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(54)

A METHOD OF DUPLEX PRINTING

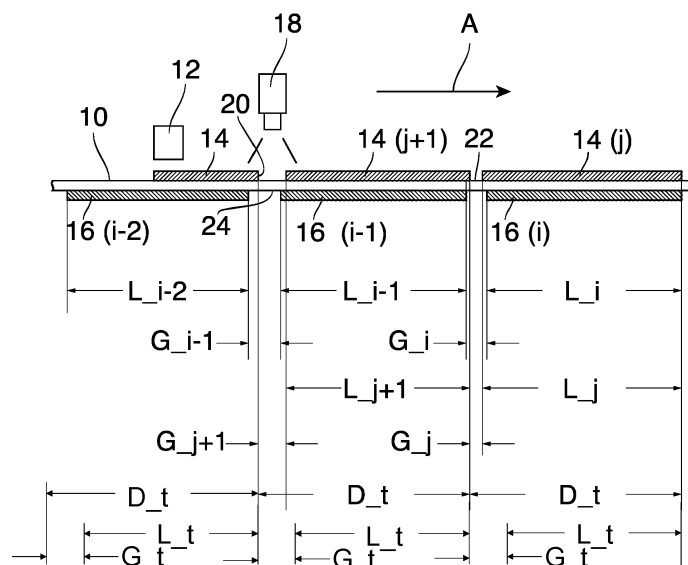
(57)

A method of duplex printing, comprising a first print cycle in which a web (10) is advanced step-wise relative to a print station (12) in order to print successive images (16) onto a first side of the web (10), the images (16) being separated by gaps (24), and a second print cycle in which the web is moved past the print station (12) in reverse orientation in order to print images (14) onto a second side of the web such that the images (14, 16) on the first and second sides are in registry with one another,

characterized in that the following steps are performed in each print cycle:

- measuring a length (L_i, L_j) of each printed image (14, 16) by detecting an advance of markings (20) that are formed on the side of the web (10) on which the images are being formed; and
- on the basis of the measured lengths, controlling the lengths (G_i, G_j) of the gaps (22, 24) between the images such that distances (D_t) between leading edges of successive images are kept constant.

Fig. 1



Description

[0001] The invention relates to a method of duplex printing, comprising a first print cycle in which a web is advanced step-wise relative to a print station in order to print successive images onto a first side of the web, the images being separated by gaps, and a second print cycle in which the web is moved past the print station in reverse orientation in order to print images onto a second side of the web such that the images on the first and second sides are in registry with one another.

[0002] A duplex printer that is suitable for carrying out this method has been described in EP 3 290 367 A1.

[0003] In duplex printing, it is frequently desired that the images on the opposite sides of the web are in registry with one another, in order to assure, for example, that all images have the same position when the printed web is cut into sheets. This ensures that the front and back images on e.g. two-sided posters and banners are properly aligned.

[0004] In principle, the register of the images can be adjusted by appropriately controlling the advance movements of the web in the printer on the basis of the known length of each image, the length information being typically included in the print job specifications.

[0005] In a frequently used printer design, the print station has a traversing print head assembly that is moved reciprocatingly across the width of the web in order to print successive swathes of the image, and the web is advanced by one step after each swath. Depending upon the properties of the print media web and on the operating conditions of the printer, a certain amount of slippage may occur in the web transport system, so that the step width can only be controlled with a limited accuracy. It is known to provide an optical sensor that is capable of detecting parts of the printed images or positioning marks that have been printed onto the web in order to monitor the advance of the web and to feedback-control the step width of the web transport system.

[0006] The step error in a single advance step of the web can be made so small that it does not give rise to visible artefacts in the printed image. However, when a larger number of successive images is printed, each image consisting of a large number of swathes, the step errors may accumulate and give rise to a substantial positional deviation in the order of magnitude of one or more millimeters. As a consequence, register errors in the same order of magnitude may occur between the front and back side images.

[0007] If the media webs are intransparent, it is difficult to monitor the positions of the images on the back side of the web from the side on which the print station is installed. A possible way to overcome this problem would be to provide an additional sensor on the side of the web that is opposite to the print station.

[0008] It is an object of the invention to provide a method of duplex printing by which the front/back register of the images can be improved without requiring complex detection means.

[0009] According to the invention, in order to achieve this object, the following steps are performed in each print cycle:

- measuring a length of each printed image by detecting an advance of markings that are formed on the side of the web on which the images are being formed; and
- on the basis of the measured lengths, controlling the lengths of the gaps between the images such that a distance between leading edges of successive images is kept constant with respect to a respective target distance between said leading edges as defined by print job specifications.

[0010] Rather than relying upon the digital length of the images as specified in the print job, the actual length of each physical image is measured by monitoring the advance of the markings from the side of the print station. Thus, if step errors accumulate and give rise to a deviation of the physical length of an image from the digital length, this deviation can be detected and can be compensated by appropriately adjusting the length of the gaps between the images, so that the total repeat, i.e. the sum of the image length and the gap length, can be kept constant and can be controlled to be the same on both sides of the web, so that the correct register of the images can be preserved. As the images may vary in size, a different target distance may be defined for each pair of successive images. The length of the gap located within the distance between leading edges of a pair of successive images is controlled, such that said distance corresponds to the respective target distance defined for said pair of successive images.

[0011] More specific optional features of the invention are indicated in the dependent claims.

