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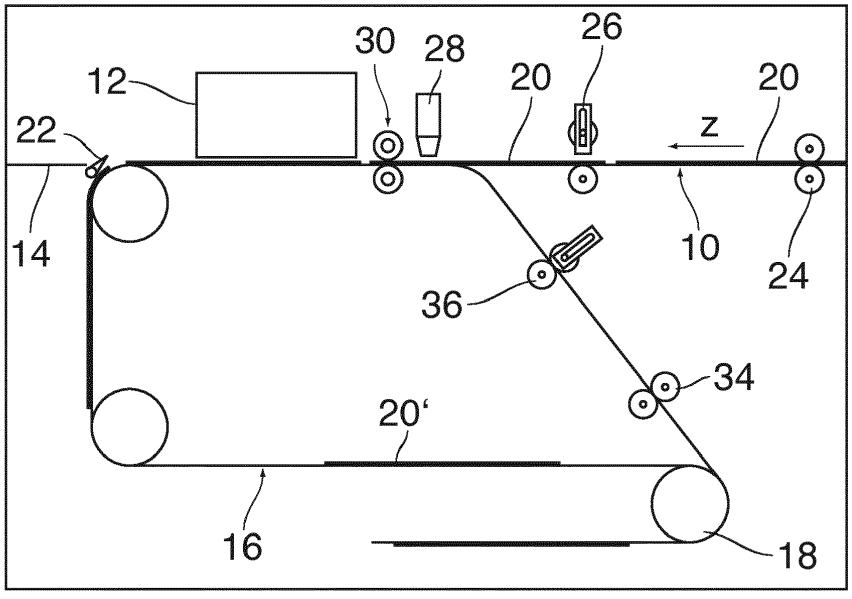
(54) A METHOD OF CORRECTING REGISTRATION ERRORS OF MEDIA SHEETS IN DUPLEX PRINTING AND A DUPLEX PRINTER THEREFOR

(57) To achieve highly productive duplex printing in a compact printer, the present invention provides a method of correcting registration errors of media sheets that are fed to a print station via a first liftable pinch and a steering mechanism. The first liftable pinch is arranged in a sheet supply path. For each sheet fed to the print station via the supply path, there is performed a step of checking the sheet for registration errors and, if a registration error is detected, lifting the first liftable pinch and operating the steering mechanism so as to rotate the sheet. A fraction of the sheets is returned via a duplex loop and fed again to the print station, again with registration error correction.

The sheets that are returned via the duplex loop are fed to the print station via a second liftable pinch without passing through the first liftable pinch again, and the liftable pinches are operated independently of one another.

Fig. 1



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Description

[0001] The invention relates to a method of correcting registration errors of media sheets that are fed to a print station in a duplex printer via a first liftable pinch and a steering mechanism, the first liftable pinch being arranged in a sheet supply path upstream of the steering mechanism, the method comprising:

- for each sheet fed to the print station via the supply path, a step of checking the sheet for registration errors and, if a registration error is detected, lifting the first liftable pinch and operating the steering mechanism so as to rotate and/or translate the sheet; and
- for a fraction of the sheets, when an image has been printed on a first side of the sheet, returning the sheet via a duplex loop and feeding it again to the print station, again with registration error correction.

[0002] In a duplex printer, the duplex loop includes a sheet flip station where the orientation of the sheet is inverted, so that, when a sheet on which an image has been printed on the first side is returned to the print station via the duplex loop, the second side of the sheet will face the print heads in the print station, so that another image can be printed on the second side of the sheet. The print head or print heads in the print station are typically configured for printing a raster image composed of pixels that are arranged in columns extending in parallel with a direction z of transport of the media sheets relative to the print station. In order for the image to have the correct orientation on the media sheet, it is required that, when the media sheet is fed to the print station, the leading edge of the sheet forms exactly a right angle with the direction of transport and, accordingly, with the direction of the pixel columns. Further, in order for the printed image to have the correct position on the media sheet in the transport direction z, the leading edge of the sheet must be fed to the print station at a timing that is coordinated with the timing of the print operation. Consequently, the sheet may be subject to three types of registration errors. In case of a first type of error, which is called skew error, the leading edge of the sheet does not exactly form a right angle with the z-direction. A second type of error is called z-registration error and means that, at the time when the print operation starts, the leading edge of the sheet does not have the correct position relative to the print station in the z-direction. The third type indicates that the sheet's position in the y-direction is not correct, which may be resolved by shifting the sheet in the y-direction.

