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(54) Color ink jet printing mechanism with elongated black nozzle array and method of operation

(57) A printer (10) having a media transport (20) operable to advance media (16) in a downstream direction (22). A print head (34, 36) includes a pair of ink cartridges, each with a respective linear array of color and black nozzles(40, 42), the black array extending farther in the downstream direction than the color array. The printer may be operated with black printing limited to use only of those black nozzles positioned downstream of all color nozzles.

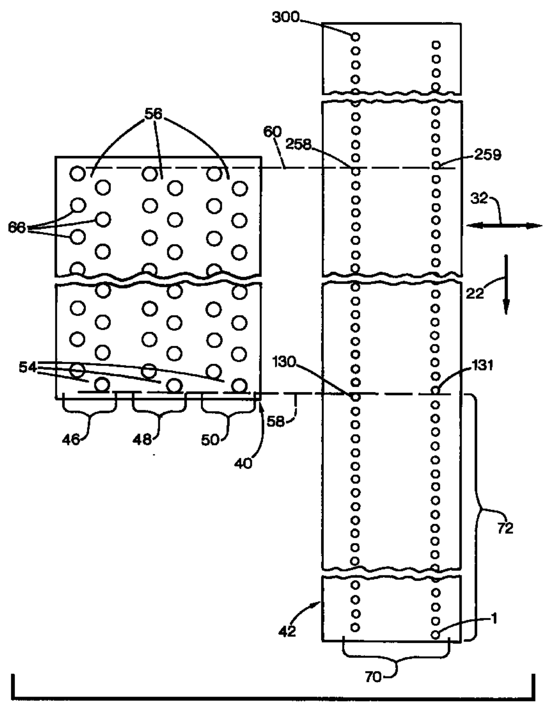

FIG. 2

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Description

Field of the Invention

This disclosure relates to color ink jet printers and printing techniques, and more particularly to printers and printing techniques using black ink in addition to color inks.

Background and Summary of the Invention

Color ink jet printers generally use cyan, yellow, and magenta inks to generate a full range of colors in a printed image. Black ink is used to generate portions of the output containing text and other black images, and to enhance the accuracy of color image tones. The same given number of data inputs is available for the three colors as for the black output alone. Thus, in existing designs, the color cartridge has three short elongated arrays of nozzles, one for each color, while the black cartridge has a single, much longer array, permitting faster printing rates when no color is present.

When printing color images that include black portions, the black portion is printed after the color image has been laid down on a particular swath. [I assume that this general concept is old] Nonetheless, the different inks may interact with each other to generate unwanted image defects. A particular defect known as "halo" occurs at the edge of a printed black region that is adjacent to a printed color region. The halo appears as a gap or density loss of the black image just inward of the black edge.

Color and black inks are often selected to have different but compatible characteristics that avoid most undesirable interactions. Color inks are selected to be quick penetrating of the paper surface to minimize spreading and bleeding with each other, while black inks tend to be slow penetrating to provide a denser image and to avoid disrupting an already-printed color swath.

Inks may be formulated to avoid halo, but these often compromise other important ink characteristics. Existing printing techniques to minimize halo include printing with additional overlapping multiple passes of partial density, heating of the print media and/or pausing to facilitate drying between printing passes. These approaches are more expensive, or undesirably reduce printing speed.

The apparatus and method disclosed herein overcomes the above disadvantages by providing a printer having a media transport operable to advance media in a downstream direction, a print head having respective linear array of color and black nozzles, the black array extending farther in the downstream direction than the color array. The printer may be operated for color printing with the use of black nozzles limited to those black nozzles positioned downstream of all color nozzles.

Brief Description of the Drawings

Fig. 1 is a schematic plan view of a preferred embodiment of the invention.

Fig. 2 is an enlarged schematic plan view of the nozzle arrays of the embodiment of Fig. 1.

Fig. 3 is a detailed isometric view of an ink jet printer according to the present invention.

Detailed Description of a Preferred Embodiment

Figure 1 illustrates a printer 10 shown in simplified schematic form for clarity. The printer 10 includes a base 12 including a media platen 14 on which a media sheet 16 may rest, and over which the sheet may pass. A paper advance mechanism 20 having feed rollers that grip the sheet 16 operates to selectably advance the sheet in a downstream direction indicated by arrow 22 during printing and feeding of the sheet.