[0012] In an embodiment, the target distance comprises a sum of a target image length and a target gap length. The target image length and the target gap length are determined by the controller of the printer from received print job specifications. The print job specification may define a value for target image length or the controller may be configured to define such a value from the print job information. Optionally a target gap length may be prescribed by the print job information received by the controller. If no target gap length is input, the controller may determine one based on an algorithm or predetermined setting stored on its memory (e.g. one of a pre-stored set of default gap length settings). The distance between leading edges of successive images comprises an image length as well as a gap length.

[0013] In an embodiment, the method further comprises the step of comparing the measured length of each printed image to its respective target image length as defined by the print job specifications. The measured length is compared

to the target image length to determine for example a difference between the actual image length and its intended value. As such, the controller may determine whether corrective actions are required. The gap length is then controlled proportional to the result of the comparison.

[0014] In an embodiment, the step of controlling the lengths of the gaps comprises determining said lengths of the gaps by adjusting a target gap length as defined by the print job specifications by a difference or comparison between the measured length of a printed image and the target image length. The controller may determine a difference between the measured image length and the target image length. To avoid displacing the effective starting position of the successive image on the web, the gap length is adjusted to correct for the determined difference. Specifically, the controller may add or subtract the difference between the measured length of a printed image and the target image length for said image to or from the target gap length. This ensures that the distance between leading edges of successive images is kept constant with respect to the target distance defined by the print job specifications for each respective image. It will be appreciated that the target image length may be varied across the web. The controller aims to maintain the distance between successive leading edges constant to the target distance for each individual pair of front and back images. For example, the respective distance for a first front and back image pair may be kept constant at e.g. 1 meter, while the distance a successive first front and back image pair may be smaller or greater, for example 3 meters.

[0015] In an embodiment, the print job specifications define pairs of front and back images to be printed in alignment on respective sides of the web, wherein the same target distance is applied for each front and back image of each pair. The target distance for the front side image is the same as for its oppositely positioned back side image, though the target distance between pair may vary. In case equal sized gaps and images are used, the target distance may be same for all front and back image pairs.

[0016] Embodiment examples will now be described in conjunction with the drawings, wherein:

Fig. 1 is a diagram of sequences of images printed on opposite sides of a media web;

Fig. 2 shows the same web as Fig. 1, but in a condition where the web has been advanced by one step;

Fig. 3 is a schematic view of a web transport mechanism of a roll-to-roll printer in a first print cycle for printing on a front side of the web;

Fig. 4 shows a configuration of the web transport system in a second print cycle for printing onto a back side of the web;

Figs. 5 and 6 illustrate another method of handling the web before and during the second print cycle; and

Fig. 7 shows a modified example of a sensor arrangement at the web.

[0017] As is shown in Fig. 1, a web 10 of a print medium is advanced in a transport direction A relative to a print station 12. The print station 12 may for example comprise a traversing carriage that carries an array of print heads, e.g. ink jet print heads, and is driven to move back and forth in transverse direction of the web 10, i.e. in the direction normal to the plane of the drawing in Fig. 1, so that the print heads may print a swath of an image 14 in each scan pass of the carriage. When a swath has been completed, the web 10 is advanced by one step in the transport direction A, the step width being smaller or equal to the width of the swath, so that an adjacent swath can be printed in a subsequent return pass of the carriage. Preferably, multi-pass printing is applied wherein the print station 12 is passed multiple times over each area of the images 14, 16. For example, for multi-pass printing in five passes, the web 10 is advanced by at most one fifth of the width of the swath in between each pass.

[0018] In the situation shown in Fig. 1, the print station 12 is busy with printing a swath of one image 14, and a sequence of preceding images 14 have already been printed in earlier scan passes. As is further shown in Fig. 1, the web 10 carries already a sequence of images 16 that have been printed on a first side of the web 10 (the bottom side in Fig. 1) in an earlier print cycle when the web had been moved past the print station in reverse orientation, i.e. with the first side facing upward. In the print cycle that is shown in Fig. 1, the images 14 are formed on a second side of the web 10. An index i counts the images 16 on the first side in the order in which they have been printed, and an index j counts the images 14 on the second side in the order in which they are printed.

[0019] The print process is controlled such that each of the images 16 on the first side of the web has a counterpart image 14 in the same position on the web 10 but on the second side thereof. Ideally, the image areas of each pair of images 14, 16 should be congruent, i.e. the images 14 and 16 should be in perfect registry with one another.

[0020] In practice, however, the image register can only be controlled with limited accuracy because of inevitable errors in the step width by which the web 10 is advanced in each step. These step errors accumulate over the length of each image. As a consequence, the images 16 have lengths L_i , L_{i-1} and L_{i-2} which are not exactly equal to the

"digital" length that was specified for the images in the print job specifications. In the given example, it is assumed that all images 16 were intended to have the same digital length, but the actual (physical) lengths L_{i-1} , L_{i-2} and L_{i-3} are different from one another, although the differences have been grossly exaggerated in Fig. 1.

[0021] Similarly, the images 14 on the second side of the web were intended to have the same digital length, equal to the digital length of the images 16 on the first side, but actually the images 14 have physical lengths L_j , L_{j+1} which are different from one another and from the lengths of the images 16. This is the reason why the register between the images 14 and 16 is not perfect.