[0003] When a media sheet is transported through the printer, the orientation and the speed of the sheet can usually be controlled only with limited accuracy, so that registration errors may be induced during the transport of the sheet. It is therefore common practice to check the sheet for registration errors immediately before it is fed to the print station. If necessary, the registration error is corrected by appropriately rotating the sheet in case of a skew error and by accelerating or decelerating the sheet in case of a z-registration error. Y-correction may be done be shifting the sheet in the lateral y-direction.

[0004] The steering mechanism for correcting the skew error may for example be formed by two sets of pinch rollers that are spaced apart in the direction transverse to the transport direction z and can be controlled to drive the sheet with differential speed, so that the sheet is rotated about an axis normal to the plane of the sheet. Another pinch roller is required upstream of the steering mechanism in order to feed the sheet to the steering mechanism before the sheet transport is taken over by the pinch rollers of the steering mechanism. The upstream pinch roller must be configured as a liftable pinch that is capable of temporarily releasing the sheet in order to allow for the rotation of the sheet under the control of the steering mechanism. It will be appreciated that any pinch roller may be formed of two or more sets of pinch rollers that are spaced apart in the direction transverse to the transport direction z.

[0005] In a duplex printer, registration errors may of course be induced also while the sheets are transported through the duplex loop. It has therefore been common practice to merge the duplex loop with the sheet supply path at a position upstream of the liftable pinch, so that the same liftable pinch and the same steering mechanism can be used for the sheets that are fed to the print station for the first time and also for the sheets that return from the duplex loop.

[0006] It is an object of the invention to provide a method of correcting registration errors which allows for a higher productivity of a duplex printer.

[0007] In order to achieve this object, in the method according to the invention, the sheets that are returned via the duplex loop are fed to the print station via a second liftable pinch and without passing through the first liftable pinch again, and the liftable pinches are operated independently of one another.

[0008] The invention is based on the observation that the time that it takes a liftable printer to be lifted and to be closed again in order to release and grip a media sheet is a factor that significantly limits the productivity of a duplex printer. The reason is that the liftable pinch has to remain open until the skew correction, i.e. the rotation of the sheet, has been completed. On the other hand, the pinch has to be closed in order to be able to take over the transport of the next sheet as soon as it arrives. Since it takes time to move the liftable pinch from the lifted position to the closed position, a considerable gap must be provided between the trailing edge of the first sheet, of which the skew error has been corrected, and the leading edge of the subsequent sheet. Since the transport speed of the sheets is also limited, a large gap between the sheets means that only a small number of sheets can be processed in a given time period.

[0009] In the method according to the invention, when

a skew correction has to be performed for a sheet that returns from the duplex loop, the second liftable pinch must be open, but the first liftable pinch can be closed already so that it can take-over the transport of the next sheet as soon as it arrives. Similarly, when a skew correction is performed for a sheet supplied via the supply path and via the first liftable pinch, this first liftable pinch must be open, but the second liftable pinch may be closed already so as to be ready to take over the next sheet from the duplex loop. Consequently, the sheets returning from the duplex loop may be inserted in the stream of sheets arriving via the sheet supply path in close succession, with only very little gaps between subsequent sheets while the sheets are moved through the print station. In this way, the time delays that have been caused by the operations of opening and closing the liftable pinch can be eliminated almost completely, so that the productivity is increased significantly.

[0010] A duplex printer configured for carrying out the method that has been described above is also subject of the invention. The duplex printer comprises:

- a print station,
- a sheet supply path for feeding media sheets to the print station in a transport direction,
- a duplex loop for returning sheets from a downstream side to an upstream side of the print station;
- a first liftable pinch arranged in the sheet supply path;
- a detection system arranged for detecting registration errors of media sheets supplied to the print station; and
- a steering mechanism disposed upstream of the print station for correcting registration errors of the media sheets, and
- a second liftable pinch disposed in the duplex loop at a position upstream of a merging point where the duplex loop merges with the sheet supply path.