A printing mechanism 24 mounted to the base 12 includes an elongated guide 26 that is spaced above the platen 14 parallel to the platen and perpendicular to the path of the sheet 16 moving in the downstream direction 22. The guide 26 is positioned downstream of the feed mechanism 20. The printing mechanism 24 includes a print head carriage 30 mounted to the guide 26 to reciprocate along the guide while constrained against rotation or translational motion other than parallel to the guide. A carriage drive mechanism (not shown) is connected to the carriage 30 for precisely moving and positioning the carriage along a print path indicated by arrow 32.

A replaceable color print head 34 containing color ink and a replaceable black print head 36 containing black ink are securely mounted on the carriage 30. Together, the color and black print heads may be considered as a single print head; in an alternative embodiment, the print heads may be thus integrated. The print heads 34, 36 include on their lower surfaces (hidden in Fig. 1) a pair of orifice plates 40, 42 oriented parallel to and facing the platen 14. The orifice plates 40, 42 are shown in detail in Fig. 2. The plates are not shown as they would normally appear from below, but are shown in mirror image, or as seen through the top of the cartridge toward the media sheet.

As shown in Fig. 2, the color plate 40 (on the color print head 34) includes three linear color nozzle arrays 46, 48, 50, each emitting a different color of ink (yellow, magenta, and cyan respectively.) The arrays are parallel to each other and perpendicular to the direction of the print path 32. Each array has a downstream end 54 and an upstream end 56. The lower ends 54 are bounded in the downstream direction by a lower color limit line 58; the upper ends 56 are bounded in the upstream direction (opposite the downstream direction 22) by an upper color limit line 60.

Each color array 46, 48, 50 comprises a plurality of nozzles 66 defined in the orifice plate 40. Adjacent nozzles are alternately offset to form a zigzag pattern, providing the benefits of close nozzle spacing without physical interference between adjacent nozzles. Thus, the odd numbered nozzles are in one line while the even numbered nozzles of the same array are centered on a second parallel line.

In the preferred embodiment, the spacing between these lines is 0.027 inch (0.68 mm), and the color arrays are spaced apart from each other by a pitch of 0.10 inch (2.54 mm.) Control software is used to time the output of the various nozzles to compensate for their different lateral positions. The resolution or dot pitch of each color array is 300 dots per inch (11.8 dots/mm.) Each color array has 64 nozzles, with the downstream nozzle being #1, and the upstream nozzle being #64. The total length of each array is 0.213 inch (5.42 mm,) permitting the printing of a swath of up to that width with a single pass of the print head over the media sheet.

On the black print head 36, the black orifice plate 42 includes a single black nozzle array 70 of 300 nozzles with a resolution or dot pitch of 600 dots per inch (23.6 dots/mm,) for an overall effective length or swath width of 0.50 inch (12.7 mm.) The black array 70 is also arranged in two lines of alternating nozzles, in this case spaced apart from each other by 0.163 inch (4.15 mm.) The nozzles are numbered from 1 to 300, with #1 being the most downstream nozzle, and residing in line with the odd numbered nozzles; #300 is the upstream nozzle residing with the even nozzles in the line to the left of the odd nozzles.

The black plate 42 is accurately positioned with respect to the color plate 40, with mechanical registration points ensuring precise alignment. The even numbered black nozzles are centered on a line positioned to the right of the even numbered blue nozzle centers by 0.290 inch (7.37 mm.) Black nozzles #1-130 comprise an extending portion 72 that extends in the downstream direction from the lower color limit line 58. Black nozzles #131-258 are registered with the color arrays and span between the lower color limit line 58 and the upper color limit line 60. Black nozzles #259-300 extend upstream of the upper color limit line 60.

Operation

A controller (not shown) serves to collect, scan, and analyze print data received from a personal computer, and determines the appropriate print mode. If the next selected portion of data contains only black data, the printer may use the entire black nozzle array 42 to provide a wide print swath and a rapid printing rate. In this mode, the entire black array is in an active state in which any black nozzle may be used for printing. If the next selected portion of data contains color data, the printer must use color printing mode. In this mode, the entire color array is in an active state, while only the extending portion 72 of the black array (i.e. nozzles #1-128) is in the active state. The remaining black nozzles #129-300 are in the inactive state.