[0022] By means of a method that will be described in the following paragraphs, it is possible, however, to assure that the register arrows between the images 14 and 16 do not accumulate over the length of the web 10 and that, instead, the centers of all pairs of images 14, 16, all along the web, are approximately coincident. As a consequence, the register error in each pair of images 14, 16 is so small that it is hardly perceptible for a human viewer.

[0023] In order to achieve this objective, a sensor 18, e.g. an optical sensor or a camera, has been installed on the same side of the web 10 as the print station 12 and in a fixed positional relation to the print station. The camera is facing the web 10 and is capable of capturing a digital image of a certain area of the web surface, which area includes a marking 20. In the example shown, the marking 20 is constituted by the leading edge of the image 14 that is being printed at the print station. It will however be observed that the marking 20 might be constituted by any structural feature at the edge or within the area of the printed images. The sensor 18 must only be capable of detecting the advance of such a marking in any of the advance steps of the web 10, so that the step width of each advance step can be measured with high accuracy. Optionally, the print station 12 could also be used for printing dedicated position markings on a margin near an edge of the web 10 and outside of the areas of the images 14, so that the step widths can be measured by monitoring the advance of these dedicated markings.

[0024] Fig. 2 illustrates a situation where the web 10 has been advanced by one step, i.e. by a step width W . It can be seen in Fig. 2 that the marking 20 is still within the field of view of the sensor 18, so that the sensor 18 can measure the step width W by comparing the position of the marking 20 in Fig. 2 to the position of the same marking in Fig. 1.

[0025] When an individual image 14 (designated by its index j) is being printed, the length L_j can be measured by adding the step widths W of all advance steps performed between the scan pass in which the leading edge of the image was printed and the scan pass in which the trailing edge of the image is printed. In the last scan pass, i.e. the pass in which the trailing end is printed, the width of the last swath may be smaller than the step width W . In that case, the sensor 18 can detect the trailing edge of the image and measure the width of the swath, and this measured width of the swath will replace the last step width W , so that the actual length L_j is obtained. Alternatively, advancement markers may be printed laterally besides the images, which advancement markers are scanned by the sensor 18 to determine the actual length L_j between the leading and trailing edges of the images 14, 16. Similarly, the actual distances between images 14, 16 and/or images and the edges of the web 10 may be determined from these markers. The measured length L_j will then be compared to a target image length L_t , i.e. the intended (digital) length of the same image. The target image length L_t is indicated on the bottom of Fig. 2. The target image length L_t is preferably determined or defined by the print job specifications. While in Fig. 2 the digital images are of equal length, images of varying length may be applied. Fig. 2 further illustrates the target gap lengths G_t between successive images 14. The target gap lengths G_t may be determined from the print job specifications, by the operator, or derived from a pre-stored setting. It is noted that in Fig. 2 the target image length L_t and the target gap length G_t are visual representations of digital information applied by the controller 30, while the above lengths L_i , L_j , G_i , G_j represent visible properties of the printed web 10. Further, the printer is controlled to operate such that the distance D_t matches its corresponding digital target value and as such in Fig. 2, the two are identical and a single representation for the distance D_t is used.

[0026] As is shown in Fig. 1, the successive images 14 are separated by gaps 22, and the successive images 16 are separated by gaps 24. Thus, when a printed image 14 has been completed, the print station 12 and the web advance mechanism are controlled so as to leave a gap with a predetermined width before the print station starts printing the leaving edge of the next image. The gaps have certain target lengths G_t which are also specified in the print job specifications. For simplicity, it can be assumed that all gaps 22 and 24 have the same target length which will be designated as G_t . However, a length G_j of the gap 22 that will actually be formed in the print process is calculated by on the basis of the following formula:

$$G_j = G_t - (L_j - L_t)$$

[0027] In this way, the deviation of the actual length L_j of each image is compensated by a corresponding deviation of the width G_j of the gap 22 from the target length G_t .

[0028] Consequently, the total repeat of the images 14, i.e. the distance D_t from the leading edge of one image 14 to the leading edge of the next image (or equivalently from the trailing edge of one image to the trailing edge of the next

image), is constant and is equal to the sum of the target length L_t and the target gap length G_t

$$D_t = L_t + G_t = L_j + G_j = L_{j+1} + G_{j+1} = \dots$$

[0029] In the previous print cycle, in which the images 16 had been formed, the width of the gaps 24 has been controlled in the same way. Thus, the lengths L_i , L_{i-1} , ... of these images and the widths G_i , G_{i-1} , ... of the gaps between them fulfil the relation:

$$D_t = L_t + G_t = L_i + G_i = L_{i-1} + G_{i-1} = \dots$$

[0030] In this way, it is assured that the sequence of images 16 and the sequence of images 14 have exactly the same repeat D_t . Consequently, the images 14 and 16 are formed in such a way that the register error is kept as small as possible. More precisely, the register error is only in the same order of magnitude as the step errors accumulated over the length of a single image. In other words, the register error will not accumulate further over the sequence of successive images, regardless how many images there will be printed.

[0031] Note that when images 14 of varying lengths are applied, the print process is controlled, such that:

$$D_t = L_t + G_t = L_j + G_j,$$

wherein D_t may be different for each printed image, at least for images which are followed by a successively printed image. The gap length G_j is then adjusted by the difference between the measured image length L_j and its target image length L_t .

