above, the printer may also be arranged such that the carriage that carries the print head 14 is moved with respect to the receiving medium. Furthermore, different solutions are possible for transporting the receiving medium and the print head with respect to each other.

The control unit 34 is adapted to control the various components of the printer. It may comprise a central processing unit (CPU), storage means such as an electronic memory and an image processing unit, whereby all of said components can be functionally connected to each other, for example through a bus or any other suitable way. The controller executes various tasks which are required to control the respective components of the printer.

The control unit 34 is arranged to receiving a document or an image to be printed in digital form, for example a page description language (PDL) file which describes the
layout and graphical objects of the document to be printed. Such a PDL file can be
submitted, together with print settings, to the image processing unit which has functions
for half toning the data of the digital document to be printed. Once half toning of the data
has been executed, image data in the form of an array of pixels (i.e. a bitmap) to be
used by the print head is available. The array of pixels (input bitmap) constitutes
information usable to control the ejectors or nozzles 22 of the nozzle heads 20a, 20b,
20c and 20d of the print head 14, so that the nozzles can eject ink dots onto the
receiving medium at corresponding pixel positions in the bitmap. During each pass of
the carriage 16 which carries the print head 14, the nozzles of the print head are
activated according to a swath print mask which allocates an ink ejecting element to
pixel positions in the bitmap in such a way that the pixels are rendered by ink dots,
where required, at the corresponding pixel positions.

The control unit 34 may also directly or indirectly control the motor 30 so as to move the
receiving medium 12 by a required length in the transport direction, once the carriage 16
with the print head 14 has performed a pass across the receiving medium. The
controller may also control the movement of the carriage 16.

The controller may also be arranged to receive signals indicative of an image sensed by
the camera 50. In an embodiment, said signals are used to execute the method for
printing an array of dots representing image data.

For a better understanding how a swath or inkjet type printer works, two basic examples
are given referring to Figure 3A and 3B.

Figures 3A and 3B schematically show ink dots as printed by a simplified print head on
a receiving medium or sheet 12, using a known method for printing an array of dots.

Figure 3A depicts an example of a so-called single pass bi-directional printing method.
For clarity purposes, throughout the description, printing ink dots is explained using a
simplified print head 20 representing any of the nozzle heads 20a, 20b, 20c or 20d or
any combination thereof or the whole print head 14. The print head 20 comprises a
limited number of ejectors or nozzles 22 arranged according to a single linear array. An
imaginary grid 40 comprising a plurality of cells 42 represents the resolution of the array
of pixels to be rendered, for example 150 pixels per inch. Since ink dots are printed at
corresponding pixel positions, the resolution of the printed image in the example of Figure 3A is 150 dpi (dots per inch). The result obtained after printing a Nth swath of the image is visible in the upper part of Figure 3A, in which upper part a number of ink dots 44 are located on the recording medium 12 at corresponding pixel positions represented by the cells 42. The Nth swath of the image is the result obtained after one pass of the carriage along the scan direction B1. Since printing is bi-directional, the scan direction has actually two sub-directions, B1 (from left to right) and B2 (from right to left) as indicated in Figure 3A. The Nth swath of the image has a height S. Once the Nth swath of the image is printed, the recording medium is advanced in the transport direction C by an amount having a step value P. In the single pass print mode, the step value P is ideally equal to the height S of each image swath. In this ideal case, the whole image is rendered by a plurality of image swaths perfectly joined with each other so as to form a single image.

After the sheet 12 and the print head 14 have been moved with respect to each other by an amount having a step value P, the (N+1)th swath of the image can be rendered during one pass of the print head 20 in the sub-direction B2. In figure 3A (lower part), the situation is depicted wherein the print head 20 is actually printing ink dots while it is moved, together with the carriage. The nozzles 22 of the print head 20 are energised in accordance with image signals controlled by the controller, so as to print ink dots 44 at cell positions 42 corresponding to the pixel positions in the bitmap. In the example, the print head 20 comprises eight nozzles 22 spaced from each other by a nozzle pitch d. The height of the print head 20 is indicated with reference sign H. The height of the print head 20 is by definition equal to the number of nozzles multiplied by the pitch d. For example, the height H of the print head may be equal to the swath height S. Alternatively, if the print head is for example provided with spare nozzles, the height H may of course be larger than the swath height S. The spare nozzles are normally not used, however, they may be useful in the case of nozzle failures.

