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(71) Applicant: **SCITEX DIGITAL PRINTING, Inc.**
Dayton, Ohio 45420-4099 (US)

(72) Inventors:
- **Piatt, Michael J.**
  Kettering, Ohio 45429 (US)
- **Stadum, Rodney J.**
  Dayton, Ohio 45458 (US)
- **Tank, Peter N.**
  Centerville, Ohio 45420 (US)

(74) Representative: **Hillier, Peter et al**
Reginald W. Barker & Co.,
Chancery House,
53-64, Chancery Lane
London, WC2A 1QU (GB)

(54) Printed reference image compensation

(57) The present invention provides for controlling image registration of images printed on a substrate of an ink jet web press. Registration marks are printed on the substrate, relative to the print location of the images, and then read. The registration marks are used to determine spatial discrepancies in subsequent images. Dynamic corrections correct for spatial discrepancies in subsequent images to assure good overlay of image data onto previously printed images, and static corrections correct for spatial discrepancies in alignment of subsequent printheads to each other to assure good reference of image data onto previously printed images.

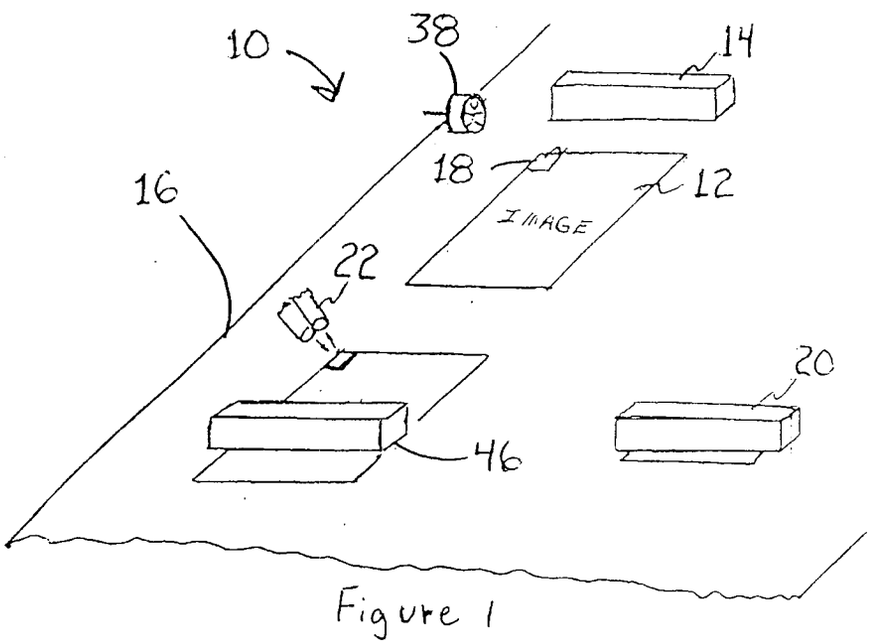


Figure 1

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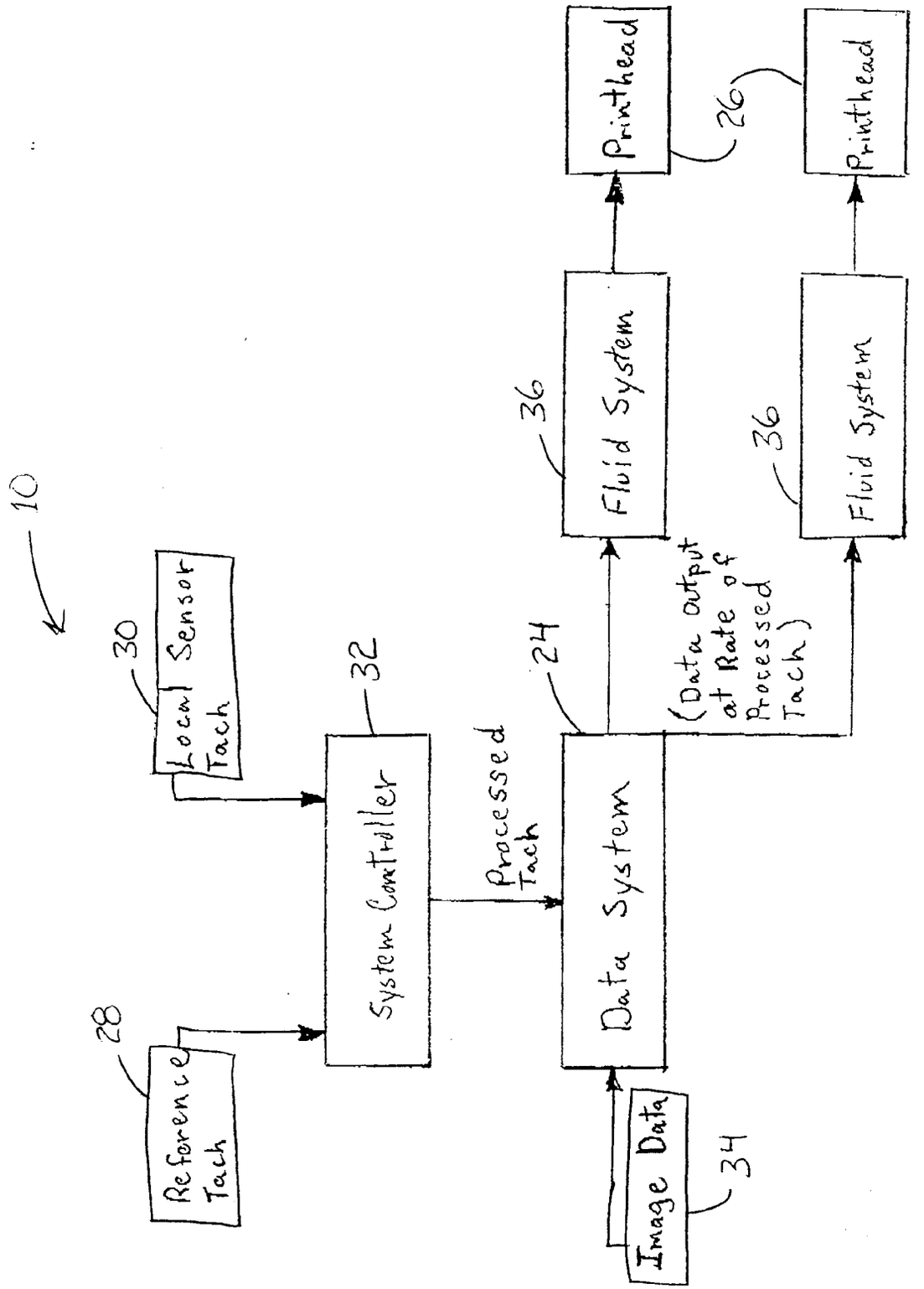