[0032] For a corresponding front side image 16, the distance D_t is preferably the same as for the back side image 14, such that:

$$D_t = L_t + G_t = L_j + G_j = L_i + G_i$$

While the actual length L_i , L_j of the front and back side images 14, 16 may be different, their respective gap lengths G_i , G_j are adjusted, such that the combined length L_i , L_j of the image 14, 16 and the length G_i , G_j of the respective gap 22, 24 corresponds to or even equals the target distance D_t . The controller 30 adjusts the gap length G_i , G_j for each front and back image pair 14, 16, such that on both sides the sum of the image length L_i , L_j and the gap length G_i , G_j matches the target distance D_t .

[0033] Fig. 3 shows essential parts of a roll-to-roll printer comprising the print station 12, the sensor 18, a platen 26, a web transport mechanism 28 and a controller 30 which controls the functionality of all the other components of the printer. The web transport mechanism 28 comprises three bearing supports 32, 34, 36 for unwinding the web 10 from a roll 38 or 40 and for winding the printed web onto a roll 42. As is well known in the art, the web transport mechanism further comprises several pairs of pinch rollers 11 and guide plates (both not shown) defining a transport path for the web and feeding the web through the transport path. Fig. 3 shows the web transport mechanism 28 in a configuration for the first print cycle in which the images 16 are printed onto the first side of the web 10. In this configuration, the web 10 is unwound from the roll 38 on which the first side of the web faces outwards. The web is supported on the platen 26 and is moved past the print station 12 and the sensor 18 and is then wound onto the roll 42. When the first print cycle has been completed, the roll 42 (which then has its full diameter) is removed from the bearing support 36 and installed on the bearing support 34, as has been shown in Fig. 4. Then, in the second print cycle, the web 10 is withdrawn from the roll 42 which now rotates in counter-clock sense and the web is then passed over the bearing support 32 which may be formed by a roll bearing support axis, for example an 'empty' roll core from which the respective web 10 was removed. The bearing support 32 preferably comprises a low friction surface over which the web 10 slides or alternatively the bearing support 32 may be configured to rotate in at least the clockwise direction. The web 10 is then fed to the print station 12 in a condition in which the first side (carrying the images 16) faces downwards towards the platen 26 and the blank second side faces the print station 12, so that the images 14 may be printed. The printed web (with images on both sides) is then wound onto a new roll 44 in the bearing support 36.

[0034] Optionally, a leader section that is made of a stiffer web material may be attached to the loose end of the web

10 on the roll 38 (Fig. 3) or on the roll 42 (Fig. 4) in order for the web to be safely fed into the web supply path.

[0035] When the first print cycle (Fig. 3) is completed, the sensor 18 will detect the trailing end of the last image 16 and will measure the distance from that trailing edge of the image to the trailing end of the web or, if a leader section has been attached to that end, to the joint between the web and the leader section. This distance will be stored in the controller 30. Alternatively, a predefined, fixed distance may be provided for cutting the web at said distance from the trailing edge of the final image 14, 16. This distance is e.g. a setting pre-stored on the controller 30, which distance setting may be provided to an operator via a user interface or as a cutting marker printed said distance from the final image 14, 16. In another example, the operator may cut the web manually, measure the distance between the final image 14, 16 and the trailing edge of the web 10, and input said distance to the controller via the user interface. In each case, the controller 30 after the first print cycle has determined the distance between the final image 14, 16 and the trailing edge of the web 10 and said distance is then stored in controller's memory. Then, when the second print cycle begins, the image 16 that has been the last image in the first print cycle will be the first to reach the platen 26, and the edge of this image that used to be a trailing edge will now be the leading edge. Then, the sensor 18 will detect the leading end of the web 10 or the joint between the leader section and the web and will cause the web transport mechanism 28 to stop at the very moment when the distance between the print station 12 and the leading end of the web is equal to the value that had been stored in the controller 30. Then, when the print station 12 starts to print the first swath of the first image 14, the leading edge of that image will coincide with the leading edge of the image 16 on the opposite side of the web. Thus, the images 14 and 16 are initially in registry and the control of the gap width as has been described above will assure that no register error will accumulate.

[0036] Fig. 5 illustrates a modified configuration and mode of operation of the web transport mechanism 28. Fig. 5 shows the situation when the first print cycle has been completed and the web bearing images 16 on one side has been wound on the roll 42, in the manner shown in Fig. 3. Then the direction of rotation of the roll 42 is reversed and the web 10 is spooled from the roll 42 to another roll 46 on the bearing support 34. After this re-spooling the side of the web 10 facing the bearing support 34 holds the images, while the unprinted side faces outward. This re-spooling may be performed by the printer on bearing supports 32, 34 or a separate re-spooling device may be provided. Next the re-spooled roll 46 is flipped and replaced on the bearing support 34. This orients the roll 46 in the correct position for being unwound as in Fig. 3. By following the operation described for Fig. 3, the unprinted, second side may be brought to the platen 26. The register of the images 14 and 16 is controlled in the same way as before. The only difference is that, in the embodiment according to Figs. 5, the end of the web on which the first image 16 was printed on the first side will also be the end on which the first image 14 is printed on the second side, so that, in Fig. 1, the index i that counts the images 16 in the order in which they are printed would increase from right to left, just as the index j .

