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(54) **DEFORMATION DETECTION FOR PRINT MEDIA**

(57) An apparatus (20) for deformation detection in a sheet printing system (1) comprising a sheet quality detection device (21) configured for sensing sheets (S) on a transport path (PP). The sheet quality detection device (21) comprises an emitter (23) for emitting an emission beam (B) towards a sheet (S) on the sheet sensing transport path (PP). The emitter (23) is mounted on a support beam (25B) extending laterally over a width of the sheet sensing transport path (PP). Adjusting means (24, 24') allow for adjusting and setting an angle (α) between the support beam (25B) and a plane (32) of the sheet sensing transport path (PP). By tilting the support beam (25B), the angle (α) of the optical beam (B) may be easily and accurately adjusted to align the optical beam (B).

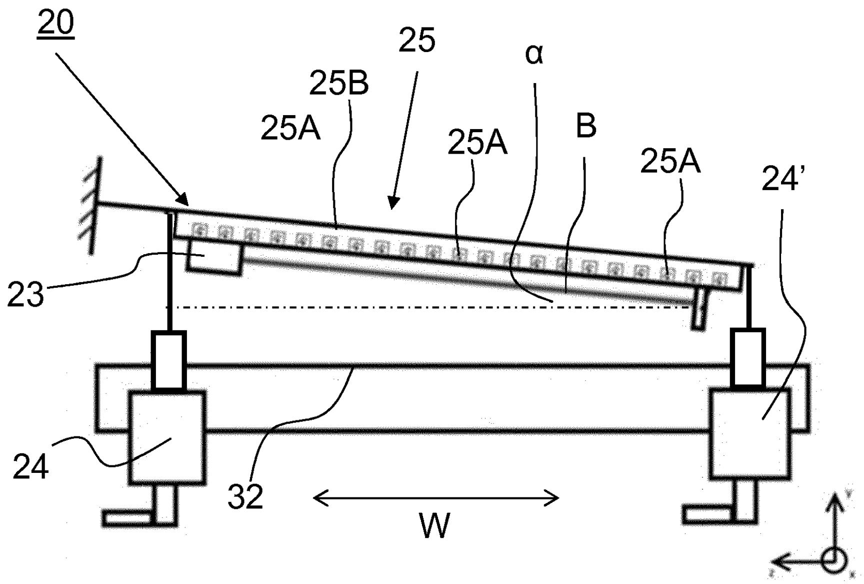

Fig. 3B

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Description

FIELD OF THE INVENTION

[0001] The present invention generally pertains to a printing system, an apparatus for deformation detection in a printing system, and a method for calibrating such an apparatus.

BACKGROUND ART

[0002] One or more deformations present within a sheet of a medium to be printed can cause serious reliability problems in a printing system, such as an inkjet printing system, where there is only a small gap between a sheet transport mechanism and an image forming device or printing head of the printing system. If the sheet to be printed touches the image forming device or the printing head as a result of such a deformation, this can lead to print quality degradation and/or to a sheet jam in the machine. To achieve high print quality in an inkjet printing system, the distance between the printing heads and sheet to be printed should be kept small. Because of this small distance (print gap) the print heads are easily touched by the sheets as they pass. Accordingly, even small deformations like dog ears, wrinkles, tears etc. can cause a so-called "head touch", which can degrade print quality, cause nozzle failure, or even sheet jams.

[0003] To address these issues, systems have been developed which employ a proofing device capable of identifying sheet deformations and rejecting sheets that contain such deformations. EP 3017948 A1 discloses such a proofing device with a height adjustable beam emitter. US 8,419,144 B2 further discloses such a proofing device, wherein multiple emitters are positioned alongside a transport path of the printing system, such that the emitters emit optical beams over the surface of the medium. For accurate sensing, the optical beams must be aligned parallel to the medium support surface which carries the sheets. Manually aligning each of the emitters is however a cumbersome and time consuming process, while improper alignment reduces the accuracy of the apparatus.

SUMMARY OF THE INVENTION

[0004] It is an object of the present invention to provide a productive and accurate apparatus and method for calibrating such an apparatus.

[0005] Thereto, the present invention provides an apparatus according to claim 1 and a method according to claim 13.

[0006] In a first aspect, the present invention provides an apparatus for deformation detection in a sheet printing system. The apparatus comprises:

- a sheet sensing transport path;
- a sheet quality detection device positioned along the sheet sensing transport path and configured for sensing sheets on the sheet sensing transport path, the sheet quality detection device comprising an emitter for emitting an emission beam over the sheet sensing transport path and a sensor assembly for detecting at least part of the emission beam;
- a support beam extending laterally over a width of the sheet sensing transport path, wherein the sheet quality detection device is mounted on the support beam;
- adjusting means for adjusting and setting an angle between the support beam and a plane of the sheet sensing transport path.

[0007] The support beam preferably extends from one lateral side of the sheet sensing transport path to the other. The emitter is rigidly attached to the support beam. The adjusting means allow the support beam to be tilted with respect to the sheet sensing transport path. The support beam and the optical beam emitted by the emitter move synchronously. The orientation of the optical beam can then be adjusted by tilting the support beam with respect to the plane of the sheet sensing transport path. Due to its relatively long length, tilting the support beam allows for a much more accurate setting of the optical beam's angle with respect to the transport path than e.g. by directly tilting the emitter. The aligning of the optical beam can thus be performed faster, more easily and with greater accuracy as compared to the prior art. Thereby, the object of the present invention has been achieved.

[0008] In an embodiment, the emitter is rigidly attached to the support beam. Thereby, the orientation of the optical beam emitted by the emitter with respect to the longitudinal direction of the support beam is fixed. The optical beam moves with the support beam.

[0009] The adjusting means are configured for tilting the support beam with respect to the plane of the sheet sensing transport path. By tilting the support beam, the angle between the optical beam and the sheet sensing transport path changes. An exact angle between the support beam and the optical beam of the emitter need not be known as long as both devices move together as a single unit. Actuating the support beam is then sufficient for re-orienting the optical beam into proper alignment.