10
Reference Tach
28
Local Sensor Tach
30
System Controller
32
Processed Tach
Data System
24
Image Data
34
(Data output at Rate of Processed Tach)
Fluid System
36
Fluid System
36
Printhead
26
Printhead

Fig. 2

Description

Technical Field

The present invention relates to physical alignment of printheads and control of image registration on an ink jet web press and, more particularly, to use of reference marks to resolve and correct for spatial discrepancies on subsequent images printed by a continuous ink jet printer on a web transport.

Background of the Invention

In continuous ink jet printing, ink is supplied under pressure to a manifold region that distributes the ink to a plurality of orifices, typically arranged in a linear array (s). The ink discharges from the orifices in filaments which break into droplet streams. The approach for printing with these droplet streams is to selectively charge and deflect certain drops from their normal trajectories. Graphic reproduction is accomplished by selectively charging and deflecting drops from the drop streams and depositing at least some of the drops on a print receiving medium while other of the drops strike a drop catcher device. The continuous stream ink jet printing process is described, for example, in U.S. Pat. Nos. 4,255,754; 4,698,123 and 4,751,517, the disclosures of each of which are totally incorporated herein by reference.

In a color printing process, there is often a need to "overlay" images of different colors. For example, in conventional color printing, three subtractive primary colors plus a separate black are used to print full color images. In order to accomplish this with conventional printing technologies such as lithography and gravure, stringent steps are taken to make sure that the print stations which print the separate images are in alignment. This process is called registration. Often, special registration targets are printed in the margins of samples. These targets are used to precisely align the separate printing stations before printing is started, and to check registration during long print runs. Subsequently, these alignment marks are trimmed off the print work after the print process is complete.

Conventional printing is a contact imaging process. Images are created by threading the substrate through a set of precisely aligned rollers which press the image into the substrate. Ink jet printing is a non-contact process.

In ink jet printing, the substrate is passed under a printhead which sprays the image forming ink onto the substrate in an imagewise fashion. Thus, the only thing which contacts the substrate is the image itself.

While there are many similarities between ink jet imaging and conventional printing, there are several problems which are unique to ink jet imaging. For example, typical ink jet ink printing systems carry much more vehicle to the substrate than conventional imaging systems. An intermediate drying step is required between image steps to prevent the two images from mixing in the liquid state, an effect called image bleed. The additional vehicle in the imaging steps can cause the paper to stretch, contract or wrinkle. This makes the process of registering one image on top of the other much more difficult because the dimensional stability of the substrate cannot be counted on to be consistent.

An additional problem in creating good registration relates to the nature of the ink jet printing process. A drop to be printed is created somewhere above the substrate. It is created with an initial velocity generally directed towards the substrate. While the drop is drifting towards the substrate, the substrate is moving under the printhead. Furthermore, the drop velocity can change with time. In a typical case, the drop is created about 2 cm above the substrate with a velocity of 1000 cm per second. Therefore, it takes 0.5 milliseconds to reach the substrate. At a substrate speed of 500 cm per second, 0.25 cm of substrate passes under the printhead while the drop is in flight. Hence, the system electronics must take account of the 0.25 cm in determining when to request the image. Thus, a problem with ink jet imaging which is uniquely different from conventional imaging is exactly determining the position of an image.

A complication in the exact placement of an ink jet image comes from variations in the ink jet process during operation. For example, a system variation in substrate speed of 5% creates a 0.01 cm difference in the position of the image, because of the drift time effect. If imaging is being carried out at 240 spots per inch, that difference would amount to well over one resolution element. That magnitude of variation must somehow be accounted for by the system electronics.

Conventional printing presses are very solidly built machines which can maintain alignment from one image station to the next. Mechanisms are built in to allow alignment of the matters from which the multiple colors of an image are printed. The system is built ruggedly enough so that alignment is maintained after initial setup. This is more difficult in an ink jet system in which the substrate is merely passed under the image station. Even when the ink jet printheads are initially set up properly, the effects of printing and drying previous images can cause the paper to shrink so that the registration can be affected in the direction perpendicular to paper motion, i.e., the cross machine direction, and in the direction parallel to paper motion, i.e., the machine direction.

Furthermore, conventional printing presses are constructed so that the imaging stations are carefully maintained perpendicular to the direction of paper motion. In an ink jet printer, this is not necessarily the case, because the printheads are replaceable parts. While care is taken to align the printheads perpendicular to substrate motion when they are installed, the alignment may not always be exact. when this happens, the image can be skewed by an angle relative to the substrate.

While the angle may be small and unnoticeable for a given printhead, when several images are superimposed and all the printheads have a small angle relative to the paper direction, the overall effect can be dramatic in the color and registration of the image.

It is seen, then, that there is a need for an improved printing system in which color ink jet printing can be accomplished with excellent image positioning.

Summary of the Invention

This need is met by the present invention which discloses a printing system for superimposing multiple ink jet images for the creation of color includes the capability of printing registration marks in the margin of the image. The form and type of the marks are devised, in accordance with the present invention, to allow multiple applications to the problems of ink jet imaging.