[0037] Fig. 6 illustrates a configuration shows another situation when the first print cycle has been completed. The printed roll 46 in Fig. 6 was wound up by the bearing support 36 in the manner described for Fig. 3. The printed roll 46 is placed on the bearing support 34 with its winding direction opposite to that shown in Fig. 3. The first side of the web 10 with the images 16 printed thereon faces outwardly on the roll 46. The roll 46 is rotated counterclockwise and guided such that the unprinted inward facing side of the roll 46 is brought up to the platen 26 facing the print station 12. The blank second side of the web will now face the print station 12 so that the images 14 can be printed. The register of the images 14 and 16 is controlled in the same way as described for Fig. 3.

[0038] In many practical cases, the print jobs will specify an identical target length L_t for all images in the job. It may then be convenient to adjust the position of the sensor 18 such that the spacing between the print station 12 and the sensor 18 corresponds to that target length, as has been shown in Fig. 7. Then, in the scan pass in which the trailing edge of an image 14 is being printed, the leading edge of that image will be the field of view of the sensor 18. Consequently, since the position of the trailing edge relative to the print station 12 is known, the sensor 18 can directly measure the actual length of the image 14 and it is not necessary to measure this length by summing over the step widths.

Claims

1. A method of duplex printing, comprising a first print cycle in which a web (10) is advanced step-wise relative to a print station (12) in order to print successive images (16) onto a first side of the web (10), the images (16) being separated by gaps (24), and a second print cycle in which the web is moved past the print station (12) in reverse orientation in order to print images (14) onto a second side of the web such that the images (14, 16) on the first and second sides are in registry with one another,
characterized in that the following steps are performed in each print cycle:

- measuring a length (L_i , L_j) of each printed image (14, 16) by detecting an advance of markings (20) that are formed on the side of the web (10) on which the images are being formed; and
- on the basis of the measured lengths, controlling the lengths (G_i , G_j) of the gaps (22, 24) between the

images such that a distance (D_t) between leading edges of successive images are kept with respect to a respective target distance between said leading edges defined by print job specifications.

2. The method according to claim 1, wherein the target distance comprises a sum of a target image length (L_t) and a target gap length (G_t).
3. The method according to any of the previous claims, further comprising the step of comparing the measured length (L_i , L_j) of each printed image to its respective target image length (L_t) as defined by the print job specifications.
4. The method according to claim 3, further wherein the step of controlling the lengths (G_i , G_j) of the gaps (22, 24) comprises determining said lengths (G_i , G_j) of the gaps (22, 24) by adjusting a target gap length (G_t) as defined by the print job specifications by a difference between the measured length (L_i , L_j) of a printed image and the target image length (L_t).
5. The method according to any of the previous claims, wherein the print job specifications define (30) a target distance for each image (14, 16) having a successive image (14, 16), and wherein the length (G_i , G_j) of the gap (22, 24) within the distance (D_t) between the images (14, 16) is controlled, such that said distance (D_t) is kept constant with respect to the target distance for the image (14, 16) located within said distance (D_t).
6. The method according to claim 5, wherein the print job specifications define the same target distance for a first side image (14) as for the to be oppositely positioned, corresponding second side image (16).
7. The method according to any of the previous claims, wherein an optical sensor (18) is used for detecting the advance of the markings (20).
8. The method according to any of the previous claims, wherein the step of measuring the length of a printed image comprises the sub-steps of measuring a step width (W) by which the web (10) is advanced in each step, and summing over the measured step widths of all the advance steps performed between the printing of the leading edge and the printing of the trailing edge of the image.
9. A roll-to-roll-printer comprising a print station (12), a web transport mechanism (28) arranged for feeding a web (10) past the print station (12) and past a sensor (18) disposed on the same side of the web as the print station (12) for detecting markings (20) on the web, and a controller (30) configured for controlling the print station (12) and the web transport mechanism (28), **characterized in that** the controller (30) is configured for carrying out the method according to any of the claims 1 to 8.
10. The printer according to claim 9, wherein the sensor (18) is adjustable in position in a transport direction (A) of the web (10).
11. A software product comprising program code on a non-transitory computer-readable medium, wherein the program code, when loaded into a computer that forms the controller (30) of a printer according to the preamble of claim 10, causes the computer to perform the method according to any of the claims 1 to 8.