The duplex printer is configured for performing the method according to the present invention. When a skew correction has to be performed for a sheet that returns from the duplex loop, the duplex printer controls the second liftable pinch to be open after keeping the first liftable pinch closed so that the first liftable pinch can transport the sheet for take-over by the steering mechanism. Similarly, when a skew correction is performed for a sheet supplied via the supply path and via the first liftable pinch, this first liftable pinch is controlled to be open, while the second liftable pinch may be closed so as to be ready to take over the next sheet from the duplex loop. Consequently, the sheets returning from the duplex loop may be inserted in the stream of sheets arriving via the sheet supply path in close succession, with only very little gaps between subsequent sheets while the sheets are moved through the print station. In this way, the time delays that have been caused by the operations of opening and closing the liftable pinch can be eliminated completely, so that the productivity is increased significantly.

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

[0012] In a preferred embodiment, a common steering mechanism may be used for the sheets arriving via the supply path and also for the sheets arriving from the duplex loop. This not only simplifies the construction and reduces the space requirement but has also the advantages that the steering mechanism can be arranged right at the entry of the print station, which reduces the risk that a new registration error is produced on the way of the sheet from the steering mechanism to the print station.

[0013] In an embodiment, the printer according to the present invention further comprises a controller configured to control a switch positioned at the merging point such that at the print station sheets supplied from the supply path alternate with sheets supplied from the duplex loop. The switch is configured to selectively direct sheets from one of the supply path and the duplex loop to the print station. To achieve high productivity duplex printing, unprinted or blank sheets from the supply path are therein alternated with one-side (or simplex) printed sheets from the duplex loop. This is so-called interweaving of sheets results in an alternating or interchanging stream of blank and simplex printed sheets passing along the print station. Therein a blank sheet is directly followed by a simplex printed sheet which in turn is directly followed by another blank sheet. This latter blank sheet is then directly followed by another simplex printed sheet, etc. It will be appreciated that this alternating sheet stream may be locally interrupted by pairs (or larger numbers) of consecutive blank or simplex printed sheets. The present invention achieves highly productive duplex printing in a compact printer by alternately lifting the liftable pinches.

[0014] In another embodiment, the controller is further configured to:

- open the first liftable pinch when and/or while the switch is positioned to transport a first sheet from the sheet supply path to the print station; and
- open the second liftable pinch when and/or while the switch is positioned to transport a second sheet from the duplex loop to the print station.

An unprinted first sheet passes via the first liftable pinch via the switch towards the print station. Initially, the first liftable pinch is closed to drive the first sheet into engagement with the steering mechanism. After the steering mechanism takes over the driving of the first sheet, the controller opens first liftable pinch. The first sheet is then engaged solely by the steering mechanism and can thus be rotated or shifted in the y- and/or z-direction. While the first liftable pinch is open and the steering mechanism drives and adjusts the skewing and/or position of the sheet, the second liftable pinch is closed to drive the second sheet towards the steering mechanism, such that the second sheet directly and preferably closely follows

the first sheet on its way to the print station. After the second liftable pinch has driven the second sheet into engagement with the steering mechanism, the second liftable pinch may be opened if a registration error of the second sheet requires correcting. The second sheet directly following the first sheet is then engaged solely by the steering mechanism which drives and adjusts the second sheet's skewing and/or position. Simultaneously, the first liftable pinch may be closed after the trailing edge of the first sheet has passed the first liftable pinch. Thereby, the first liftable pinch may receive a third blank sheet and drive this third sheet into engagement with the steering mechanism directly following the second sheet. The process mutatis mutandis may be repeated for additional sheets following the third sheet. It will be appreciated that a respective liftable pinch need only be opened in case the detection system determines that a registration error of a respective sheet requires correcting.

[0015] In a further embodiment, the controller is further configured to:

- open the first liftable pinch while the steering mechanism corrects a registration error for the first sheet; and
- open the second liftable pinch while the steering mechanism corrects a registration error for the second sheet.

Preferably, each respective liftable pinch is opened after a sheet from said liftable pinch is engaged and driven by the steering mechanism. The respective liftable pinch is maintained in its open state at least for the duration of the registration error correction. Preferably, the respective liftable pinch is kept open until the trailing edge of a sheet passes by said liftable pinch.