In accordance with one aspect of the present invention, image registration of images printed on a substrate of an ink jet web press is controlled. Registration marks are printed on the substrate, relative to the print location of the images, and then read. The registration marks are used to determine spatial discrepancies in subsequent images. Dynamic corrections correct for spatial discrepancies in subsequent images to assure good overlay of image data onto previously printed images, and static corrections correct for spatial discrepancies in alignment of subsequent printheads to each other to assure good reference of image data onto previously printed images.

An object of the present invention is to control image registration on an ink jet web press. It is a further object of the present invention to use reference marks printed by a continuous ink jet printer on a web transport to resolve and correct for spatial discrepancies on subsequent images. It is an advantage of the present invention that it provides for an improved printing system in which color ink jet printing can be accomplished with excellent image positioning.

Other objects and advantages of the invention will be apparent from the following description and the appended claims.

Brief Description of the Drawings

Fig. 1 illustrates a portion of an ink jet web press system in accordance with the present invention;

Fig. 2 is a block diagram of the ink jet web press system of Fig. 1;

Figs. 3a through 3e are signal diagrams of velocity versus time, in an ink jet web press system;

Fig. 4 illustrates a plurality of equally spaced horizontal reference marks, printed in accordance with the present invention;

Fig. 5 illustrates a plurality of varying length, equally spaced horizontal reference marks, printed in accordance with the present invention; and

Fig. 6 illustrates a portion of an ink jet web press system for making static corrections, in accordance with the present invention.

Detailed Description of the Invention

In accordance with the present invention, control of image registration on an ink jet web press is facilitated through the application of reference marks printed by the imaging source and recorded by sensors that in turn control the timing and image content of subsequent printheads. More specifically, printed registration marks are used to assure proper alignment of overlaying planes of data from separate printheads that together compose a single image. Further, adjustments in image size to compensate for changes in media through the press are affected by analysis of the sensed registration marks at the downstream print stations.

In order to obtain good image quality, especially in color printing, it is desirable to be able to lay down ink from independent printheads at precise locations on the paper. Typically, in a web press operation, the printheads are physically separated one behind the other. The length of paper between adjacent printheads varies from one press to another. This is a function of the particular paper path. The necessity to dry the paper between applications of ink requires that the paper be routed through drying mechanisms, such as heaters, before passing into the next print station. It can be appreciated that the web paper in the press during operation is composed of hundreds of unique partially printed images at any given time. At paper speeds ranging up to hundreds of feet per minute, maintaining alignment between the paper and the printheads is a constant challenge in the ink jet printing art.

This alignment problem can actually be realized as two separate, but related, problems. First, there is the problem of maintaining alignment of the multiple printheads to each other. The printheads are field replaceable parts that require frequent routine maintenance. In order to perform this maintenance, it may not be possible to hold the printhead in its exact physical location in the press. Therefore, it becomes necessary to be able to re-align the printhead to the rest of the press after such procedures.

The second alignment problem relates to controlling the misregistration as a result of changes in the media relative to the printheads. High speed paper webs tend to move laterally to the direction of forward motion. The moisture content in the paper changes dramatically with subsequent applications of ink and drying. The physical dimensions of the paper may change as a result of this.

In accordance with the present invention, the printing and sensing of registration marks by the forward head or heads in the press can be used to correct for both printhead position errors and dynamic paper changes.

Referring now to the drawings, in many instances it is desirable to position an image on the paper, relative to some other attribute, such as another image on the same page. For example, it may be necessary to align printing on the left hand side of the paper with printing on the right hand side of the paper. In accordance with the present invention, this can be accomplished as illustrated in Fig. 1. Fig. 1 illustrates a portion of an ink jet web press system 10, in accordance with the present invention. A left hand image 12 is created by a first printhead 14 and printed on a substrate 16. A cue mark 18 is associated with the image 12. The substrate 16 travels through the system to the location of a subsequent (second) printhead 20.

Continuing with Fig. 1, a sensor 22, typically a focused infrared beam that is reflected off of the substrate 16, identifies the printed cue mark 18 created by the printhead 14. Present day infrared sensor technology provides resolution of the printed mark within 0.001 inch. This is approximately one fourth the pixel spacing in a typical high speed web ink jet system and, therefore, is a small percentage of the total error associated with overlaying images in this system. The sensor 22 output of Fig. 1 is a control signal into data system 24 of Fig. 2, providing image information to any subsequent printhead 20, 46 or any other downstream printhead.

Referring now to Fig. 2, there is illustrated a block diagram of an ink jet web press system 10. As is well known and understood in the art, the ink jet web press system 10 comprises a number of subsystems. The paper transport system includes a paper feed system at one end. This feed system is typically a large (four foot diameter) roll of continuous paper on a spindle. The paper is pulled off of the spindle by a set of drive rollers that feed the paper web under an imaging head. The encoder 38 of Fig. 1 is typically mounted on the feed roller shaft. It is assumed that there is no slip between the feed rollers and the paper being pulled through the system. Next, the paper is routed through a dryer to remove the moisture from the first imaging station. This combination of print station and dryer is referred to as a tower. Separate towers are set back-to-back to each other. Each tower has its own set of feed rollers.

Since the substrate is a single continuous web under tension, there is typically only one encoder mounted on the first roller shaft. The information from this encoder is used to determine average web speed, rather than the exact web position at each tower location. This is the whole purpose for printing cue marks. The final part of the transport is the finishing station after the last tower. The finishing station may be any suitable means, such as a take up reel for the roll of paper, or a device that cuts, folds, or even glues the paper exiting the last tower.

The ink jet system is also a portion of the ink jet web press system 10. The ink jet system is the ink handling system of pumps, valves, filters, etc. and the printhead itself, along with all of the necessary control electronics to assure proper application of ink onto the substrate. Additionally, the ink jet web press system includes the data system 24, which is responsible for formatting and transmitting the image information to the printheads 26, which correspond to the printheads 14 and 20, and subsequent printheads, in Fig. 1.