[0010] In a further embodiment, the emitter is positioned on a first lateral side of the transport path and configured to emit the emission beam over the transport path to a second lateral side of the transport path. The emission beam thus travels over the width of the transport path and over the width of a sheet on the transport path (assuming the sheet is deformation free). The emission beam may be positioned at an angle with respect to the sheet transport direction of the transport path, though a perpendicular configuration is preferred to keep the system compact. The present invention allows for accurate alignment of emission beam's path parallel to the plane of the transport path (or of a sheet on said path).

[0011] In an embodiment, the sensor assembly is positioned with respect to the emitter, such that when a deformation in the sheet comes into contact with emission beam the sensor assembly detects a change in a received intensity (the portion or intensity of the emission beam reaching the sensor assembly changes). When a deformation is sufficiently large to enter the emission beam, the amount of emission beam reaching the sensor assembly changes. The presence of a deformation larger than a predetermined threshold height can thus be derived from a change in the emission beam intensity being received by the sensor assembly. Such a change may be a drop or rise in the detected intensity. In one example the sensor assembly is positioned opposite the emitter (i.e. on the opposite side of the transport path), such that when a sufficiently large deformation blocks part of the emission beam from reaching the sensor assembly, this results in a drop in detected intensity. In a preferred example, the sensor assembly is positioned over the transport path to receive light from the emission beam substantially only when light is reflected to the sensor assembly from a sufficiently large deformation positioned inside the emission beam.

[0012] In another embodiment, the adjusting means comprise an actuator moveable perpendicular to the plane of the sheet sensing transport path for adjusting the angle.

[0013] The actuator engages the support beam preferably at one side or end of the support beam. By raising or lowering a portion of the support beam with respect to the sheet sensing transport path, the support beam is tilted. Thereby, the angle of the optical beam is altered. The actuator preferably comprises a drive or motor for accurately positioning the attached portion of the support beam at a predefined height over the sheet sensing transport path. A controller may be provided to control the actuator, such that the optical beam may be tilted into alignment without manual interference and with high accuracy.

[0014] In a preferred embodiment, the adjusting means comprise a pair of actuators positioned at opposite ends of the support beam with respect to one another. A first height adjustment actuator engages a first end of the support the beam while a second height actuator is attached to or near the other end. Preferably, the pair of actuators are independently moveable with respect to one another perpendicular to the plane of the sheet sensing transport path for:

- tilting the support beam with respect to the plane of the sheet sensing transport path; and
- setting a height of the emission beam with respect to the plane of the sheet sensing transport path to determine a sheet rejection threshold.

By moving the first actuator with respect to the second actuator the support beam is tilted. This allows for adjustment of the angle of the optical beam. By properly aligning the optical beam parallel to the plane of the sheet sensing transport path an accurate apparatus is achieved. In a printing system, a wide variety of media of different materials and thicknesses are used. It is preferred to set different sheet rejection criteria per media type, e.g. based on their tendency to deform or on their thickness. When the optical beam is aligned parallel to the plane of the sheet sensing transport path, driving both actuators synchronously results in the raising or lowering of the optical beam over the sheet sensing transport path. Thereby, the height of the optical beam may be selected and set for each print job or sheet type passing the apparatus according to the present invention. The height of the relatively narrow optical beam defines the sheet rejection threshold. Sheets with a maximum sheet height below the height of the optical beam do not trigger deformation detection by the apparatus and these sheets are passed to the image forming unit. Only sheets with deformations exceeding the optical beam height come into contact with the optical beam. The intensity of light detected by a detector assembly is then changed. This intensity change triggers the controller to designate the sheet as unsuitable for printing. Unsuitable sheets are preferably removed to prevent these from reaching the image forming unit.

[0015] In another embodiment, the apparatus according to the present invention further comprises a sensor assembly positioned with respect to the emitter, such that:

the emission beam is prevented from reaching the sensor assembly when a sheet on the sheet sensing transport path is suitable for printing; and
at least part of the emission beam is reflected from a sheet on the sheet sensing transport path to the sensor assembly when a deformation in the sheet enters into the emission beam.

The suitability of a sheet is determined from a change in intensity detected by the sensor assembly as the sheet passes the optical beam. An accurate baseline is established by positioning the sensor assembly with respect to the optical beam such that substantially no light from the optical is directed to the sensor assembly when the sensed sheet has a maximum sheet height below the height of the optical beam. Sheets with sufficient height to come into contact with the optical beam result in light being reflected onto the sensor assembly. Per default, the sensor assembly is in the dark resulting in a low or zero intensity base line. When the detected intensity moves away from this base line and passes a predefined minimum intensity level, the controller determines that the sheet being sensed is unsuitable for printing. Thereby, the accuracy is improved further.

[0016] In a further embodiment, the sensor assembly extends laterally over a width of the sheet sensing transport path. The sensor assembly is a page-wide sensor array extending laterally across the sheet sensing transport path. The sensor assembly extends above the sheet sensing transport path, preventing light from reaching the sensor assembly when no sheet is present on the sheet sensing transport path.

[0017] In a preferred embodiment, the sensor assembly is mounted on the support beam. The support beam has a lateral width greater than the width of the sheet sensing transport path. Preferably the sensor assembly comprises a plurality of sensor units positioned along a length of the support beam. A lateral array of photosensitive devices is mounted onto the support beam facing the sheet sensing transport path. The emitter is preferably positioned near an end of the support beam. The support beam thus holds both the emitter and the sensor assembly resulting in a compact apparatus.

[0018] In an embodiment, the apparatus according to the present invention further comprises: a processor to determine the suitability of the sheet for printing from sensor data generated by the sensor assembly and representative of a deformation in the sheet; wherein the controller is configured for controlling further progress of the sheet along the transport path in dependence of the determined sheet's suitability for printing;

a removal device for removing the sheet from the transport path of the printing system, wherein the controller is configured to control the removal device to remove the sheet from the transport path if the processor determines the sheet to be unsuitable for printing.