Figure 3B represents a situation in which printing is performed according to the so-called bi-pass bi-directional method, using the same print head 20 as depicted in figure 3A, having the same nozzle pitch d. The imaginary grid 40 comprising a plurality of cells 42 represents the resolution of an array of pixels to be rendered, now for example 300 pixels per inch. Since ink dots are printed at corresponding pixel positions, the final resolution of the printed image is 300 dpi (dots per inch). During a Nth swath of the
image, ink dots 45 are printed on the recording medium 12 with a print resolution (150 dpi) which is the half of the final resolution (300 dpi). The Nth swath of the image is the result obtained after one pass of the carriage in the direction B1. During a (N+1)th swath of the image, ink dots 46 are printed in one pass of the carriage in the direction B2. Ink dots 46 are also printed on the receiving medium 12 with a print resolution (150 dpi) which is the half of the final resolution. As can be seen in figure 3B, the Nth swath of the image and the (N+1)th swath of the image are interlaced so as to form a part of the printed image with the final required resolution (300 dpi). The print head 20 can produce a print resolution of 150 dpi in one swath. After the Nth swath of the image, the receiving medium 12 is advanced by a step having a length P1, which is equal to half the swath height S1 plus the side length x of a cell 42.

The tolerances allowed for or the deviations that are still acceptable for the length of step P and P1 are smaller than the printing resolution of the printer. This is mainly caused by the ability of the human eye to detect printing errors such as dark lines where the step length is too short and subsequent swaths overlap, or white lines when the step is too large and the images printed in subsequent swaths do not connect properly. Also a combination of these printing errors may arise when the receiving medium and the print head are moved with respect to each other with a so-called left-right error, i.e. a difference in (paper-)step between both longitudinal sides of the receiving medium as seen in transport direction.

Now that the general functioning of a swath printer has been described, a more detailed description of solutions proposed according to the invention for alleviating the problems associated with paper step or transport step errors will be provided.

As mentioned above, a swath printer such as an inkjet type printer requires that the receiving medium and the carriage that carries the print head to be moved with respect to each other in order for several swaths to be printed, whereby the printed swaths form a single image. These swaths must be properly aligned with respect to each other in order to print a defect free image. A possible way of achieving such alignment is described with reference to Figures 4A to 4C.

Figures 4A to 4C schematically show a single column of the imaginary grid 40 together with the relative position of the print head 20. In figure 4A, cells 42a, 42b, ..., 42o and
42p are labelled and correspond to pixel positions in the array of pixels (bitmap) to be printed by the print head 20. The print head 20 is shown to comprise eight nozzles for ejecting ink droplets which form dots 44 on the receiving medium or sheet 12. The nozzles are labelled: 22c, 22d, 22e, 22f, 22g, 22h, 22i, 22j. In the example of Figure 4A the sheet 12 is stepwise transported to allow for subsequent print swaths to be printed. However, it is to be understood that what is described will also apply to a stationary sheet or receiving medium and a carriage holding a print head that is stepwise transported or moved with respect to the sheet.

A sensor or camera 50 is mounted on the carriage of the print head 20. The sensor 50, for example a CCD camera is adapted for imaging an area on the receiving medium 12 and to transmit electric signals to the controller 34 in accordance with the imaged area. In the example of Figures 4A-4C, the lens of the camera comprises a marker 23, for example a stroke, which can be used as a reference or reference pattern for the camera and which overlaps the imaged area on the receiving medium, such that the image taken by the camera comprises an image of the area, and superposed thereon, an image of the marker or reference pattern 23. By comparison of the reference pattern or patterns with the observations of the camera a position of the print head with respect to the reference pattern can be determined. However, such a marker is preferably provided on the surface of the receiving medium 12 itself, whereby such a marker or reference pattern can be either printed on the receiving medium 12 by the printer, be preprinted thereon or may be formed by the fabric of the receiving medium itself, for example may be formed by the fibres of the receiving medium such as paper fibre patterns, in case the receiving medium is paper. This will be explained in more detail for example with reference to Figures 5A and 5B. The electric signals transmitted to the controller represent an image of the reference pattern or marker 23 together with the imaged area on the recording medium and enable thus the control unit to determine precisely the position of the print head with respect to a reference pattern on the recording medium.