Both the reference tach signal 28 and the sensor tach 30 are fed into system controller 32. This controller 32 calculates the output tach rate and performs such functions as scaling up or down the input signal rates and delaying the signal for compensation for droplet flight time. The processed output is fed to the data system 24 along with actual image data 34. The image data is clocked out to a fluid system 36 at the processed tach rate. The data passes through the fluid systems 36 to the printheads 26 for imaging.

Continuing with Fig. 2 and referring to Figs. 3a through 3e, signal diagrams of velocity versus time are shown, illustrating how the processed tach output from the system controller 32 is influenced by the input of the local tach sensor 30. Fig. 3a is a signal diagram showing the reference tach 28 for the master, or first, printhead 14, and output from an encoder 38 in Fig. 1. Fig. 3b is the signal output from the sensor 22, illustrating instantaneous velocity sensed where there is no image. The reference tach 28 and the local sensor tach 30 signals are input to the system controller 32, which outputs a processed tach signal 40, as shown in Fig. 3c. Fig. 3d illustrates a signal 42, which is a local sensor tach signal from sensor 22 indicative of paper stretch, sensed at the image 12. Knowing the reference tach indicated by Fig. 3a, the instantaneous velocity indicated by Fig. 3b, and the paper stretch indicated by Fig. 3d, a final processed tach signal 44, for assuring good reference and overlay of image data to previously printed images, can be determined, as illustrated in Fig. 3e. In Figs. 3a-3e, the processed tach is set equal in period but delayed in time to the local sensor tach. Depending on the nature of the local sensor tach, the processed tach may be some other multiple of the local sensor tach, but always derived from the local sensor tach.

The initiation of print by printhead 20 is referenced to the input signal from the sensor 22. It will be appreciated that the command to print from head 20 may be delayed in space or time from the sensor output. Other references may be incorporated herein, such as input from the encoder 38 coupled to the paper motion at printhead 14. The encoder 38 may be used to resolve paper velocity in order to accurately determine when to start the printing with printhead 20 relative to the sensor 22 response.

Many times, particularly in color printing, it is necessary to print an image from one printhead 14 directly on top of the image from another, subsequent, printhead 46. The printheads 14 and 46, then, are in a direct line with each other along the web direction. The overlaid images can be printed in accordance with the present invention, which teaches the use of registration marks.

For the overlay of one image on an existing image, it is necessary to sense the cue mark 18, printed by the first head 14, before the image 12 reaches the printhead 46. Hence, the cue mark 18 must be sensed sufficiently in advance of the subsequent printhead 46 to allow the control signal from sensor 22 to be used to initiate the start of print by head 46 at the proper instant in time.

It will be understood by those skilled in the art that the length of paper between printheads 14 and 46 may be rather significant. Consequently, changes in paper tension, moisture content, and other such parameters may have taken place between the locations of the printheads. By positioning the sensor 22 in close proximity with head 46, placement errors due to changes in the media between the two printheads is minimized. Of course, this process can be extended to any number of printheads in a line, in order to assure good registration and overlay in full color processed images.

Aligning the start of print from one head on top of the print from another head is very often a requirement for processed color imaging. However, simply aligning the start of print from one head on top of the print from another head is not always sufficient for excellent image registration. The paper may change physical dimensions in the web direction as a result of the web tension coupled with subsequent wetting and drying of the media as it passes through the various print stations. The image data for a given printhead can be adjusted to the length of the paper if such information is made available. The technique of the present invention of printing and reading cue marks can be used to resolve paper stretch, provided cue sensor feedback information is coupled with another reference signal, such as encoder 38, which is coupled to the paper movement. In a preferred embodiment of the present invention, printed cue marks 18 are in direct relationship with the encoder signal means or tach wheel 38 measuring paper movement, because the encoder is in close proximity to the imaging head 14 and directly coupled to the paper motion.

Continuing with Fig. 1 and referring to Fig. 4, a plurality of cue marks 18' imaged by head 14 may comprise a plurality of equally spaced horizontal lines, as illustrated in Fig. 4. If the average velocity of the substrate 16 remains constant through the web, the relationship between the encoder 38 signal and the sensor 22 output recording the horizontal cue lines 18' will remain constant.

Paper stretch is a local phenomenon over the length of the image. Local paper stretch can be resolved by comparing the period of the encoder 38 signal with the period of the sensor 22 output, using any suitable means, as it reads the printed cue marks 18'. The period of the reference signal 38 is an indication of the paper velocity. The relationship between this signal and the one read by sensor 22 is known if the local velocity at the position of sensor 22 is known. For example, if the instantaneous velocity at sensor 22 is 10% greater than the instantaneous velocity at printhead 14, then the period of the signal from sensor 22 will be exactly 10% less than the signal from reference sensor 38. If there is paper stretch in the local area of the paper where the encoded signature 18 is being read, and the effect of this stretch is to increase the distance between the lines printed in signature 18' as shown in Fig. 4, then the sensor 22 will read these lines at a slower instantaneous rate, even though the local instantaneous velocity is higher. If the paper has stretched by 10%, this will increase the period of signal 22 by 10%. Since the velocity happened to be 10% greater at sensor 22 and the paper stretch happened to be 10%, the two effects would cancel each other out and signal 22 would be the same period as signal 38.

Since both instantaneous velocity and paper stretch can be measured independently, it is possible to correct the data rate for either or both of these effects. It should be noted that in order to measure changes in instantaneous velocity, it is necessary to print a signature 18' such as is illustrated in Fig. 4, in an area where there is no image, so that paper stretch will not be a factor. It should also be noted that paper stretch, illustrated by the signal diagram of Fig. 3d, can be determined only after instantaneous paper velocity, illustrated by the signal diagram of Fig. 3b, is determined. Although in some cases it may be correct to assume that local instantaneous velocity at sensor 22 is always the same as the velocity at the tach wheel 38, this is not always necessarily the case.

Once paper stretch and/or local velocity are determined, it is possible to alter the rate of data transfer from the data system to the printhead to assure that the overlay image will be the same length as the previously printed image. This can be accomplished by increasing or decreasing the rate of printing in time to effectively stretch or shrink the image on the paper to the correct size. Hence, by printing and sensing the cue marks 18', and aligning with the image just prior to printing by the downstream heads, the effects of stretch can be corrected in the data.