Fig. 1

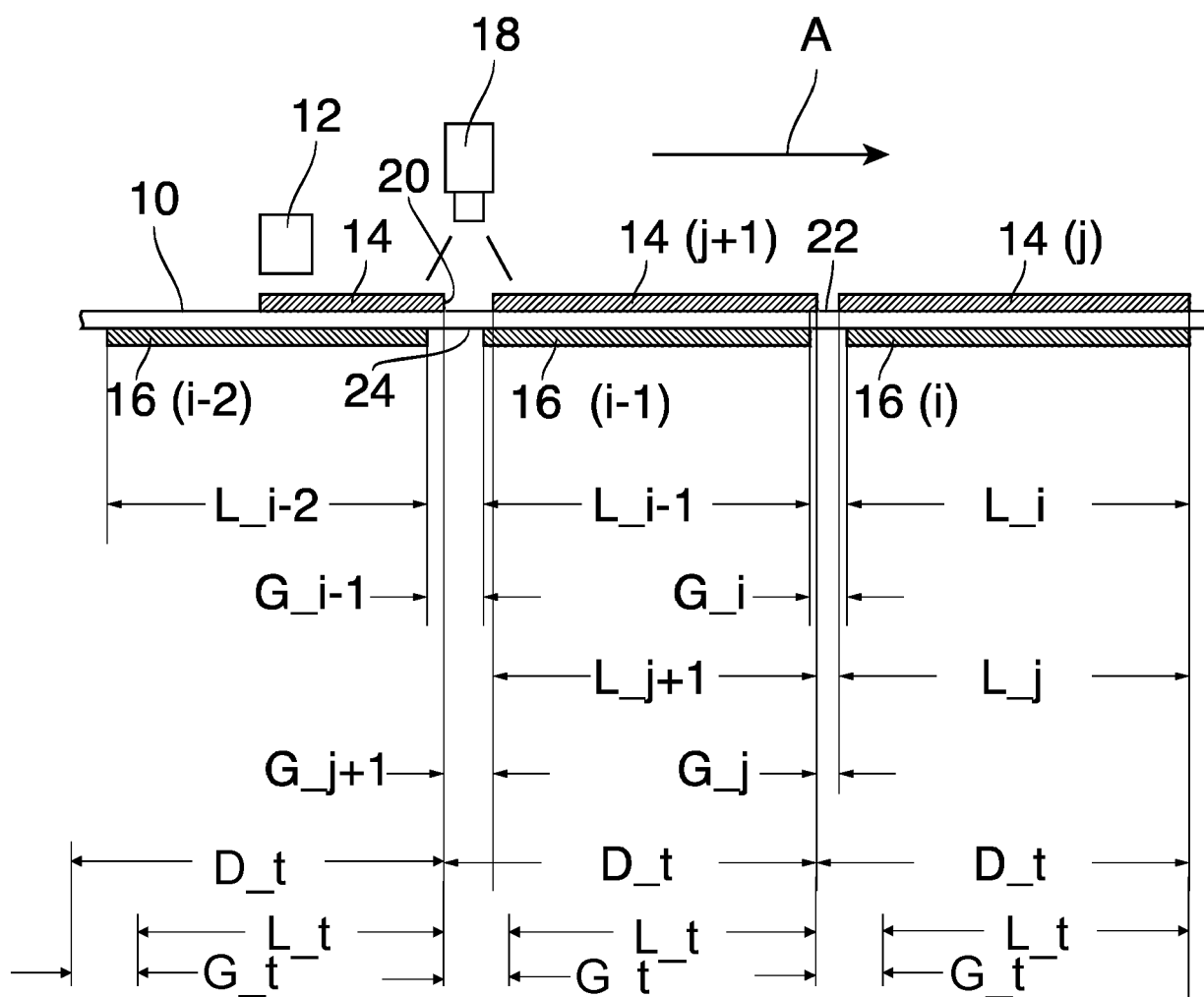


Fig. 2

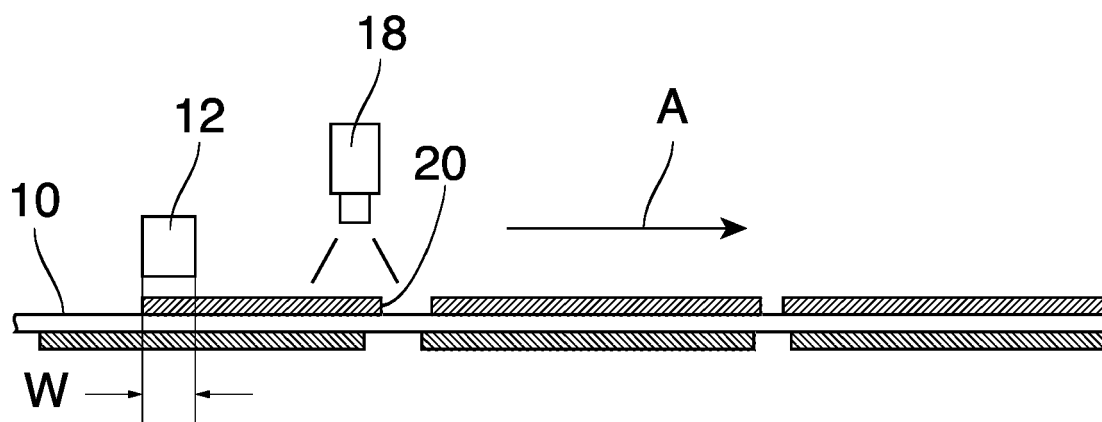


Fig. 3

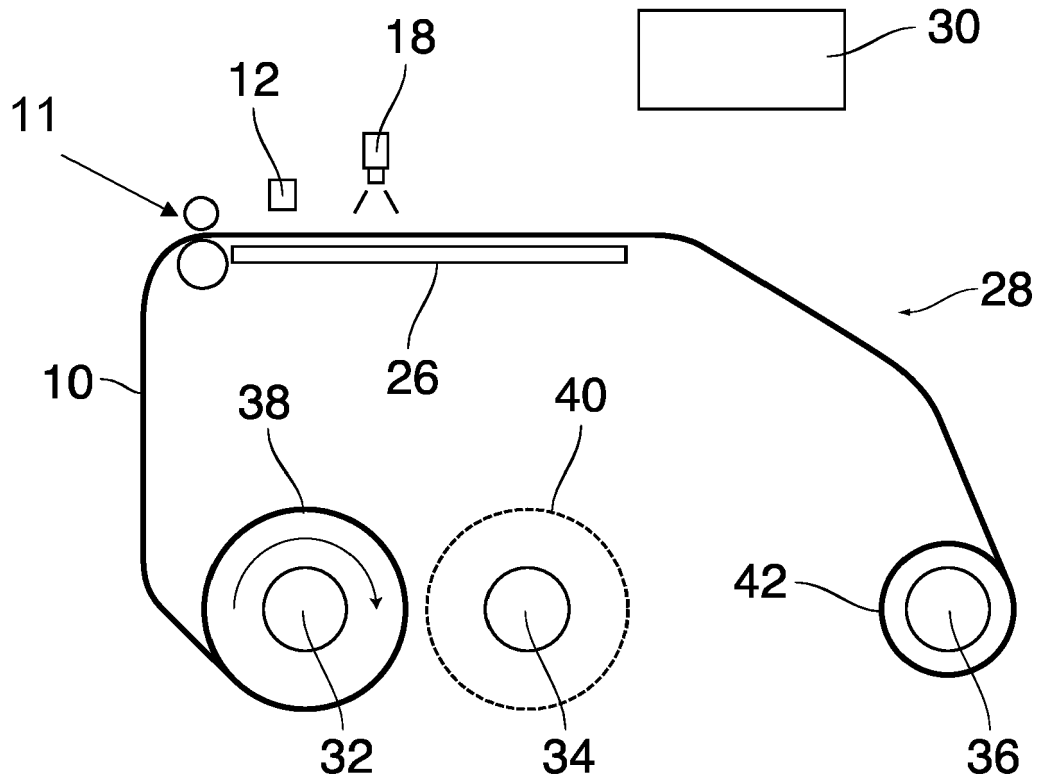


Fig. 4

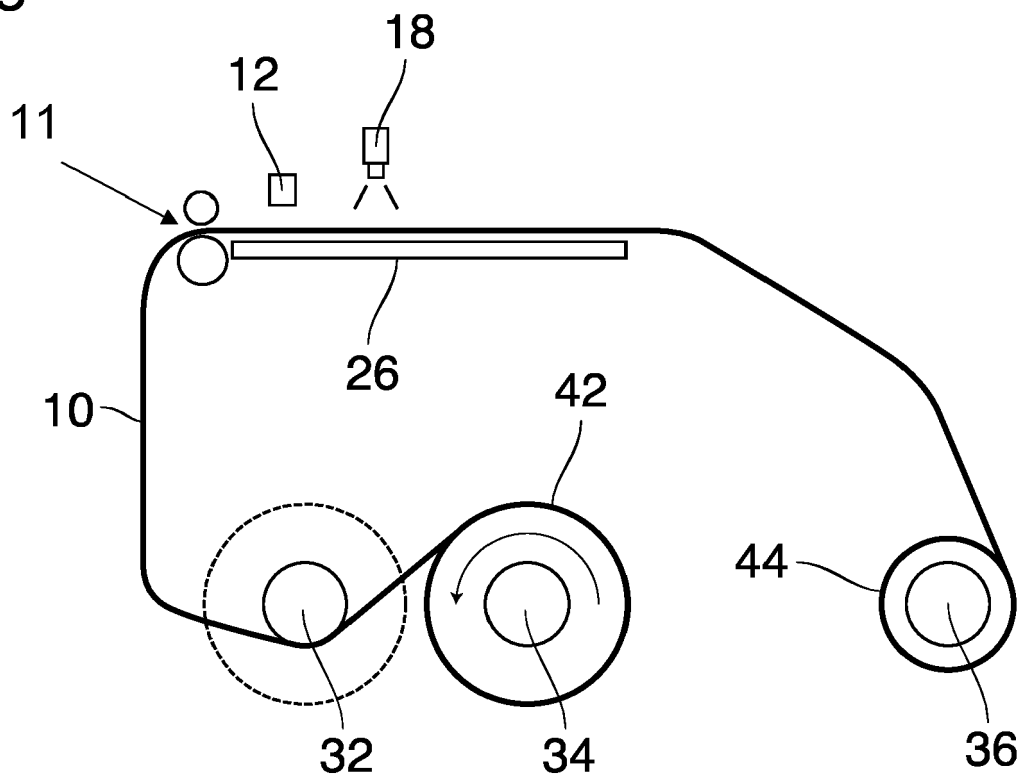