In the example of Figure 4A a reference mark or reference pattern 48 is printed by the nozzle 22j of the print head 20 in a marginal area of the printed image, i.e. on the right side of the image. Such a marginal area is usually located next to one of the longitudinal sides of the sheet 12, i.e. a side which extends in the transport direction. The reference mark 48 may be a yellow pattern that is not visible to the human eye. Alternatively, the
reference mark 48 may also be formed by the structure or fabric of the receiving material itself. However, the invention will be further explained using a printed reference mark or reference pattern, which is the preferred way of providing a reference pattern, because of its ease and simplicity.

Figure 4A represents the situation occurring immediately after the carriage has performed one pass in the direction B1. The height of the resulting image swath is S2. During said pass, the nozzles have been activated according to a first swath print mask which allocates an ejector (nozzle) to a pixel position in such a way that said pixel is rendered by an ink dot. According to said first swath print mask, the nozzles 22c, 22d, 22e, 22f, 22g, 22h, 22i and 22j are allocated to the pixel positions 42a, 42b, 42c, 42d, 42e, 42f, 42g and 42h, respectively.

After the reference pattern 48 has been printed, for example by the nozzle 22j, the controller 34 controls the motor 30 so as to rotate the feed roller 10 and to advance the recording medium 12 by a length of the sheet advance step. Ideally the length of the advance step should be equal to S2, the height of the preceding image swath. If the length of the advance step was S2, the second print mask for the second image swath to be printed would attribute the nozzles 22c, 22d, 22e, 22f, 22g, 22h, 22i and 22j, respectively to the pixel positions 42i, 42j, 42k, 42l, 42m, 42n, 42o and 42p.

However, due to a transport error, an error in the length of the advance step occurs in transport direction. This is shown in Figure 4B in which it is seen that the actual length of the advance step P2 is smaller than the desired length thereof. The deviation of the actual step value P2 from the desired value is equal to Δ. After the medium has been advanced by the advance step P2, the sensor 50 optically senses the imaging area represented in figure 4B by the area of the rectangle 50. The image taken by the sensor 50 comprises at least a part of the printed reference pattern 48 and the reference marker 23 in case that the lens is provided with the reference marker 23. This image is sent to the controller 34 for analysis. Thereon, the controller 34 determines the deviation Δ, based on the position of the reference pattern 48 with respect to the position the reference marker 23 in the taken image and thus with respect to the print head 20 (carriage). Ideally, if the length of the advance step P2 is equal to the desired value S2, the reference mark 48 should be perfectly aligned with the pattern 23. The distance between the pattern 48 and the marker 23 on the taken image enables the controller 34
to determine the value of the deviation $\Delta$. In the example illustrated in figure 4B, the value of the deviation $\Delta$ is equal to about three quarters of the nozzle pitch $d$ ($\Delta=0.75d$). The controller determines whether the deviation $\Delta$ is larger than half the nozzle pitch $d$. Since the value of the deviation $\Delta$ is larger than half the nozzle pitch $d$, the image processing unit of the controller 34 reshuffles the swath print mask for the next swath (i.e. the second swath) of image to be printed. This is required, because without reshuffling, the nozzle 22c would be allocated to the pixel line to which the pixel position 42i belongs. However, the nozzle 22c is not aligned with the cell 42i in the main-scan direction B2. This would lead to a visible error in the printed image. The overlap between the first and the second swath of image would produce a dark line on the printed image.

Reshuffling the next swath print mask (i.e. putting the mask into a new arrangement) is performed by the image processing unit of the controller 34 such that the first ink dot line of the second swath is printed by the nozzle that is the closest to a position on the sheet 12 corresponding to the next pixel line to be rendered, based on the deviation $\Delta$. Figure 4C illustrates the result of the reshuffling. Among all nozzles of the print head 20, nozzle 22d is the closest to cell 42i which is the corresponding position of the first pixel of the next pixel line to be printed. After reshuffling, the nozzles 22d, 22e, 22f, 22g, 22h, 22i and 22j are allocated to the pixel positions 42i, 42j, 42k, 42l, 42m, 42n and 42o, respectively. As can be seen in figure 4B, the nozzle 22c is disabled while printing the second image swath. Consequently, less nozzles (seven) are used than are available (eight) on the print head 20, and the swath height $S3$ of the second swath is smaller than $S2$. The second swath has a height $S3$ which is smaller than the maximum printable swath $S2$. If the steps described above are repeated, and if a comparable deviation $\Delta$ is determined after each image swath, additional swaths are required to print the whole image. Hence, the ink image to be printed can be adjusted to compensate for the detected errors.