In accordance with the present invention, paper stretch can be determined by assuming that the paper velocity is constant or known. In areas of no print where paper stretch is typically negligible, the technique of the present invention, as described above, can be used to determine local paper velocity. The period of the encoder 38 signal is compared with the period of the sensor 22 output reading the printed cue marks 18'. The relation between these periods should be the same as when the cue marks 18 were initially printed by the first printhead 14. Any variation is a measure of a change in the instantaneous velocity between the location of the encoder 38 and the sensor 22. This velocity information is valuable in determining the rate at which to print the image data from printhead 46 or printhead 20, in order to maintain good registration over the length of the image.

In order to assure good overlay of image data onto previously printed image planes, the instantaneous ve-

locity and paper stretch resolution determinations can be combined. The horizontal cue lines 18' shown in Fig. 4 should appear just above the image, for example, by a couple of inches, for an instantaneous velocity measurement; and throughout the image for determination of paper stretch. The sensor 22 can read the first set of cue lines and use the information to resolve the instantaneous paper velocity. The following set of cue lines that are aligned with the image can be used to resolve paper stretch. After this information is recorded, the data and/or the rate of imaging can be adjusted, just prior to the start of the application of ink by the downstream head 46.

Continuing with Fig. 1, and referring to Fig. 5, in order to accurately overlay images, the printheads 14 and 46, and subsequent downstream printheads, as desired, are in direct line with each other in the direction of paper movement. In accordance with one embodiment of the present invention, one means for obtaining this alignment is to use the leading printhead 14 to print a set of cue marks 18", as shown in Fig. 5. Sensors rigidly attached to subsequent printheads in the press read these marks. In a preferred embodiment of the present invention, the cue signature 18" illustrated in Fig. 5 is designed so that each parallel line is one pixel different in length to adjacent lines. All lines start along the same edge. The downstream printheads are positioned across the web until the correct number of cue lines are received by the infrared sensor 22 associated with the corresponding printhead. It is not necessary to physically attach the cue sensor 22 to the individual printheads for dynamic measurements, such as paper stretch and instantaneous velocity. However, in a preferred embodiment of the present invention, in order to make accurate static measurements of one printhead in relation to another, the sensors 22 are attached to the corresponding printheads so that each sensor and printhead can be moved as a unit. In a preferred embodiment of the present invention, the sensors are attached to a printhead support that is always referenced to the array. In this way, the printheads can be removed without the sensors. Further, in a preferred embodiment of the present invention, the printhead can be mounted on a member which can be moved in a direction substantially perpendicular to direction of substrate motion. Actuator means can then be provided which are capable of slight movements of the printhead structure. The actuator means are responsive to the sensor means to provide sub pixel accuracy image overlay through interpolation.

With the present invention, printhead positioning across the web is achievable within one pixel. Direct alignment of the printheads to each other can be done at a slow web speed, where it is assumed that there is little or no lateral drift in the paper web itself. As will be obvious to those skilled in the art, the process of printing, sensing, and positioning the printheads can be automated under computer control. Fig. 5 illustrates a set of lines 18", printed by printhead 14, that vary in length by one pixel. The length of the lines is determined by the jet spacing in the array. Each printhead is adjusted perpendicular to the web until each printhead in the direct line reads exactly the same portion of the pattern of lines of Fig. 5 as every other printhead in the direct line. Furthermore, the position of sensor 22 on printhead 46 is exactly duplicated at each subsequent printhead.

Printhead angular alignment is also critical in achieving proper overlay of images. Hence, the ink jet arrays for each printhead must be parallel to each other and substantially orthogonal to the direction of web travel. The printed cue mark technique of the present invention can be used to assure this alignment. For example, consider cue marks printed by the first head in a sequence such as is illustrated in Fig. 6. Two cue marks 18a and 18b are printed from opposite ends of the array of printhead 14. Two cue sensors 22a and 22b properly aligned and attached to subsequent printhead 46, and additional downstream printheads, as desired, detect the cue marks 18a and 18b as the cue marks pass by the sensors. The angle of the downstream printheads 46 are adjusted about the z-axis, as shown in Fig. 6, until the sensors 22a and 22b read the cue marks 18a and 18b at the same instant. As will be obvious to those skilled in the art, this process can also be automated under computer control.

Once the printheads have been positioned and aligned, the technique of the present invention can be used to determine errors due to paper shifts at high web velocities (once the speed of the web is increased to a typical operating speed), and make appropriate corrections. If the number of cue marks read by a given printhead changes, that is an indication that the paper has moved by one pixel increment. The number of cue marks being read also indicates the direction of paper shift.

Typically, each printhead has more jets than are needed for printing, so there are usually extra jets at each end of the printhead. In accordance with the present invention, then, the data sent to that particular printhead (i.e., the printhead where the paper shift is noticed) can be shifted by a pixel to compensate for web tracking errors. Alternatively, the printheads can be shifted to accomplish the same.

The present invention provides a system and method for controlling image registration of images printed on a substrate of an ink jet web press. A reference tachometer provides a first signal indicative of substrate distance and substrate speed. Registration marks are printed on the substrate, relative to the images. A sensor means reads the registration marks and provide a second signal indicative of instantaneous substrate speed. The first signal and the second signal are compared to indicate instantaneous substrate speed discrepancies on subsequent images. In this manner, the registration marks are used to assure good reference and overlay of image data onto previously printed images.

In accordance with the present invention, the indi-

cated instantaneous substrate speed discrepancies on subsequent images are corrected, such as by changing the speed at which data is sent to subsequent printheads. The instantaneous substrate speed can be used to provide a third signal indicative of substrate stretch, which can be corrected for according to the present invention. Substrate stretch can be corrected by changing the speed at which data is sent to subsequent printheads; or by adjusting data, thereby forcing a subsequent image to have a length equal to a previous image.