Color printing speed is limited by the length and swath width of the color array. Because the active extending portion 72 of the black array has the same length and swath width at least as large as the color array, it does not limit color printing speed. In alternative embodiments, the extending portion may be a different length relative to the color array length, as long as the extending portion is greater than or equal to the length of the color array.

On a single pass of the carriage 30 over the media sheet during color printing, color and black ink swaths are laid down in distinct, adjacent swaths without overlap, avoiding the bleeding that may occur when the liquid inks are nearly simultaneously applied to the same area. Because the black active region is downstream of the color region, the black swath will generally be overprinting the color swath printed on the previous path. Given the brief but important time between passes, the color ink will have had time to penetrate the media surface, dry, and stabilize, and the black ink will not exhibit any undesirable interaction with the printed color image.

Although the operation is described in terms of color and black-only printing, the disclosed apparatus and method are effective in transitions between these two modes. In addition, the printing process in any mode may employ the technique known as shingling, in which multiple partial density passes are used to build up a complete image to minimize artifacts visible at the boundaries between swaths. Separately replaceable black and color ink cartridges may be substituted for the single cartridge shown.

While the invention is described in terms of a preferred embodiment, the following claims are not intended to be so limited.

Claims

1. A color ink jet printing mechanism (10) for generating images on a surface (16), the printer comprising:

   a transport (20) operable to advice the surface in a downstream direction (22) relative to the printing mechanism;
   a print head carriage mechanism (26) operable to carry a print head in a linear print path (32) over the sheet of media, the print path being parallel to the media sheet and perpendicular to the downstream direction;
   a print head (34, 36) connected to the carriage mechanism and having a plurality of color nozzles (66) arranged in an array (46, 48, 50) oriented perpendicular to the print path, and having a first length extending between an upstream end (56) and a downstream end (54);
   the print head having a plurality of black nozzles (1-300) arranged in an array oriented perpendicular to the print path, and having a

second length extending between an upstream end (300) and a downstream end (1); and

an extending portion (72) of the black nozzle array extending downstream of the downstream end of the color array, such that during color printing, black printing may be limited to the extending portion to avoid simultaneous printing of color and black ink on a common portion of the sheet on a single pass of the print head.

2. A color ink jet printing mechanism according to claim 1 wherein the extending portion (72) of the black nozzle array is at least as long as the first length.

3. A color ink jet printing mechanism according to claim 1 or claim 2 wherein the extending portion of the black nozzle array has a length substantially the same as the first length.

4. A color ink jet printing mechanism according to any one of claims 1 to 3 wherein the print head includes a plurality of different color arrays (46, 48, 50), each extending the same length and having aligned ends.

5. A color ink jet printing mechanism according to any one of claims 1 to 4 wherein the second length is at least double the first length.

6. A color ink jet printing mechanism according to any one of claims 1 to 5 wherein the black nozzle array has greater resolution than the color nozzle array.

7. A color ink jet printing mechanism according to any one of claims 1 to 6 wherein the black nozzle array has at least double the resolution of the color nozzle array.

8. A method of printing an image onto a surface (16) with an ink jet printing mechanism (10) having a print head (34, 36) with a color nozzle array (40) of a first length and a black nozzle array (42) of a second length greater than the first length and parallel to the color array such that at least an extending portion (72) of the black nozzle array extends beyond an end of the color array, the method comprising the steps:

passing the print head over the surface through a linear print path perpendicular to the nozzle arrays;

while passing the print head, printing color ink onto a first portion of the surface; and

while passing the print head, printing black ink onto a second portion of the surface distinct from the first portion, such that the black ink does not overlap color ink printed on the same print pass.

9. A method of printing an image according to claim 8 wherein the step of printing black ink includes printing only from nozzles within the extending portion (72) of the black array.

10. A method of printing an image according to claim 8 or claim 9 wherein the black array includes a registered portion registered with the color array and distinct from the extending portion, and wherein the step of printing black ink includes maintaining the registered portion in an inactive state such that the registered portion does not print during the print pass.