It is noted here again, that the above is of course equally applicable to the preferred embodiment wherein a reference pattern that is present on the surface of the receiving medium itself is used to determine deviations between the actual length of the advance step and the desired length thereof.

In a further preferred embodiment the print head 20 may be provided with additional
nozzles that are disabled when there is no deviation between the desired transport step and the actual transport step. However, in case that the actual transport step is larger than the desired step, in a way that is similar as described above, these nozzles can be activated to compensate or correct for the detected error.

Another way of applying a correction for the detected errors or deviations can be effected by controlling the volume of the ink droplets that are ejected by the ejectors. The droplets of ink are ejected in response to a driving signal that originates from the controller and adjusting of said volume is effected by changing a voltage level and/or a pulse width of said driving signal.

Yet another alternative way of correcting errors is to eject droplets of ink on the receiving medium in response to a driving signal, whereby the timing of providing the driving signal to said ejectors is adjusted so as to vary the moment at which the ink droplets are ejected towards the receiving medium. As the correction is preferably done while printing, timing of the moment at which the droplets are ejected can correct detected errors. In particular, when the detected error would result in a white line in the image, the moment of ejection of the droplets can be brought forward. In case the detected error would lead to a dark line to be printed, the moment of ejection of the droplets may put backward.

Yet another alternative way of correcting errors comprises shifting a remaining part of the input bitmap to be printed in a swath by an amount substantially equal to the detected errors or deviations from the ideal or desired position.

With the above-described method using a single sensor that can detect the position of a reference pattern located on the receiving medium an error in the stepwise displacement of the receiving medium and the carriage holding the print head can be detected. When this solution is extended, i.e. the sensor 50 is also used to detect a position of a second reference pattern located in a second marginal area of the receiving medium in a way that is similar to the way described above with reference to Figures 4A – 4C, two separate measurements result for the deviation in the transport step for the two marginal areas. In particular when the reference patterns are located in opposite marginal areas it is possible to detect any so-called left-right errors that introduce a skewed orientation of the receiving medium with respect to the carriage.
holding the print head. This will be explained in more detail with reference to Figures 5A and 5B.

Figure 5A shows a schematic plan view of a swath printer 100 for printing an ink image on a receiving medium or sheet 112. The printer 100 comprises a carriage 116 on which a multi-nozzle print head 114 is mounted. In the example of Figure 5A the print head 114 is shown to comprise a total of four nozzles 122, but it is noted that the number of nozzles may of course be different. Here the number of four nozzles is mainly shown for illustrative simplicity of the drawing. The carriage 116 is guided over a guide rail 118 in a driven manner by means of a non-shown motor. The carriage 116 that is holding the print head 114 can be moved back and forth along the guide rail 118 in a direction B or scan-direction as is indicated by means of a double arrow in Figure 5A. In the example of Figure 5A the sheet 112 can be moved with respect to the carriage 116 in a transport direction C by means of non-shown transport means under control of a controller. It is noted however that it is also conceivable that the sheet 112 is stationary and that the carriage 116 is moved by the transport means along the length of the sheet 112 so as to print the ink image.

In the example of Figure 5A the sheet 112 is located on a schematically depicted support surface 170 and transported in the transport direction C in a stepwise manner so as to enable the printing of subsequent print swaths as explained above. As can be seen, the situation of Figure 5A shows that a transport error has occurred that has led to the situation that the sheet 112 and the carriage 116 with the print head 114 are in a skewed orientation with respect to each other. This situation is also known as a left-right error, wherein the sheet 112 has moved during printing, such that the ink image 144 is no longer substantially orthogonal with the direction of transport C.