[0016] In an embodiment the controller is further configured to:

- close the first liftable pinch after a first sheet leaves the first liftable pinch and while the second sheet passes through the closed second liftable pinch, wherein the second sheet is positioned directly upstream of the first sheet in a stream of sheets moving towards the print station. The liftable pinches are operated roughly out-of-phase with respect to one another. When the first liftable pinch is open to allow registration correction on a first sheet, the second liftable is closed to drive a second sheet to directly follow behind the first sheet. And vice versa: in an embodiment, the controller is further configured to:
- close the second liftable pinch after the second sheet leaves the second liftable pinch and while a third sheet passes through the closed first liftable pinch, wherein the third sheet is positioned directly upstream of the second sheet in a stream of sheets moving towards the print station.

It will be appreciated that each liftable pinch is controlled independent of the other, so that variations in sheet size and inter-sheet spacing can be easily accommodated by the printer according to the present invention.

[0017] An embodiment example will now be described in conjunction with the drawings, wherein:

Fig. 1 is a schematic sectional view of a duplex printer configured for carrying out the method according to the invention;

Fig. 2 is a plan view of essential parts of the printer shown in Fig. 1 and illustrates a process of skew error correction; and

Fig. 3 is a sectional view corresponding to Fig. 1 but showing the printer in a different operational state.

[0018] The printer shown in Fig. 1 has a sheet supply path 10, a print station 12, a sheet discharge path 14, and a duplex loop 16 including a sheet flip mechanism 18. The sheet supply path 10 is arranged to supply media sheets 20 successively to and past the print station 10 where an image is printed on the top side of each media sheet passing through. When a media sheet has moved past the print station 12 for the first time and an image has been formed on a front side of the sheet, a switch 22 deflects the sheet into the duplex loop 16 which, in the example shown, is capable of accommodating a plurality of media sheets 20 at a time. The orientation of the media sheet is inverted in the sheet flip mechanism 18, and then the sheet is returned back to a point upstream of the print station 12 where the duplex loop 16 merges with the sheet supply path 10; so that another image can be printed on the back side of the sheet.

[0019] The sheet supply path 10 includes a pinch 24 formed by at least two pinch rollers forming a nip through which the media sheets 20 pass through. At least one of the pinch rollers is driven for rotation so that the media sheets are advanced in a transport direction z towards the print station 12.

[0020] A first liftable pinch 26 is arranged in the sheet supply path 10 in a position downstream of the pinch 24. The distance between the pinches 24 and 26 in the transport direction z is smaller than the length of the media sheets 20 in that direction, so that the leading edge of the sheet 20 can be clamped in the liftable pinch 26 before the trailing edge of that sheet has left the pinch 24. Accordingly, a continuous transport of the media sheets can be assured.

[0021] A detection system 28 and a steering mechanism 30 are arranged downstream of the point where the duplex loop 16 merges with the sheet supply path 10. The detection system 28 is arranged to detect the arrival of the leading edge of each media sheet 20 in at least two positions that are offset in the direction normal to the plane of the drawing in Fig. 1, so that it is possible to detect not only the timing at which the leading edge of

the sheet arrives but also a possible skew angle of the sheet. Further, the detection system 28 is configured to detect the lateral position of the sheet 20, e.g. by a lateral array of optical sensor-detector pairs. In this way, the detection system 28 is capable of detecting any possible registration error of the media sheets 20, which error may be expressed in term of an z-position error, y-position error, and/or a skew angle error. In an advantageous embodiment, the detection system 28 is positioned downstream of the steering mechanism 30, such that the sheet 20 is detected when it is already passing through the steering mechanism 30. The detection system 28 is e.g. positioned between the steering mechanism 30 and the print station 12. This allows the steering mechanism 30 to be positioned close to the merging point between the sheet supply path 10 and the duplex loop 16, resulting in an even compacter system.

[0022] If a registration error has been detected, an electronic control system (not shown) controls the steering mechanism 30 so as to correct the registration error immediately before the leading edge of the sheet enters into the print station.