The sensor assembly transmits data to the processor, which in an example compares the detected intensity to a minimum intensity threshold. If said intensity threshold is exceeded, the processor designates the sheet as unsuited for printing. The controller then operates the removal device to remove the respective sheet from the transport path of the printing system to a rejected sheet holder. Printing may thus continue uninterrupted and productivity is increased.

[0019] In a further aspect, the present invention provides a printing system comprising the apparatus according to the present invention.

[0020] In a further aspect, the present invention provides a method for calibrating an apparatus for detecting deformations in sheets in a printing system, the apparatus comprising an emitter for emitting an emission beam over a sheet sensing transport path, the method comprising the steps of:

- positioning a calibration structure with a predefined height on a first lateral side of the sheet sensing transport path;
- moving the emitter perpendicular to the sheet sensing transport path with the calibration structure on its first side;
- determining a first height parameter of the emitter when detecting a variation in an intensity of the detected emission beam;
- positioning the calibration structure with a predefined height on a second lateral side of the sheet sensing transport path;
- moving the emitter perpendicular to the sheet sensing transport path with the calibration structure on its second side;
- determining a second height parameter of the emitter when detecting a variation in an intensity of the detected emission beam;
- comparing the first and second height parameters to determine an angle for aligning the emission beam with respect to the sheet sensing transport path.

The calibration structure has a predefined height when supported on the medium support surface of the sheet sensing transport path. First, the calibration structure is positioned to one side of the middle of the sheet sensing transport path, preferably near or at the lateral edge of the sheet sensing transport path. Next, the emitter is moved in the height direction. When the optical beam passes the top of the calibration structure the light intensity detected by the sensor assembly changes. The height of the emitter at that moment is determined and stored in the controller's memory. Next, the calibration structure is moved to the other lateral side of the sheet sensing transport path. The emitter is activated and then moved up or down perpendicular to the sheet sensing transport path. Again, the change in light intensity is determined by the sensor assembly and the corresponding height of the emitter stored. The height values are compared to one another to determine the angle of the optical beam. This determined angle is then compared to a desired predefined range to see whether adjustment of the optical beam is required. If not, the optical beam is properly aligned. If yes, the emitter is tilted in correspondence to the determined angle to align the optical beam. As such, an easy method for aligning an optical emitter in an apparatus according to the present invention is provided.

[0021] In an embodiment, the method according to the present invention further comprises tilting the emitter such that when in use the emission beam extends parallel to the sheet sensing transport path. The comparison between the height parameters may yield an angular difference by which the optical beam is angled with respect to the sheet sensing transport path. The optical beam may then be aligned by tilting the emitter in correspondence to said angular difference. In another embodiment, the method according to the present invention further comprises the step of detecting a deformation in a sheet passing into the emission beam and qualifying the sheet as unsuitable for printing.

[0022] Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating embodiments of the invention, are given by way of illustration only, since various changes and modifications within the scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The present invention will become more fully understood from the detailed description given herein below and the accompanying schematical drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

Fig. 1 shows a schematic representation of an inkjet printing system for printing sheets;
Fig. 2 shows a schematic top view of an apparatus for deformation detection in a printing system according to the present invention;
Fig. 3 shows a schematic side view of the apparatus in Fig. 2 with: A) an aligned optical beam and B) a tilted optical beam;
Fig. 4A and B show schematic representations of the steps of a method for aligning the apparatus in Figs 2, 3A, and 3B.

DETAILED DESCRIPTION OF THE DRAWINGS

[0024] The present invention will now be described with reference to the accompanying drawings, wherein the same reference numerals have been used to identify the same or similar elements throughout the several views.

Printing process

[0025] A printing process in which the inks according to the present invention may be suitably used is described with reference to the appended drawings shown in Fig. 1. Fig. 1 shows a schematic representation of an inkjet printing system 1.

[0026] Fig. 1 shows that a sheet of a receiving medium, in particular a machine coated medium, P, is transported in a direction for conveyance as indicated by arrows 50 and 51 and with the aid of transportation mechanism 12. Transportation mechanism 12 may be a driven belt system comprising one (as shown in Fig. 1) or more belts. Alternatively, one or more of these belts may be exchanged for one or more drums. A transportation mechanism may be suitably configured depending on the requirements (e.g. sheet registration accuracy) of the sheet transportation in each step of the printing process and may hence comprise one or more driven belts and/or one or more drums. For a proper conveyance of the sheets of receiving medium, the sheets need to be fixed to the transportation mechanism. The way of fixation is not particularly limited and may be selected from electrostatic fixation, mechanical fixation (e.g. clamping) and vacuum fixation. Of these vacuum fixation is preferred.

[0027] The printing process as described below comprises of the following steps: media pre-treatment, image formation, drying and fixing and optionally post treatment.

Media pre-treatment

[0028] To improve the spreading and pinning (i.e. fixation of pigments and water-dispersed polymer particles) of the ink on the receiving medium, in particular on slow absorbing media, such as machine coated media, the receiving medium may be pretreated, i.e. treated prior to printing an image on the medium. As an application way of the pre-treatment liquid, any conventionally known methods can be used. Specific examples of an application way include: a roller coating, an ink-jet application, a curtain coating and a spray coating. There is no specific restriction in the number of times with which the pre-treatment liquid is applied. It may be applied at one time, or it may be applied in two times or more. Application in two times or more may be preferable, since cockling of the coated printing paper can be prevented and the film formed by the surface pre-treatment liquid will produce a uniform dry surface having no wrinkle by applying in 2 steps or more.

[0029] Especially a roller coating (see 14 in Fig. 1) method is preferable because this coating method does not need to take into consideration of ejection properties and it can apply the pre-treatment liquid homogeneously to a recording medium.