The printer 100 comprises a first sensor 150 and a second sensor 160 which are mounted on the carriage 116 on opposite sides thereof. As explained above with reference to Figures 4A to 4C, the sensors 150, 160 may be a camera such as a CCD camera that is arranged to detect a reference pattern. In the example of Figure 5A, a first reference pattern 148 and a second reference pattern 149 are present in a first respectively second marginal area of the sheet 112, which areas are located along the longitudinal sides of the sheet 112 as can be gleaned from the Figure. These reference patterns 148, 149 are for example printed by the print head 114 as has been explained
earlier in a previous print swath. By detecting the positions of both reference patterns using the sensors on the carriage 116, the relative position of both reference patterns 148, 149 with respect to the carriage can be determined. More in particular, deviations from the detected positions of said reference patterns compared to a desired position, i.e. the correct transport step, can be determined and it can be determined whether or not there is any skewed orientation between the carriage 116 and the sheet 112. It is noted that said comparison of the detected position with the desired position does not necessarily involve the provision of a reference marker on a lens of one of the sensors as described with reference to Figures 4A-4C. In fact, the comparison may also be done by comparing the “image” made or detected by the sensor of the reference pattern in an electronic memory where the desired “image”, or at least its electronic representation, is available. Here the term “image” may also include an electronic signature or optical signature that is indicative of the reference pattern. Such a signature is than compared with a desired signature. Deviations there from can than be calculated back into actual deviations from a desired position.

So with the exemplified set-up the relative position of the sheet 112 with respect to the carriage 116 can be determined after every print swath and corrective actions such as described above can be used to correct any errors detected.

As an alternative to providing the sensors 150, 160 on the carriage 116 it is also possible to provide sensors in the support surface 170. This example is also shown in Figure 5A, where the alternate sensors are shown as reference numbers 180 and 190. In this example the sensors 180, 190 will face a surface of the sheet 112 that faces away from the print head 114 and preferably the reference patterns to be detected are formed by the structure of the material of the sheet 112. In yet another alternative the sensors 180, 190 are mounted in a frame (not-shown) that is located over the surface of the sheet 112 that faces the print head 114 such that the sensors 180, 190 are facing ‘downward’. Furthermore, it is also conceivable to use a combination of both sensor set-ups for improved accuracy of the printer 100.

In addition to the solutions described with reference to Figures 4A to 4C for correcting transport errors, a further solution is described with reference to Figure 5B.

Figure 5B shows the same set-up as Figure 5A with the difference that the sheet 112
has been transported in the transport direction C so that another print swath could be printed. This subsequent swath or ink image is indicated with reference numeral 145. As can be seen the subsequent swath 145 connects correctly to the previous swath 144 as it has the same angle with respect to the transport direction C as the previous swath.

This has been achieved by moving the sheet 112 with respect to the carriage 116 during movement of the carriage 116 along the scan axis B. In this manner it is possible to provide an ink image that may have a skewed orientation on the sheet 112, but will be correctly printed without visible errors. The movement of the sheet 112 may be in the same or opposite direction as the transport direction C. It is of course also possible to move the carriage 116 along the transport direction C to achieve the same effect.

As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention, which can be embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present invention in virtually any appropriately detailed structure. Further, the terms and phrases used herein are not intended to be limiting, but rather, to provide an understandable description of the invention.

The terms "a" or "an", as used herein, are defined as one or more than one. The term plurality, as used herein, is defined as two or more than two. The term another, as used herein, is defined as at least a second or more. The terms including and/or having, as used herein, are defined as comprising (i.e., open language, not excluding other elements or steps). Any reference signs in the claims should not be construed as limiting the scope of the claims or the invention.

The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

A single processor or other unit may fulfil the functions of several items recited in the claims.
CLAIMS

1. A method of applying an ink image to a receiving medium using a swath printer, the method comprising:
   a) moving a print head along a scan direction to print a swath;
   b) moving the receiving medium and the print head with respect to each other in a transport direction, which transport direction is substantially orthogonal to the scan direction;
   c) detecting a position of a first reference pattern in a first area of the receiving medium;
   d) detecting a position of a second reference pattern in a second area of the receiving medium;
   e) determining a relative position between the receiving medium and the print head in the transport direction using said detected first and second positions, and
   f) moving the print head along the scan direction to print a further swath taking into account the determined relative position between the receiving medium and the print head in the transport direction.