[0023] As is shown in Fig. 2, the steering mechanism 30 is constituted by two pairs of pinch rollers 32 which are offset relative to one another in a lateral direction y of the sheet transport path. The two pairs of pinch rollers 32 can be driven for rotation independently of one another so as to cause a rotation of the media sheets 20 about an axis that is normal to the directions y and z. The pinch rollers 32 can be briefly synchronously accelerated or decelerated to momentarily adjust adjust the velocity of the sheet 20 and thereby its relative z-position. By driving the pinch rollers 32 at different angular velocities and/or different angles with respect to the z-direction, the sheet 20 may be shifted in the y-direction, thereby allowing a correction of an error in the y-position of the sheet 20.

[0024] Fig. 2 also shows the positions of two optical sensors 28a and 28b which constitute the detection system 28. If the media sheet 20 that is being supplied to the detection system 28 and to the steering mechanism 30 is subject to a skew error, as has been indicated in dashed lines in Fig. 2, this error is detected by the detection system 28, and the steering mechanism 30 is controlled to rotate the sheet into the position that has been shown in continuous lines in Fig. 2, so as to correct the skew error. Similarly, errors in the z-position and the y-position of the sheet 20 may be corrected.

[0025] The detection system 28 and the steering mechanism 30 are also capable of detecting and correcting a z-registration error (an advance or delay in the timing at which the leading edge of the sheet reaches the print station 12) by decelerating or accelerating the sheet.

[0026] In this example, the liftable pinch 26 is also constituted by two pairs of pinch rollers 26a and 26b which are driven for (synchronous) rotation. Further, one roller of each pair can be lifted into the position shown in Fig. 1, so that the media sheet is released and is free to move in the nip between the pinch rollers. Note that this measure need only be applied for sheets 20 of sufficient length in the z-direction. For sheets 20 shorter than the distance between respectively the pinches 26, 36 and the steering mechanism 30, the pinches 26, 36 may be controlled to stay closed to further improve productivity.

[0027] The distance between the liftable pinch 26 and the steering mechanism 30 in the direction z is smaller than the length of the media sheet 20 in that direction, so that the steering mechanism 30 can take over the transport of the media sheet immediately before the liftable pinch 26 loses grip of the trailing edge of the sheet.

[0028] In the condition shown in Fig. 1, the first liftable pinch 26 is in the lifted (open) position so as to release the trailing edge of the media sheet 20 and not to compromise the correction of a possible skew error.

[0029] As is further shown in Fig. 1, the leg of the duplex loop 16 between the sheet flip mechanism 18 and the point where the duplex loop merges with the sheet supply path 10 includes also a fixed pinch 34 and, at a suitable distance downstream thereof, a liftable pinch 36. It will be appreciated that within the present invention, the pinches 24, 34 may further be configured as liftable pinches 24, 34 operating in accordance with their respective one of the liftable pinches 26, 36.

[0030] In a preferred mode of operation, the media sheets 20 are supplied via the sheet supply path 10 in a sequence in which the gaps between two sheets is only minimally larger than the length of an individual sheet in the transport direction z, the print station 12 is controlled to print a front side image on each of the sheets that are supplied from the supply path 10, and the switch 22 is controlled to divert these sheets into the duplex loop 16. Consequently, the sheets that return from the duplex loop are inserted into the stream of media sheets from the supply path 10 so as to fill the gaps between these sheets. The print station 12 is controlled to print a back side image on each of the sheets that have returned from the duplex loop 16, and the switch 22 is controlled to direct these sheets, which then bear an image on both sides, into the sheet discharge path 14.

[0031] In the situation shown in Fig. 1, the steering mechanism 30 and the liftable pinch 26 are controlled to perform a registration error correction for a sheet 20 that has been supplied via the sheet supply path 10. Fig. 3 illustrates a situation in which a media sheet 20' is just being inserted into the gap between two sheets fed from the supply path 10. The leading edge of the sheet 20' has passed the detection system 28 and has reached the steering mechanism 30, so that registration errors can be corrected in the same manner as has been described above in conjunction with Fig. 2. Although the sheet 20' is slightly bent at the point of merger of the duplex loop and the supply path 10, the deflection angle is so small that the trailing part of the sheet 20 is still capable of swiveling in the lateral direction when a skew angle has to be corrected. The second liftable pinch 36 is in the lifted (open) position so as not to compromise the skew error correction. Meanwhile, however, the first

liftable pinch 26 has time enough to return into the closed position so that the transport of the next sheet arriving on the supply path 10 can be taken over as soon as the leading edge of that sheet reaches the pinch 26. Consequently, since the liftable pinch 26 is already in the required position, the gap between the trailing edge of the sheet 20' and the leading edge of the next sheet arriving from the supply path 10 can be made extremely small. A further advantage is that the steering mechanism 30 may be positioned closely to the turn in the duplex loop 16. This aids in reducing the friction on the sheet 20 as it is being rotated by the steering mechanism 30 in a skew correction operation.