[0030] Fig. 1 shows that the sheet of receiving medium S may be conveyed to and passed through a first pre-treatment module 13, which module may comprise a pre-heater, for example a radiation heater, a corona/plasma treatment unit, a gaseous acid treatment unit or a combination of any of the above. Optionally and subsequently, a predetermined quantity of the pre-treatment liquid is applied on the surface of the receiving medium S at pre-treatment liquid applying member 14. Specifically, the pre-treatment liquid is provided from storage tank 15 of the pre-treatment liquid to the pre-treatment liquid applying member 14 composed of double rolls 16 and 17. Each surface of the double rolls may be covered with a porous resin material such as sponge. After providing the pre-treatment liquid to auxiliary roll 16 first, the pre-treatment liquid is transferred to main roll 17, and a predetermined quantity is applied on the surface of the receiving medium S. Subsequently, the coated printing paper S on which the pre-treatment liquid was supplied may optionally be heated and dried by drying member 18 which is composed of a drying heater installed at the downstream position of the pre-treatment liquid applying member 14 in order to decrease the quantity of the water content in the pre-treatment liquid to a predetermined range. It is preferable to decrease the water content in an amount of 1.0 weight% to 30 weight% based on the total water content in the provided pre-treatment liquid provided on the receiving medium S.

[0031] To prevent the transportation mechanism 12 being contaminated with pre-treatment liquid, a cleaning unit (not shown) may be installed and/or the transportation mechanism may be comprised multiple belts or drums as described above. The latter measure prevents contamination of the upstream parts of the transportation mechanism, in particular of the transportation mechanism in the printing region.

Image formation

[0032] Image formation is performed in such a manner that, employing an inkjet printer loaded with inkjet inks, ink droplets are ejected from the inkjet heads based on the digital signals onto a print medium.

[0033] Although both single pass inkjet printing and multi pass (i.e. scanning) inkjet printing may be used for image formation, single pass inkjet printing is preferably used since it is effective to perform high-speed printing. Single pass inkjet printing is an inkjet recording method with which ink droplets are deposited onto the receiving medium to form all pixels of the image by a single passage of a receiving medium underneath an inkjet marking module.

[0034] In Fig. 1, 11 represents an inkjet marking module comprising four inkjet marking devices, indicated with 111, 112, 113 and 114, each arranged to eject an ink of a different color (e.g. Cyan, Magenta, Yellow and blacK). The nozzle pitch of each head is e.g. about 600 dpi. In the present invention, "dpi" indicates a dot number per 2.54 cm.

[0035] Fig. 1 shows that after pre-treatment, the receiving medium S is conveyed to upstream part of the inkjet marking module 11. Then, image formation is carried out by each color ink ejecting from each inkjet marking device 111, 112, 113 and 114 arranged so that the whole width of the receiving medium S is covered.

[0036] Optionally, the image formation may be carried out while the receiving medium is temperature controlled. For this purpose a temperature control device 19 may be arranged to control the temperature of the surface of the transportation mechanism (e.g. belt or drum) underneath the inkjet marking module 11. The temperature control device 19 may be used to control the surface temperature of the receiving medium S, for example in the range of 30°C to 60°C. The temperature control device 19 may comprise heaters, such as radiation heaters, and a cooling means, for example a cold blast, in order to control the surface temperature of the receiving medium within said range. Subsequently and while printing, the receiving medium S is conveyed to the down stream part of the inkjet marking module 11.

Drying and fixing

[0037] After an image has been formed on the receiving medium, the prints have to be dried and the image has to be fixed onto the receiving medium. Drying comprises the evaporation of solvents, in particular those solvents that have poor absorption characteristics with respect to the selected receiving medium.

[0038] Fig. 1 schematically shows a drying and fixing unit 60, which may comprise a heater, for example a radiation heater. After an image has been formed, the print is conveyed to and passed through the drying and fixing unit 60. The print is heated such that solvents present in the printed image, to a large extent water, evaporate. The speed of evaporation and hence drying may be enhanced by increasing the air refresh rate in the drying and fixing unit 60. Simultaneously, film formation of the ink occurs, because the prints are heated to a temperature above the minimum film formation temperature (MFT). The residence time of the print in the drying and fixing unit 60 and the temperature at which the drying and fixing unit 60 operates are optimized, such that when the print leaves the drying and fixing unit 60 a dry and robust print has been obtained. As described above, the transportation mechanism 12 in the fixing and drying unit 60 may be separated from the transportation mechanism of the pre-treatment and printing section of the printing apparatus and may comprise a belt or a drum.

Post treatment

[0039] To increase the print robustness or other properties of a print, such as gloss level, the print may be post treated, which is an optional step in the printing process.

Deformation detection

[0040] With reference now to Fig. 2 of the drawings, the inkjet printing system 1 according to the preferred embodiment of the invention is shown to include an apparatus 20 for detecting deformations in the printing system 1, and particularly for identifying deformations D in the sheets S of print medium when the sheets S are on the transport path or paper path PP of the printing system 1. In this particular embodiment, the apparatus 20 comprises a sensing unit 21, which processes the sheets S on the transport path PP before those sheets S enter the image forming device 11.

[0041] When performing the sensing or measuring of the surface geometry or topology of the sheets S on the transport path PP of printing system 1 with the sensing unit 21, it is highly desirable for the purposes of accuracy and reliability that the sheets S are transported or conveyed in the sensing unit 21 in substantially the same manner as those sheets S are later transported in the image forming unit or inkjet marking module 11. To this end, the sensing unit 21 includes a sheet conveyor mechanism 30 that simulates the sheet transport conditions provided by the transport mechanism within the inkjet marking module 11. In this regard, both the conveyor mechanism 30 and the transport mechanism include a belt transport device 31 with vacuum sheet-holding pressure, as seen in Fig. 2. The transport mechanism 30 comprises a pair of rotatable support rollers 33A, 33B for driving the movement of the endless belt member 31. The belt member 31 is provided with a plurality of vacuum holes or perforations through which air may be sucked to a suction system (not shown). The sheets S are held by suction against the medium support surface 32 of the transport mechanism 30 in a manner identical to that during printing. The manner of transport, i.e. the configuration of the transport mechanism (materials, dimensions, vacuum hole pattern, etc.), the transport speed, and/or the suction force are preferably similar or identical to those in the inkjet marking module 11. Additionally, the sensing unit 21 may comprise atmospheric control means to maintain the atmospheric conditions (such as temperature, humidity, etc.) in the sensing unit 31 similar to those in the inkjet marking module 11.