2. The method of claim 1, wherein step e) is effected by determining deviations in said detected positions of the first and second reference patterns from a desired position thereof.

3. The method of claim 2, wherein the print head is moved along the scan direction to print the further swath while applying a correction to correct for said detected deviations.

4. The method according to any of the previous claims, wherein step f) further comprises moving the receiving medium and the carriage with respect to each other in a direction that is substantially orthogonal to the scan direction during printing of the further swath.

5. The method according to any of the previous claims, wherein step f) further comprises moving the receiving medium and the print head with respect to each other in a direction that is angled with respect to the transport direction during printing of the further swath.
6. The method of any of the previous claims, wherein step b) comprises a stepwise moving of the receiving medium and the print head with respect to each other.

7. The method of any of the previous claims, wherein the print head comprises a plurality of ejectors arranged to eject droplets of ink on the receiving medium, and step f) further comprises adjusting a volume of the droplets of ink during printing of the further swath.

8. The method of claim 7, wherein step f) further comprises adjusting the volume of the droplets of ink for those ejectors that print a border of an input bitmap adjoining an input bitmap printed in a previous swath.

9. The method of any of the previous claims, wherein step f) further comprises adjusting the ink image to be printed for the detected deviations.

10. The method of claim 9, further comprising shifting a remaining part of the input bitmap to be printed by an amount substantially equal to said detected deviations.

11. The method of any of the previous claims, wherein said reference patterns are provided in an area of the receiving medium that forms a margin in transport direction thereof.

12. A swath printer, comprising:
   - a print head, the print head being moveable along a scan direction for applying an ink image to the receiving medium;
   - transport means for moving the receiving medium and the print head with respect to each other in a transport direction that is substantially orthogonal to the scan direction;
   - a first sensor arranged to detect a position of a first reference pattern present on the receiving medium in a first area thereof;
   - a second sensor arranged to detect a position of a second reference pattern present on the receiving medium in a second area thereof, and
   - a controller arranged to control the printer on the basis of the detected positions of said reference patterns during use of the printer.

13. The printer of claim 12, wherein the controller is further arranged to determine
deviations in said detected positions from a desired position thereof.

14. The printer of claim 12 or 13, wherein the sensors are provided in a support surface of the printer arranged to support the receiving medium, and wherein the reference patterns are provided at a surface of the receiving medium that faces away from the print head.

15. The printer of claim 12 or 13, wherein the sensors are provided over a receiving surface of the receiving medium, which receiving surface faces the print head.

16. The printer of any of claims 12 - 15, wherein the sensors comprise a CCD camera.

17. The printer of any of claims 12 - 16, wherein the controller is further arranged to move the receiving medium and the print head with respect to each other in a direction that is substantially orthogonal to the scan direction during printing of the further swath.

18. The printer of any of claims 12 - 16, wherein the controller is further arranged to move the receiving medium and the print head with respect to each other in a direction that is angled with respect to the transport direction during printing of the further swath.

19. The printer of any of claims 13 - 18, wherein the controller is further arranged to adjust the ink image to be printed for the detected deviations.
FIG. 2
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. B41J11/00 B41J13/00 B41J19/14 B41J2/05 B41J11/46

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B41J

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>Y</td>
<td>GB 2 359 045 A (HEWLETT PACKARD CO [US]) 15 August 2001 (2001-08-15) abstract; claims 1,2</td>
<td>7,8</td>
</tr>
<tr>
<td>X</td>
<td>US 6 698 861 B1 (DRAKE DONALD J [US]) 2 March 2004 (2004-03-02) column 5, line 1 - line 8; figure 9</td>
<td>7,8</td>
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</table>

[ ] Further documents are listed in the continuation of Box C. [x] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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

"P" document published prior to the international filing date but later than the priority date claimed

"P" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel of cannot be considered to involve an inventive step when the document is taken alone

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"A" document member of the same patent family

Date of the actual completion of the international search: 10 February 2010

Date of mailing of the international search report: 26/02/2010

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Authorized officer: Wehr, Wolfhard
<table>
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<th>Publication date</th>
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