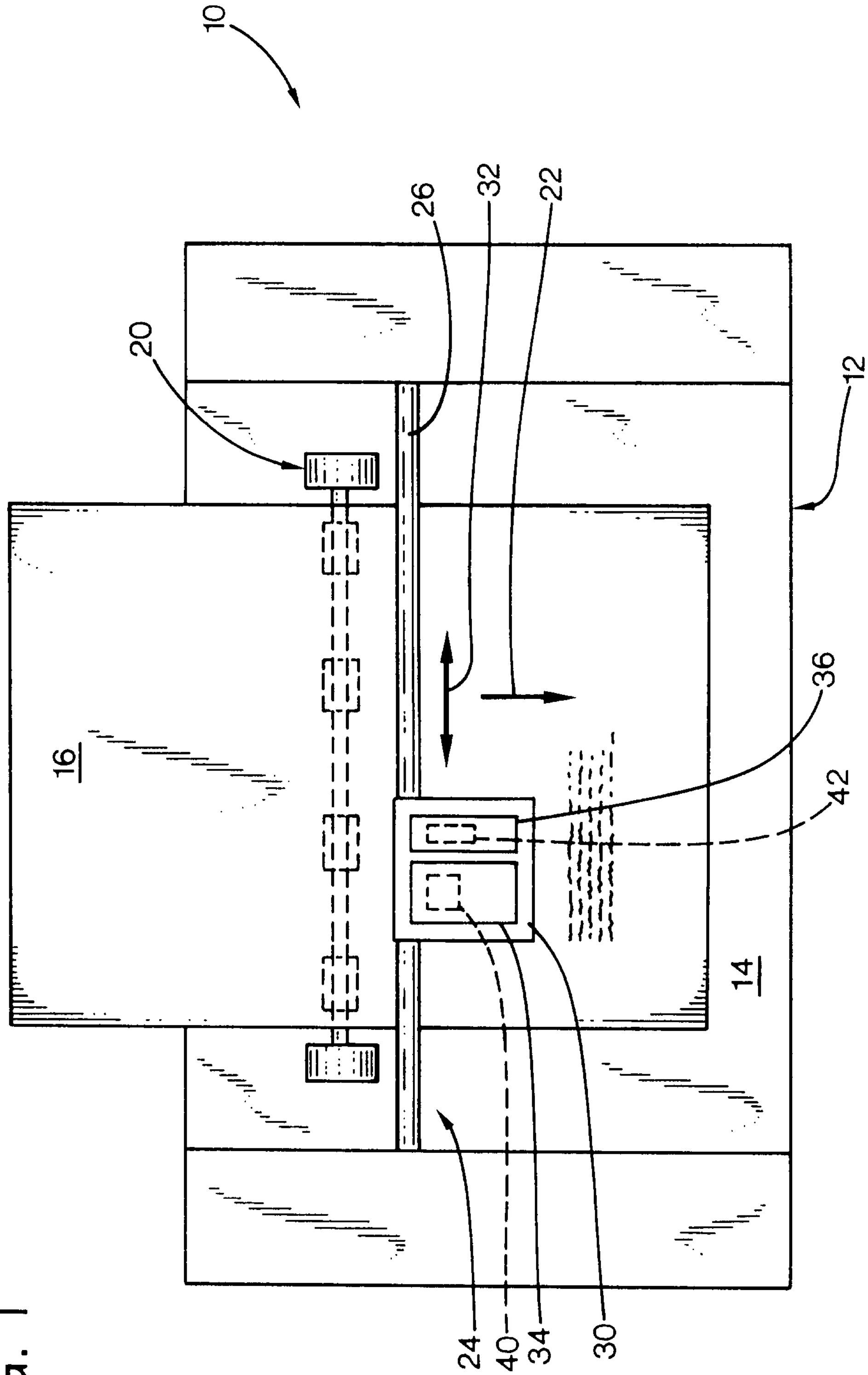

FIG. 1

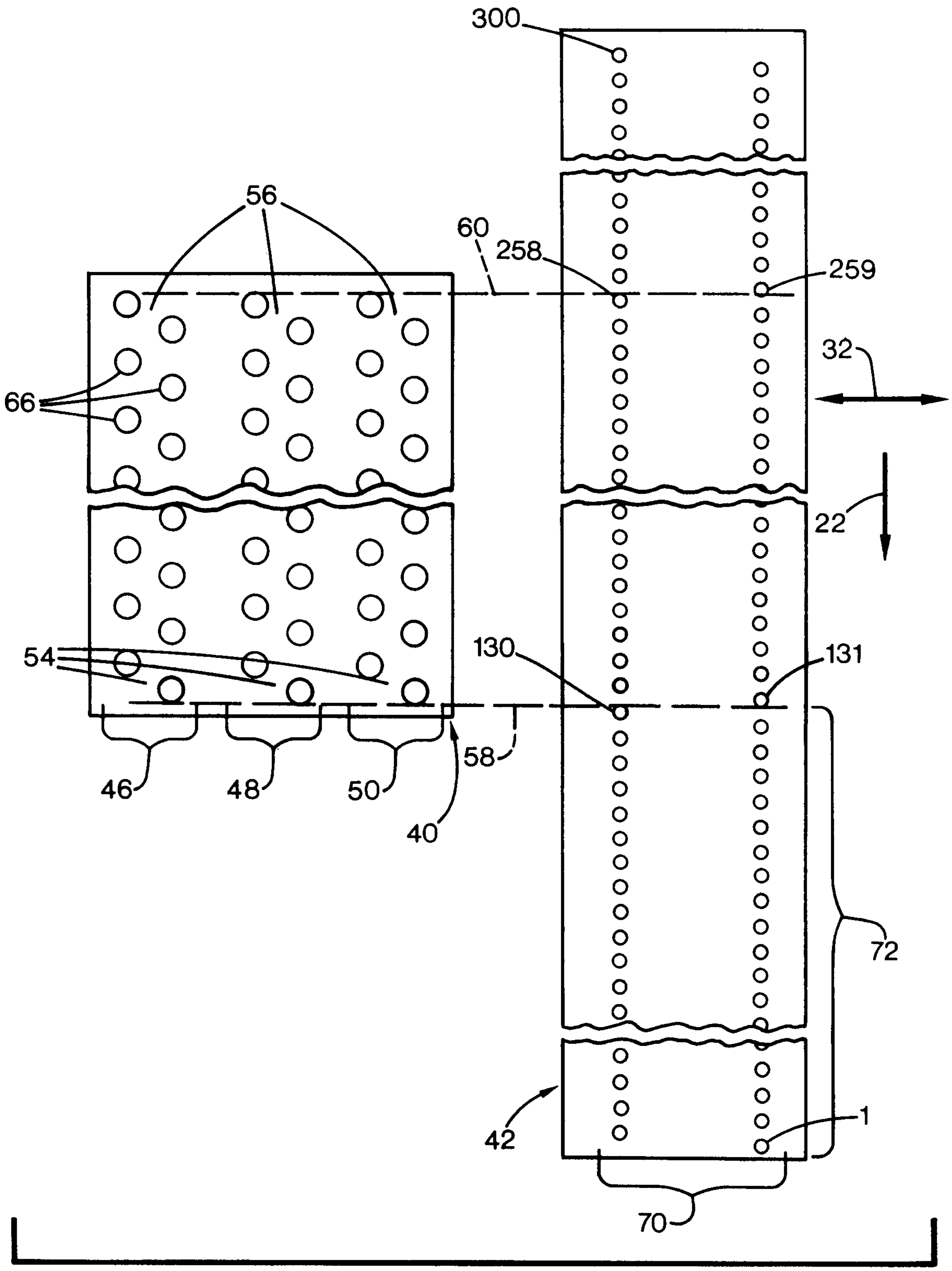

FIG. 2

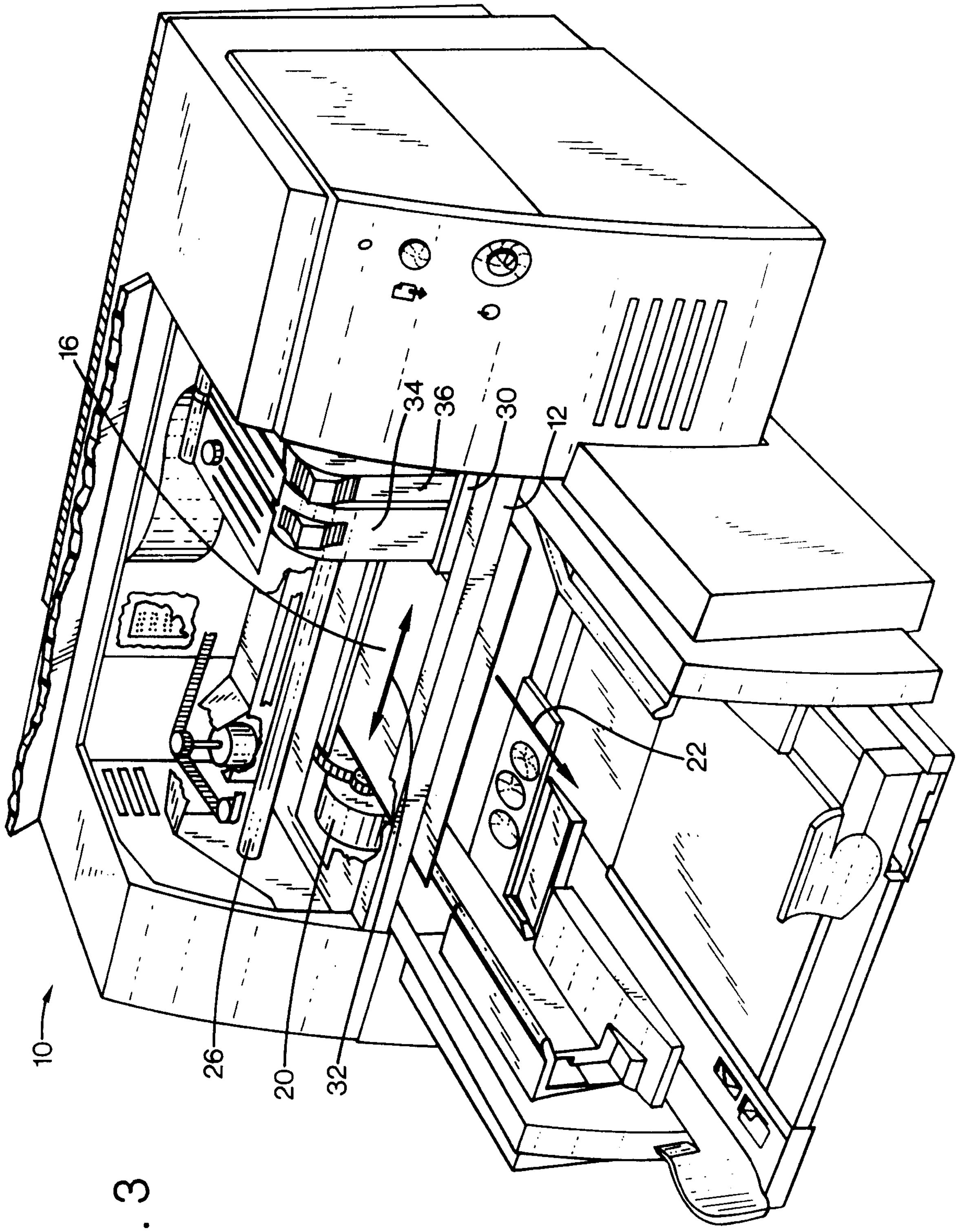

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 95 30 6912

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP-A-0 595 657 (CANON K.K.) * column 11, line 25 - column 12, line 50; figures 12A,B,41A,B * ---	1,5,8	B41J2/21
A	PATENT ABSTRACTS OF JAPAN vol. 18, no. 25 (M-1542), 14 January 1994 & JP-A-05 261941 (RICOH CO LTD), 12 October 1993, * abstract * ---	2-4	
A	WO-A-91 08902 (SPECTRA INC.) * page 9, line 15 - page 10, line 28; figure 3 * -----	1,4,6,7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	6 June 1996	De Groot, R

CATEGORY OF CITED DOCUMENTS

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