[0042] The sensing unit 21 comprises an emitter 23 positioned on a lateral side of the sheet sensing transport path PP formed by the belt member 31. The optical emitter 23 is arranged for emitting an optical emission signal or beam B at a predefined height or distance over the medium support surface 32. In Fig. 2, the preferably collimated light beam B is aligned in the lateral direction W. The emitter 23 during operation emits its beam B substantially parallel to the medium support surface 32. The predefined height of the beam B is selected such that said beam B travels unimpeded over the sheet S on the medium support surface 32 when said sheet S is substantially free of deformations (or when said deformations do not exceed a predefined height). However, when a deformation in the sheet S extends sufficiently upwards from the medium support surface 32 to come into contact with the beam B, light from said beam B is reflected or scattered in other directions than the lateral direction W. A portion of the reflected light is then directed upwards.

[0043] To receive a portion of the light reflected of a deformation, the sensing unit 21 comprises a sensor assembly 25 extending in the lateral direction W over the medium support surface 32 of the transport mechanism 30. The sensor assembly 25 comprises at least one first sensor device 25A in the form of an optical sensor 25A, such as an optical line scanner, laser scanner, or light sensitive diode. The sensor assembly 25 is provided within the sensing unit 21 for sensing the surface geometry or topology of the sheets S as they travel on a first pass or a second pass along the transport path PP. The one or more optical sensor devices 25A on the support beam 25B in the sensor assembly 25 generate sensor data indicative of deformations in the three-dimensional surface geometry or topology of each sheet S sensed or scanned. The first sensor devices 25A are positioned beside one another in the lateral direction W. Each first sensor device 25A in this lateral array then corresponds to a lateral range or position (e.g. a portion of the width of transport path PP). When a first sensor device 25A receives light reflected of a deformation, the lateral position (or an indication thereof) of said deformation can be derived from the data generated by the one or more first sensor devices 25A, as the lateral position of the respective first device sensor device 25A is stored in the processor 29.

[0044] The workings of the sensing unit 21 are illustrated in Fig. 3A and 3B. Fig. 3A shows a cross-section of the sensing 21 unit taken perpendicular to the transport direction D. The sheet S is supported on and held against the medium support surface 32 below the support beam 25B. The support beam 25B extends from one side of the sheet sensing transport path PP to the opposite side. The support beam 25B is at least page-wide compared to the sheets S on the sheet sensing transport path PP. The support beam 25B is supported on either lateral side of the medium support surface 32 by actuators 24, 24'. The actuators 24, 24' are configured to move in the height direction Y perpendicular to the medium support surface 32 independently of one another. The controller 28 preferably determines the individual heights of the respective ends of the support beam 25B and controls the actuators 24, 24' to set their respective height accordingly.

[0045] The emitter 23 is rigidly mounted onto the support beam 25B. The angle α between the beam B of the emitter 23 and the medium support surface 32 can be adjusted by controlling the actuators 24, 24'. The emitter 23 is secured to the support beam 25B, so tilting the support beam 25B changes the angle α of the emitter 23. The actuators 24, 24' may be applied for adjusting or setting the height of the emitter 23 with respect to the plane 32 of sheet sensing transport path PP. Both actuators 24, 24' are then driven synchronously to adjust the height of the support beam 25B without changing its angle α. The angle α may be adjusted by asynchronous movement of one end of the support beam 25B with respect to the other, for example by raising or lowering one actuator 24, 24' as compared to the other actuator 24, 24'. A high angular accuracy is achieved by e.g. adjusting the angle α by controlling the actuator 24' remote from the emitter 23. The relatively large lateral distance between the emitter 23 and the actuator 24' allows for precise adjustment of the angle α. Thereby the distance and angle α between the medium support surface 32 and the respective emitted optical beam B, B' may be accurately selected and set.

[0046] The sensor assembly 25 generates data or signals which are transmitted to the processor 29. The processor 29 compares the received data to a light intensity threshold, which when exceeded prompts the processor 29 to send a sheet unsuitability signal to the controller 28. The controller 28 then designates the sensed sheet S as unsuitable for printing. The respective sheet S is then preferably removed from the transport path PP by a removal device 26 controlled by the controller 28. The support beam 25B further supports the sensor assembly 25, which is formed of a lateral array of sensor devices 25A, such as light sensitive diodes 25A, on the support beam 25B. The sensor devices or units 25A form a page-wide sensor array arranged to receive light reflected from deformations D in the sheet S. In Fig. 3A, when a sheet S free of deformations passes the emitter 23, the beam B is able to extend freely through the volume between the sheet S and the sensor assembly 25 without a signal light being received by the sensor assembly 25. Substantially no light from the emitter 23 is directed onto one or more of the first sensor devices 25A of the sensor assembly 25. A signal or intensity below a predefined light intensity threshold then identifies a sheet S as suitable for printing. To improve the accuracy, the sensing unit 21 may be optically shielded to prevent ambient light from entering the sensing unit 21. When the sensor assembly 25 receives no reflected light, the sheet S is deemed suitable for printing and will be passed on to the inkjet marking module 11.

[0047] By controlling the actuators 24, 24' the height of the beam B over the medium support surface 32 is set to its desired value. The height of the emitter 23 and thus of beam B determines the sheet rejection threshold height: sheets S with a maximum sheet height below said height value do not trigger the processor 29 to classify said sheet S as unsuitable for printing and are passed through to the inkjet marking module 11. When a deformation D passes through the beam B set at its predefined height, light is reflected from the deformation D onto the sensor assembly 25. The corresponding data generated by the sensor assembly 25 is transmitted to the processor 29, which, after comparison of the data to a minimum light intensity threshold, classifies the sheet S as unsuited for printing. The processor 29 transmits this classification to the controller 28, which then controls the removal device 26 to remove the sheet S from the transport path PP.