Static corrections can be made in the ink jet web press to assure good reference and overlay of image data onto previously printed images, by providing in-line positioning of each printhead in a direct line path. In-line positioning of each printhead in a direct line path can be accomplished by printing a reference pattern on the substrate, relative to the images, running the ink jet web press at a relatively slow speed, and aligning each printhead in a direct line path until each subsequent printhead reads exactly the same portion of the reference pattern as each previous printhead. A first reference mark can be printed, readable by a first sensor; and a second reference mark can be printed, readable by a second sensor. Each printhead rotation can then be adjusted along an axis in a direction orthogonal to the plane of the substrate until the first sensor reads the first reference mark simultaneously with the second sensor reading the second reference mark.

Finally, the present invention recognizes and corrects for substrate shift discrepancies on subsequent images. Substrate shift discrepancies can be corrected by varying which nozzles of each printhead receive data for printing the subsequent images. Each printhead can be mounted on a member which can be moved in a direction substantially perpendicular to direction of substrate motion. Actuator means can then be provided which are capable of slight movements of the printhead structure. The actuator means are responsive to the sensor means to provide sub pixel accuracy image overlay through interpolation.

Industrial Applicability and Advantages

The present invention is useful in the field of ink jet printing, and has the advantage of improving image registration of an ink jet printing image. The present invention has the further advantage of resolving and correcting for spatial discrepancies on subsequent images printed on downstream imaging stations. The present invention is particularly advantageous for use in a color printing process. The present invention can be used to automate the static alignment of printheads in a web press by interfacing the output of sensors with appropriate control electronics and actuation devices for the purpose of shifting printheads to the desired positions.

The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that modifications and variations can be effected within the spirit and scope of the invention.

Claims

1. A method for controlling image registration of images printed on a substrate of an ink jet web press having a plurality of printheads having nozzles for ejecting ink for printing the images, the method comprising the steps of:

   providing a reference tachometer for providing a first signal indicative of substrate distance and substrate speed;
   printing registration marks on the substrate, relative to the images;
   reading the registration marks;
   using the registration marks to assure good overlay of image data onto previously printed images.

2. A method for controlling image registration as claimed in claim 1 wherein the step of reading the registration marks further comprises the steps of:

   using a sensor means to read the registration marks and provide a second signal indicative of instantaneous substrate speed;
   comparing the first signal and the second signal to indicate instantaneous substrate speed discrepancies on subsequent images;
   correcting for the indicated instantaneous substrate speed discrepancies on subsequent images by changing the speed at which data is sent to subsequent printheads.

3. A method for controlling image registration as claimed in claim 2 wherein the step of using a sensor means to read the registration marks and provide a second signal indicative of instantaneous substrate speed further comprises the steps of:

   using the instantaneous substrate speed to provide a third signal indicative of substrate stretch;
   correcting for substrate stretch discrepancies on subsequent images;
   changing the speed at which data is sent to subsequent printheads;
   adjusting data to force a subsequent image to have a length equal to a previous image.

4. A method for controlling image registration as claimed in claim 1 further comprising the steps of:

   making static corrections in the ink jet web press to assure good overlay of image data on-

to previously printed images;
providing in-line positioning of each printhead in a direct line path;
printing a reference pattern on the substrate, relative to the images;
running the ink jet web press at a relatively slow speed; and
aligning each printhead in a direct line path until each subsequent printhead reads exactly the same portion of the reference pattern as each previous printhead.

5. A method for controlling image registration as claimed in claim 4 further comprising the steps of:

providing a first reference mark readable by a first sensor, and a second reference mark readable by a second sensor; and
adjusting each printhead rotation along an axis in a direction orthogonal to a plane of the substrate until the first sensor reads the first reference mark simultaneously with the second sensor reading the second reference mark to provide a static alignment of each printhead in a direct line path.

6. A method for controlling image registration as claimed in claim 2 further comprising the steps of:

mounting the printhead on a member which can be moved in a direction substantially perpendicular to direction of substrate motion; and
providing actuator means capable of slight movements of the printhead structure, the actuator means being responsive to the sensor means to provide sub pixel accuracy image overlay.

7. A method for controlling image registration as claimed in claim 1 further comprising the steps of;

correcting for substrate shift discrepancies on subsequent images; and
varying which nozzles of each of the plurality of printheads receive data for printing the subsequent images.

8. A method for controlling image registration of images printed on a substrate of an ink jet web press having a plurality of printheads having nozzles for ejecting ink for printing the images, the method comprising the steps of:

printing registration marks on the substrate, relative to print location of the images;
reading the registration marks;
using the registration marks to determine spatial discrepancies in subsequent images;
making dynamic corrections to correct for spatial discrepancies in subsequent images to assure good overlay of image data onto previously printed images; and
making static corrections to correct for spatial discrepancies in alignment of subsequent printheads to each other to assure good reference of image data onto previously printed images.

9. A method for controlling image registration as claimed in claim 8 wherein the step of making dynamic correction further comprises the steps of:

changing the speed at which data is sent to subsequent printheads; and
adjusting data to force a subsequent image to have a length equal to a previous image.

10. A method for controlling image registration as claimed in claim 8 wherein the step of making static corrections further comprises the steps of:

providing in-line positioning of each printhead in a direct line path;
printing a reference pattern on the substrate, relative to the images; and
aligning each printhead in a direct line path so each printhead reads the same reference pattern.