[0032] Conversely, when the registration error of the sheet 20' has been corrected, the second liftable pinch 36 can return into the closed position so that it will be ready to take-over as soon as the next sheet arrives from the sheet flip mechanism 18.

Claims

1. A method of correcting registration errors of media sheets (20; 20') that are fed to a print station (12) in a duplex printer via a first liftable pinch (26) and a steering mechanism (30), the first liftable pinch (26) being arranged in a sheet supply path (10) upstream of the steering mechanism (30), the method comprising:

- for each sheet (20) fed to the print station (12) via the supply path (10), a step of checking the sheet for registration errors and, if a registration error is detected, lifting the first liftable pinch (26) and operating the steering mechanism (30) so as to rotate the sheet; and
- for a fraction of the sheets (20'), when an image has been printed on a first side of the sheet, returning the sheet via a duplex loop (16) and feeding it again to the print station (12), again with registration error correction,

characterized in that the sheets (20') that are returned via the duplex loop (16) are fed to the print station (12) via a second liftable pinch (36) without passing through the first liftable pinch (26) again, and the liftable pinches (26, 36) are operated independently of one another.

2. The method according to claim 1, wherein the print station (12) and a switch (22) for deflecting the sheets into the duplex loop (16) are controlled such that, at the print station (12), sheets supplied from the supply path (10) alternate with sheets (20') supplied from the duplex loop (16).

3. A duplex printer comprising:

- a print station (12),
- a sheet supply path (10) for feeding media sheets (20) to the print station (12) in a transport direction (z),
- a duplex loop (16) for returning sheets from a downstream side to an upstream side of the print station (12);
- a first liftable pinch (26) arranged in the sheet supply path (10);
- a detection system (28) arranged for detecting registration errors of media sheets supplied to the print station (12); and
- a steering mechanism (30) disposed upstream of the print station (12) for correcting registration errors of the media sheets,

characterized by further comprising a second liftable pinch (36) disposed in the duplex loop (16) at a position upstream of a merging point where the duplex loop (16) merges with the sheet supply path (10).

4. The printer according to claim 1, wherein the steering mechanism (30) is arranged between the print station (12) and the merging point.

5. The printer according to claim 4, wherein the detection system (28) is arranged between the steering mechanism (30) and the merging point.

6. The printer according to claim 4, wherein the detection system (28) is arranged between the steering mechanism (30) and the print station (12).

7. The printer according to any of the claims 3 to 6, further comprising a controller configured to control a switch (22) positioned at the merging point, such that at the print station (12) sheets supplied from the supply path (10) alternate with sheets (20') supplied from the duplex loop (16).

8. The printer according to claim 7, wherein the controller is further configured to:

- open the first liftable pinch (26) while the switch (22) is positioned to transport a first sheet (20) from the sheet supply path (10) to the print station (12); and
- open the second liftable pinch (36) while the switch (22) is positioned to transport a second sheet (20) from the duplex loop (16) to the print station (12).

9. The printer according to claim 8, wherein the controller is further configured to:

- open the first liftable pinch (26) while the steering mechanism (30) corrects a registration error

for the first sheet (20); and
- open the second liftable pinch (36) while the steering mechanism (30) corrects a registration error for the second sheet (20).

9. The printer according to claim 8 or 9, wherein the controller is further configured to:

- close the first liftable pinch (26) after a first sheet (20) leaves the first liftable pinch (26) and while the second sheet (20) passes through the closed second liftable pinch (36), wherein the second sheet (20) is positioned directly upstream of the first sheet (20) in the stream of sheets (20) moving towards the print station (12).