Fig. 5

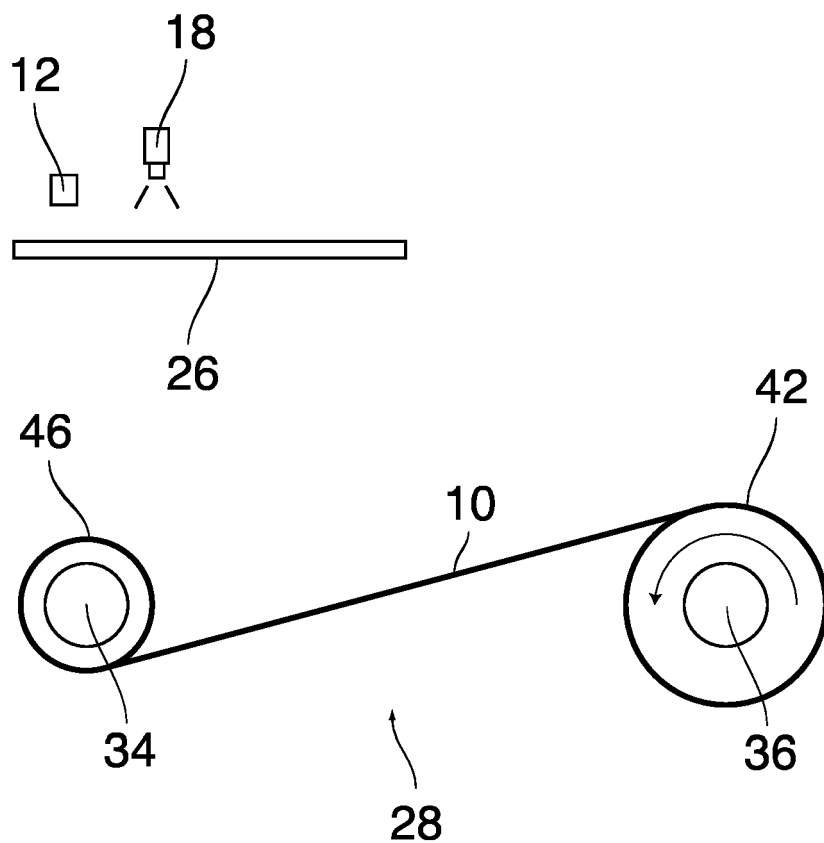


Fig. 6

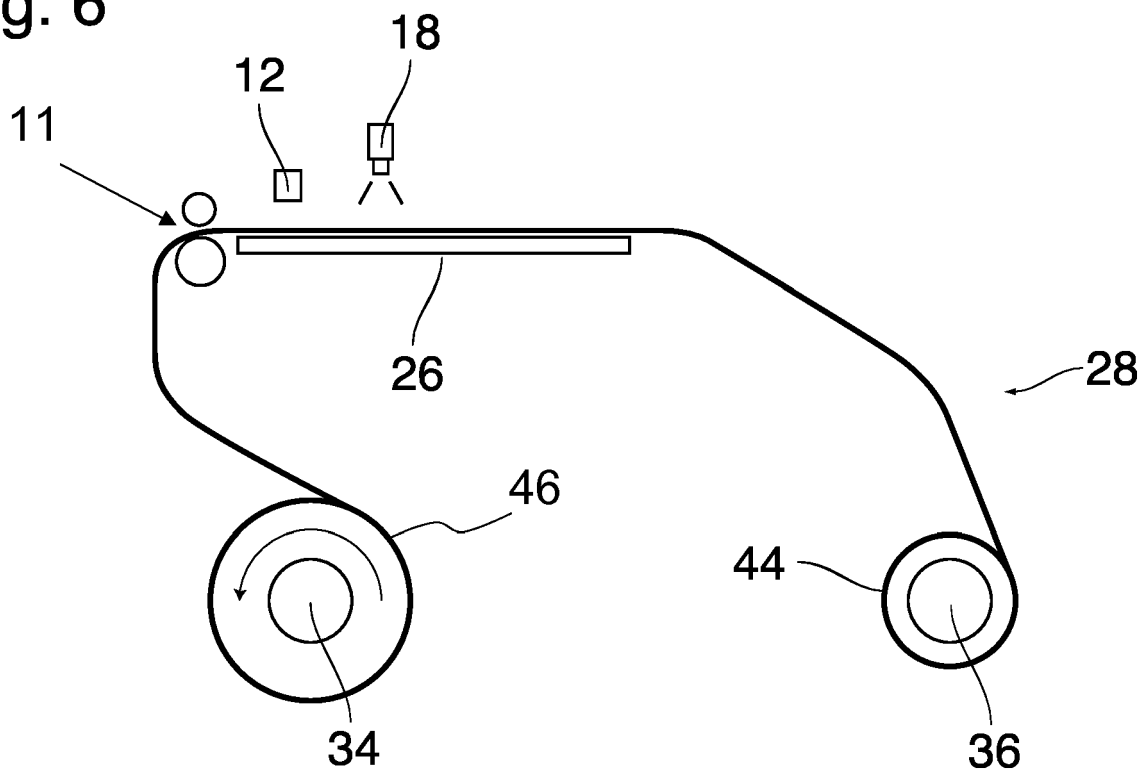
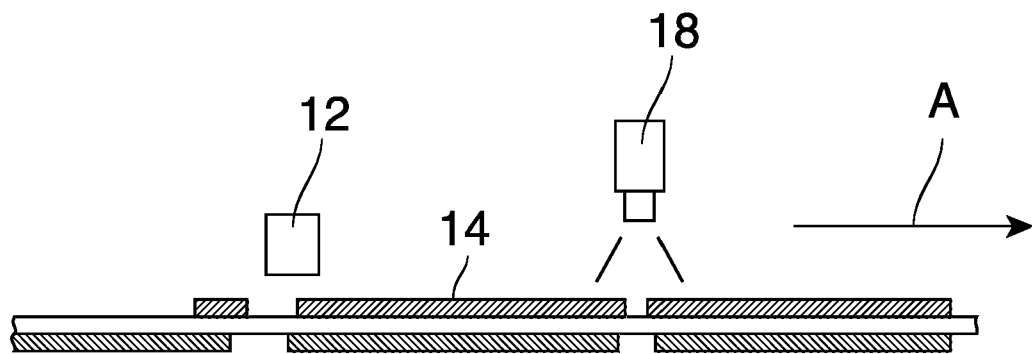


Fig. 7





EUROPEAN SEARCH REPORT

Application Number
EP 19 19 3073

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Place of search The Hague		Date of completion of the search 10 February 2020	Examiner Dewaele, Karl
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