[0048] By controlling the actuators 24, 24' the height of the B over the medium support surface 32 may be set to a desired value. Preferably, the controller 28 sets the sheet rejection threshold height of the emitter 23, and thus of the optical beam B, at the start of a print job in correspondence to received print job settings. Thereby, the sheet rejection threshold may be adjusted to the specific conditions of the print job, such as the media type used.

[0049] To prevent unsuitable sheets S from reaching the inkjet marking module 11, the sensing unit 21 is therefore desirably provided as a separate sentry unit 21 positioned on the transport path PP sufficiently upstream of the inkjet marking module 11. The controller 28 and processor 29 may be integrated within the sentry unit 21 or they may be separately or remotely located. The apparatus 20 according to the present invention further comprises a removal device 26 or ejector device 26 shown in Fig. 5 for directing a sheet S from the transport path PP to a rejection transport path before said sheet S reaches the inkjet marking module 11. The removal device 26 may be a transport switch 26 controlled by the controller 28. When the processors 29 determines that a sheet S is unsuitable for printing based on the data from the sensing unit 21, the controller 28 controls the removal device 26 to direct said sheet S from the transport path PP onto a rejection transport path RP leading to a reject output tray.

[0050] Fig. 3B illustrates the tilting of the support beam 25B. By moving one actuator 24 disproportional to the other actuator 24', one end of the support beam 25B is raised above the other end. The emitter 26 is rigidly fixed to the support beam 25B, such that the optical beam B extends substantially along or parallel to the support beam 25B. As such, when the actuators 24, 24' tilt the support beam 25B, the angle α of the beam B with respect to the medium support surface 32 is adjusted. For accurate sheet quality detection, the beam B during operation should be parallel to the medium support surface 32. Thereto, the emitter 23 must be tilted with a high degree of precision. This precision is achieved within the present invention by securely mounting the emitter 23 on the support beam 25B and aligning the optical beam B by tilting the support beam 25B by means of the actuators 24, 24'. The actuator 24, 24' each comprise an inherent inaccuracy in positioning their respective side of the support beam 25B, which translates into an inaccuracy of the angle α. Changes to the angle α are proportional to the ratio between the height changes by an actuator and the length of the support beam 25B in the lateral direction W in between the actuators 24, 24'. The influence of the height inaccuracy of the actuators 24, 24' on the angle α is thereby significantly reduced. The present invention thereby allows for finely and accurately tilting the beam B into alignment with the medium support surface 32.

Alignment method

[0051] Referring now to Fig 4A and 4B of the drawings, an embodiment of the alignment method according to the present invention is illustrated.

[0052] In the first step, a calibration structure 40 is positioned on the lateral right side of the medium support surface 32. The calibration structure 40 comprises a body with a well defined lower support surface, such that the calibration structure 40 rests stably on the medium support surface 32 regardless of its exact lateral position. The calibration structure 40 has a predefined height, for example by means of a straight top edge, substantially parallel to the medium support surface 32 when resting thereon.

[0053] In the next step, the emitter 23 is activated and the actuators 24, 24' are driven synchronously to change the height of the support beam 25B and therewith the optical beam B. As both actuators 24, 24' are controlled to match each other's motion, the angle α of the beam B is not changed. Preferably, the optical beam B is lowered from above the calibration structure 40. In the following step, the calibration structure 40 passes into the beam B and light is reflected onto the sensor assembly 25. The controller 28 then stores the height of the actuator 24' on the right side at the moment of detecting the reflected light. This first height value is stored onto the memory of the controller 28.

[0054] In the next step, the calibration structure 40 is moved to the left side of the medium support surface 32. After that, the emitter 23 is activated and the support beam 25B is lowered towards the medium support surface 32. The sensor assembly 25 detects when light of the optical beam B reflects of the calibration structure 40 on the left side. The controller 28 then stores the height of the right side actuator 24' at the moment of detection as the second height value.

[0055] The first and second height values are then compared to one another to determine an angle parameter for the angle α of the beam B. This may for example be done by determining a height difference between the first and second height values. This height difference is then divided by the distance between the two positions wherein the calibration structure 40 was positioned. The resulting value is proportional to $\tan(\alpha)$. From there, a value for the angle α can be determined.

[0056] The determined angle α is then compared to a reference to determine whether the angle α is within predefined tolerances. Dependent on the comparison, the controller 28 may asynchronously actuate the actuators 24, 24' to adjust the angle α accordingly such that the beam B is aligned with the medium support surface 32. Thereby, the present invention provides an easy method for aligning the beam B of the emitter 23.

[0057] It will be appreciated that the present invention can be applied to any type of parallel beam emitter based sheet proofing device. The detailed embodiments are aimed at a configuration wherein the sensor assembly is positioned to receive light from the sheet only when a deformation comes into contact with the emission beam. For sheets with deformations below a predetermined threshold height no light is reflected from the sheet to the sensor assembly. As explained, this reduces signal noise due to the vibrations in the printing system. The beam aligning concept of the present invention can also be applied to a proofing device wherein the sensor assembly is positioned on a laterally opposite side of the transport path with respect to the beam emitter. In case of deformations below the threshold height, the substantially entire emitter beam reaches the sensor assembly. Deformations are detected by a drop in intensity as a deformation enters the emission beam and reflects light away from the sensor assembly. In both configurations the reliability of the proofing device is improved by ensuring that the emission beam travels parallel to the plane of the sheet (and/or the transport path), which can be achieved by means the method and apparatus according to the present invention.

Detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention, which can be embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present invention in virtually any appropriately detailed structure. In particular, features presented and described in separate dependent claims may be applied in combination and any advantageous combination of such claims are herewith disclosed.

Further, it is contemplated that structural elements may be generated by application of three-dimensional (3D) printing techniques. Therefore, any reference to a structural element is intended to encompass any computer executable instructions that instruct a computer to generate such a structural element by three-dimensional printing techniques or similar computer controlled manufacturing techniques. Furthermore, such a reference to a structural element encompasses a computer readable medium carrying such computer executable instructions.