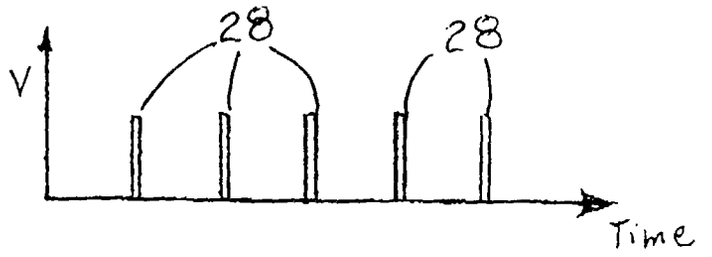


Fig. 3a

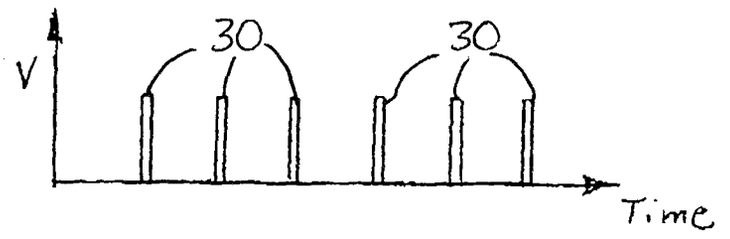


Fig. 3b

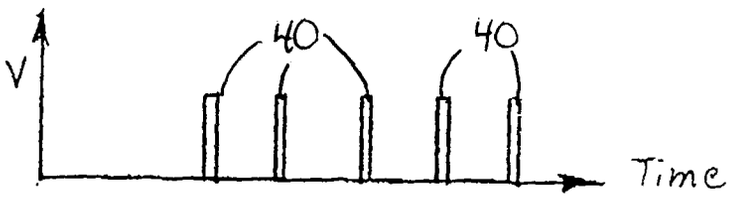


Fig. 3c

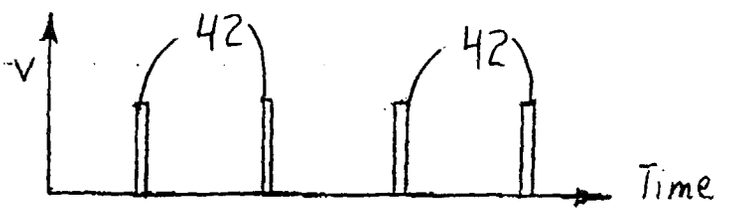


Fig. 3d

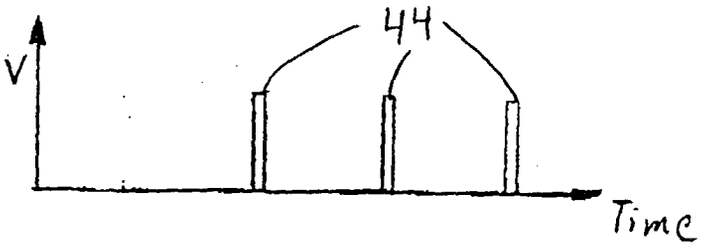


Fig. 3e

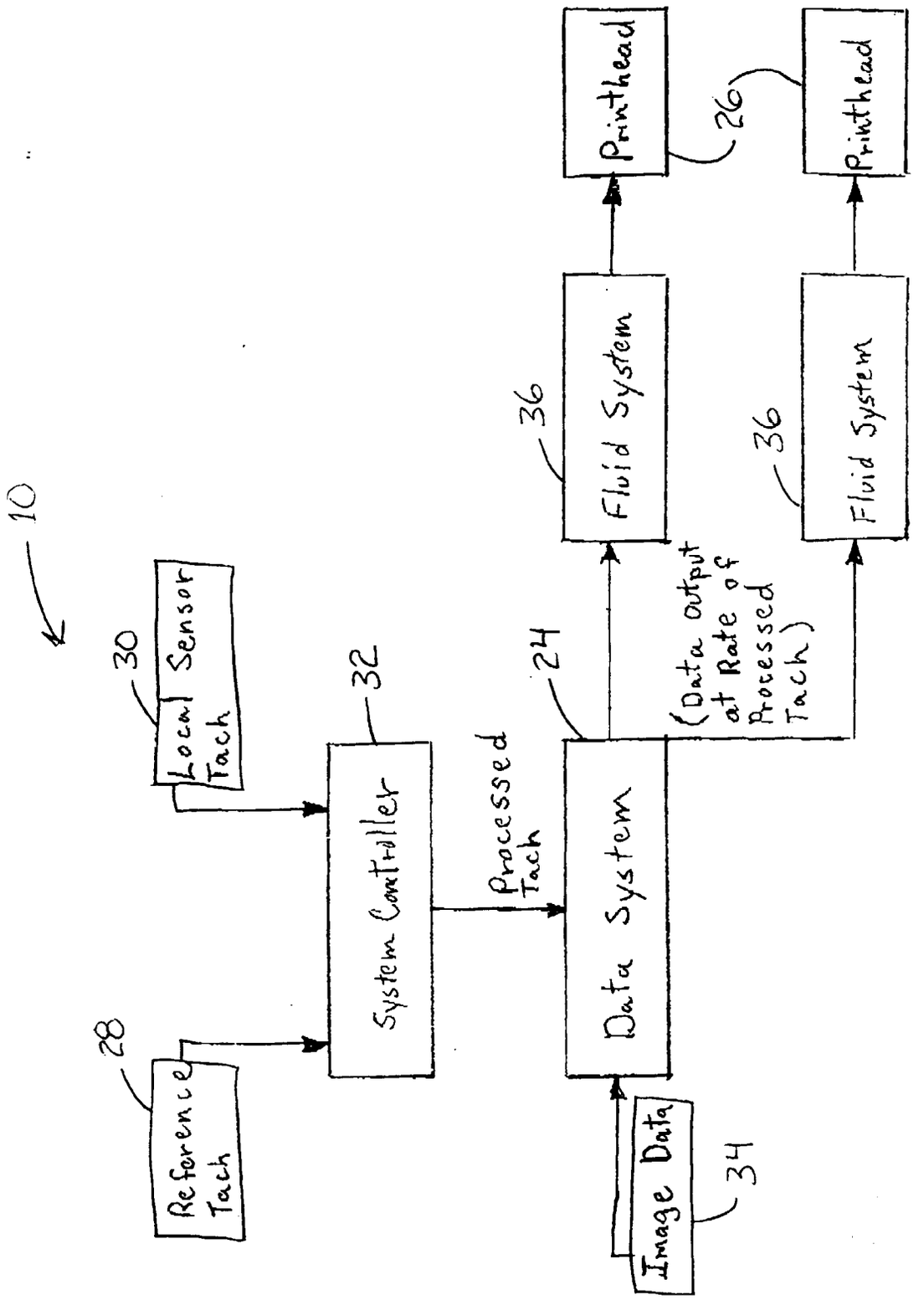

10
Reference Tach
28
Local Sensor Tach
30
System Controller
32
Processed Tach
Data System
24
Image Data
34
(Data output at Rate of Processed Tach)
Fluid System
36
Fluid System
36
Printhead
26
Printhead