10. The printer according to claim 8, wherein the controller is further configured to:

- close the second liftable pinch (36) after the second sheet (20) leaves the second liftable pinch (26) and while a third sheet (20) passes through the closed first liftable pinch (26), wherein the third sheet (20) is positioned directly upstream of the second sheet (20) in the stream of sheets (20) moving towards the print station (12).

Fig. 1

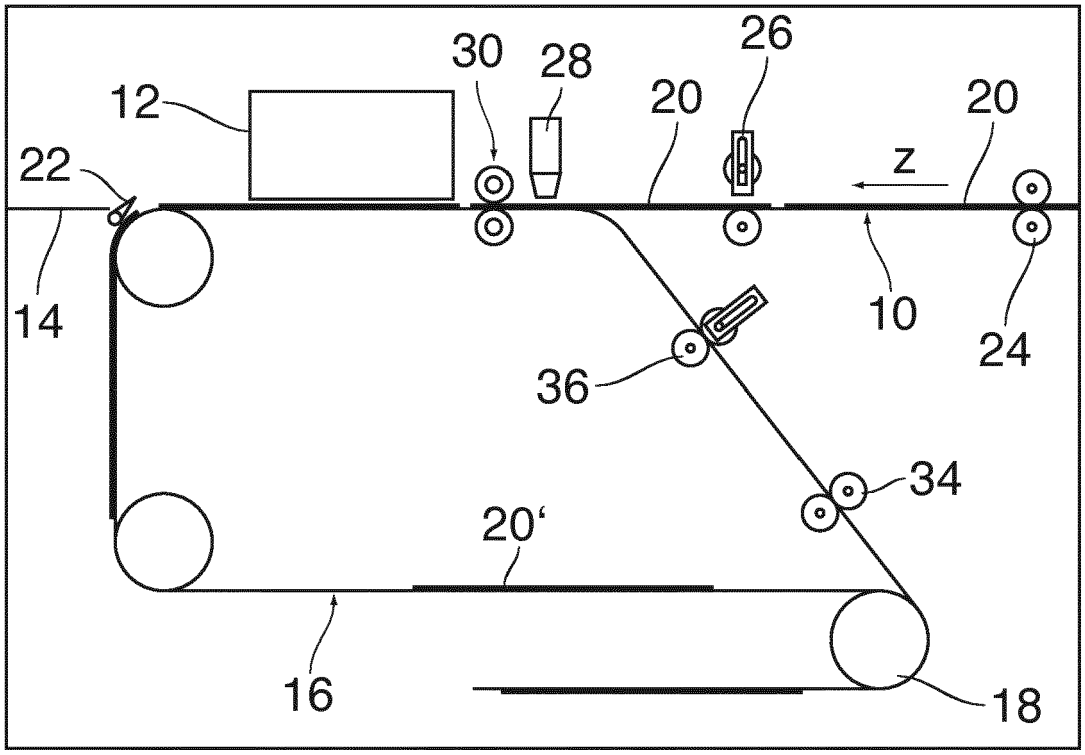
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Fig. 2