[0058] Further, the terms and phrases used herein are not intended to be limiting; but rather, to provide an understandable description of the invention. The terms "a" or "an", as used herein, are defined as one or more than one. The term plurality, as used herein, is defined as two or more than two. The term another, as used herein, is defined as at least a second or more. The terms including and/or having, as used herein, are defined as comprising (i.e., open language). The term coupled, as used herein, is defined as connected, although not necessarily directly.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. An apparatus (20) for deformation detection in a sheet printing system (1), comprising:

   - a sheet sensing transport path (PP);
   - a sheet quality detection device (21) positioned along the sheet sensing transport path (PP) and configured for sensing sheets (S) on the sheet sensing transport path (PP), the sheet quality detection device (21) comprising an emitter (23) for emitting an emission beam (B) over the sheet sensing transport path (PP) and a sensor assembly (25) for detecting at least part of the emission beam (B);
   - a support beam (25B) extending laterally over a width of the sheet sensing transport path (PP), wherein the emitter (23) is mounted on the support beam (25B);
   - adjusting means (24, 24') for adjusting and setting an angle (α) between the support beam (25B) and a plane (32) of the sheet sensing transport path (PP).

2. The apparatus (20) according to claim 1, wherein the emitter (23) is rigidly attached to the support beam (25B).

3. The apparatus (20) according to any of the previous claims, wherein the adjusting means (24, 24') com-

prise an actuator (24, 24') moveable perpendicular to the plane (32) of the sheet sensing transport path (PP) for adjusting the angle (α).

4. The apparatus (20) according to claim 3, wherein adjusting means (24, 24') comprise a pair of actuators (24. 24') positioned at opposite ends of the support beam (25B) with respect to one another.

5. The apparatus (20) according to claim 4, wherein the pair of actuators (24, 24') is independently moveable with respect to one another perpendicular to the plane (32) of the sheet sensing transport path (PP) for:

- tilting the support beam (25B) with respect to the plane (32) of the sheet sensing transport path (PP); and
- setting a height of the emission beam (B) with respect to the plane (32) of the sheet sensing transport path (PP) to determine a sheet rejection threshold.

6. The apparatus (20) according to any of the previous claims, further comprising a sensor assembly (25) positioned with respect to the emitter (23) such that:

the emission beam (B) is prevented from reaching the sensor assembly (25) when a sheet (S) on the sheet sensing transport path (PP) is suitable for printing; and
at least part of the emission beam (B) is reflected from a sheet (S) on the sheet sensing transport path (PP) to the sensor assembly (25) when a deformation (D) in the sheet (S) enters into the emission beam (B).

7. The apparatus (20) according to claim 6, wherein the sensor assembly (25) extends laterally over a width of the sheet sensing transport path (PP).

8. The apparatus (20) according to claim 6 or 7, wherein the sensor assembly (25) is mounted on the support beam (25B).

9. The apparatus (20) according to claim 8, the sensor assembly (25) comprises a plurality of sensor units (25A) positioned along a length of the support beam (25B).

10. The apparatus (20) according to any of the claims 6-9, further comprising:

a processor (29) to determine the suitability of the sheet (S) for printing from sensor data generated by the sensor assembly (25) and representative of a deformation (D) in the sheet (S);
wherein the controller (28) is configured for controlling further progress of the sheet (S) along the transport path (PP) in dependence of the determined sheet's suitability for printing;
a removal device (26) for removing the sheet (S) from the transport path (PP) of the printing system (1), wherein the controller (28) is configured to control the removal device (26) to remove the sheet (S) from the transport path (PP) if the processor (29) determines the sheet (S) to be unsuitable for printing.

11. A printing system (1) comprising the apparatus (20) according to any of the previous claims.

12. A method for calibrating an apparatus (20) for detecting deformations in sheets in a printing system (1), the apparatus (20) comprising an emitter (23) for emitting an emission beam (B) over a sheet sensing transport path (PP), the method comprising the steps of:

- positioning a calibration structure (40) with a predefined height on a first lateral side of the sheet sensing transport path (PP);
- moving the emitter (23) perpendicular to the sheet sensing transport path (PP) with the calibration structure (40) on its first side;
- determining a first height parameter of the emitter (23) when detecting a variation in an intensity of the detected emission beam (B);
- positioning the calibration structure (40) with a predefined height on a second lateral side of the sheet sensing transport path (PP);
- moving the emitter (23) perpendicular to the sheet sensing transport path (PP) with the calibration structure (40) on its second side;
- determining a second height parameter of the emitter (23) when detecting a variation in an intensity of the detected emission beam (B);
- comparing the first and second height parameters to determine an angle (α) for aligning the emission beam (B) with respect to the sheet sensing transport path (PP).

13. Method according to claim 12, further comprising tilting the emitter (23) such that when in use the emission beam (B) extends parallel to the sheet sensing transport path.

14. Method according to claim 12 and 13, further comprising the step of detecting a deformation (D) in a sheet (S) passing into the emission beam (B) and qualifying the sheet (S) as unsuitable for printing.