Fig. 2

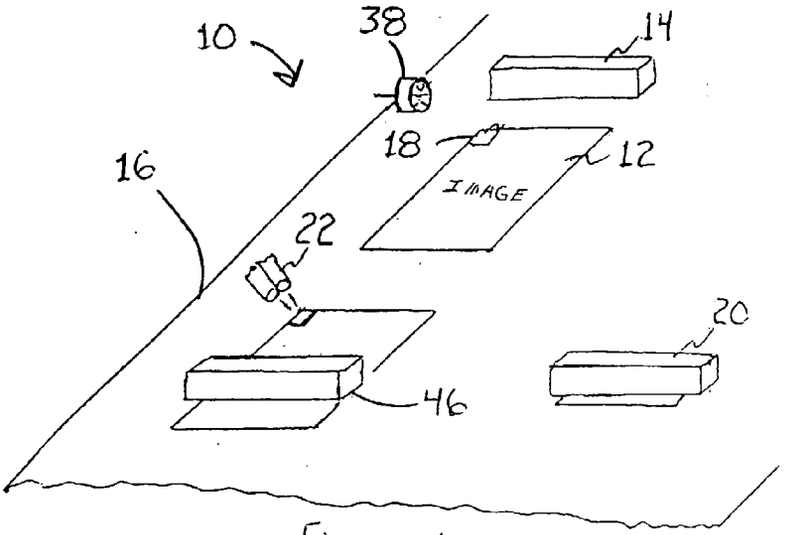


Figure 1

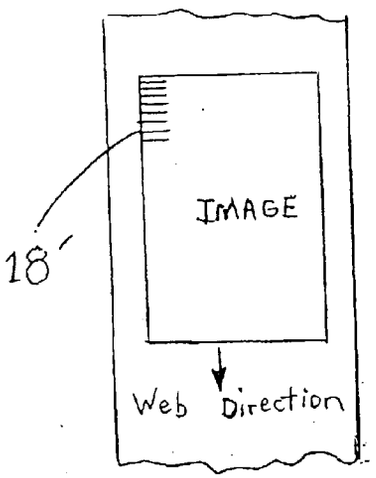


Figure 4

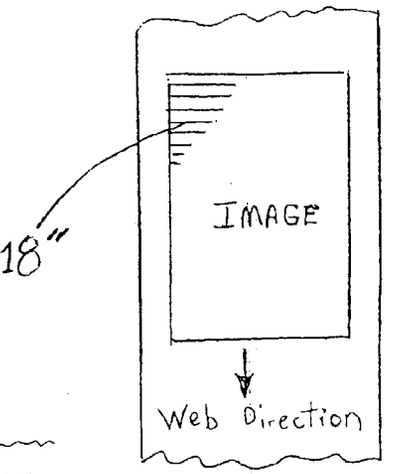


Figure 5

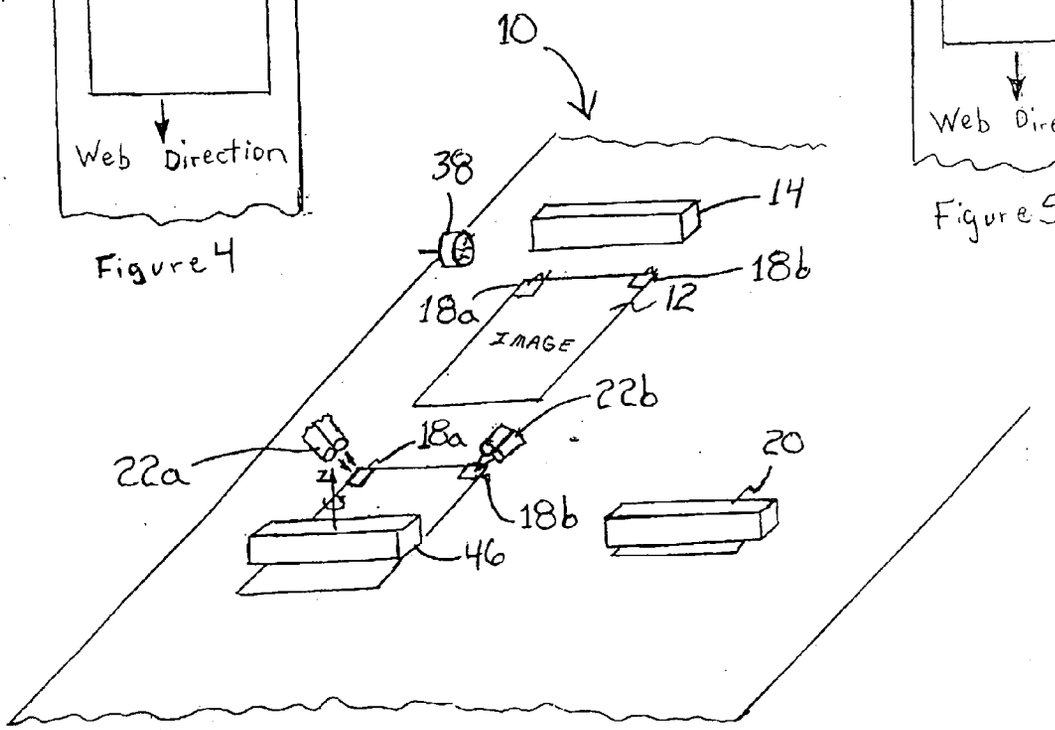


Figure 6