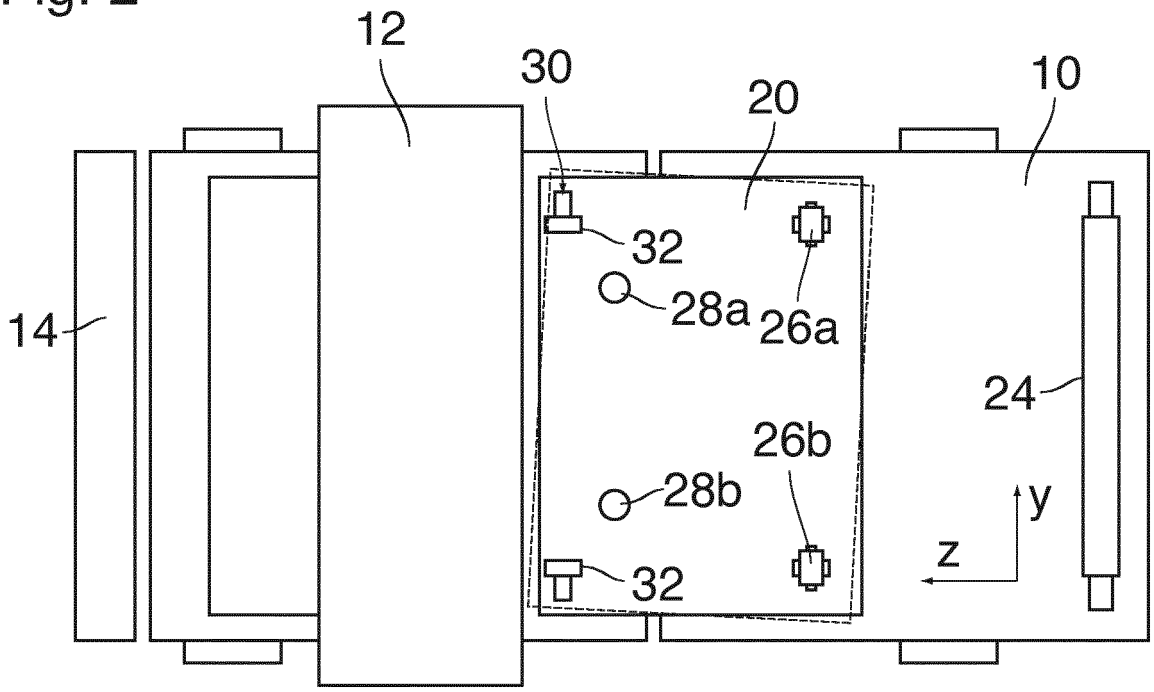
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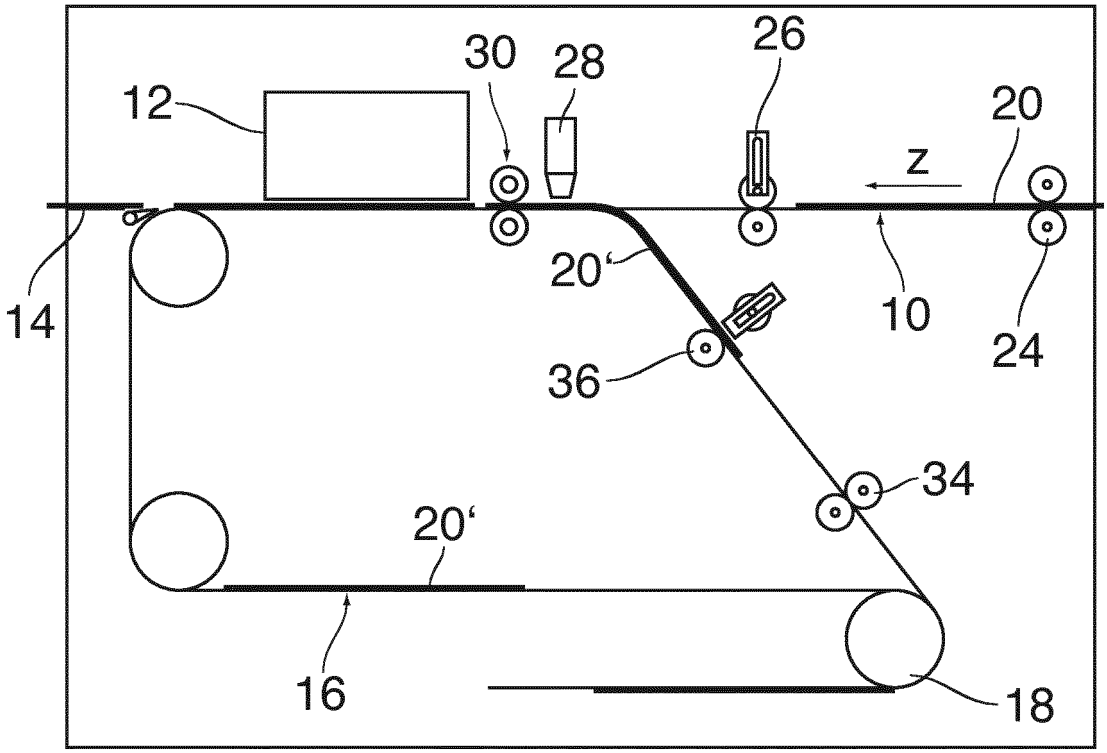
Fig. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 18 15 7369

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

G03G
B65H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	16 August 2018	Herbreteau, D

CATEGORY OF CITED DOCUMENTS

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