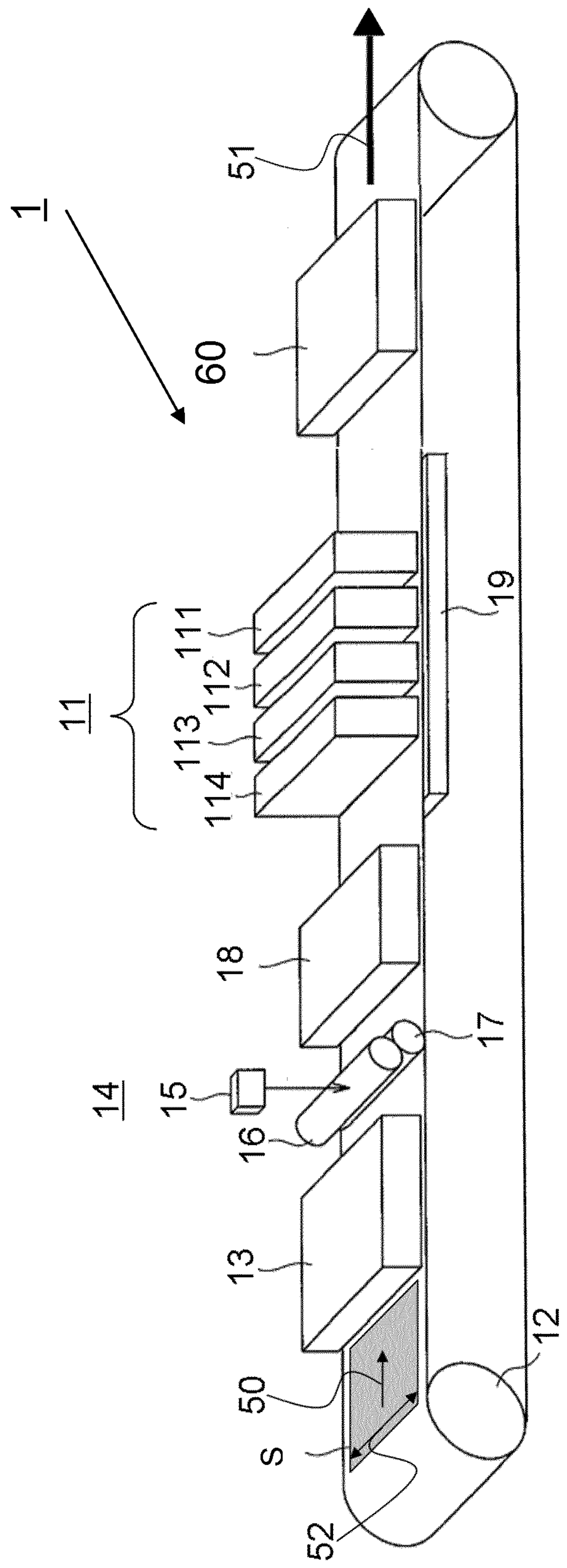


Fig. 1

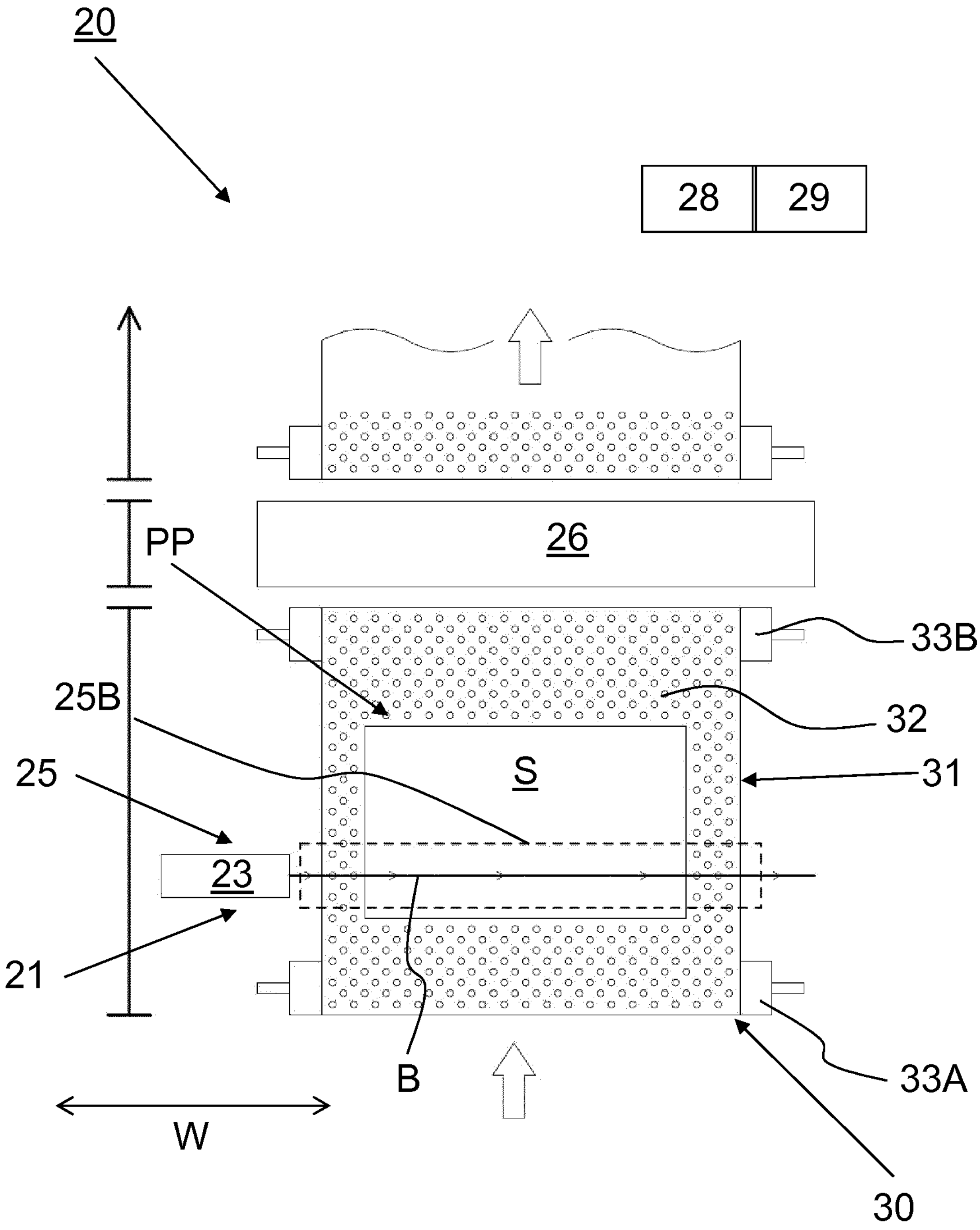


Fig. 2

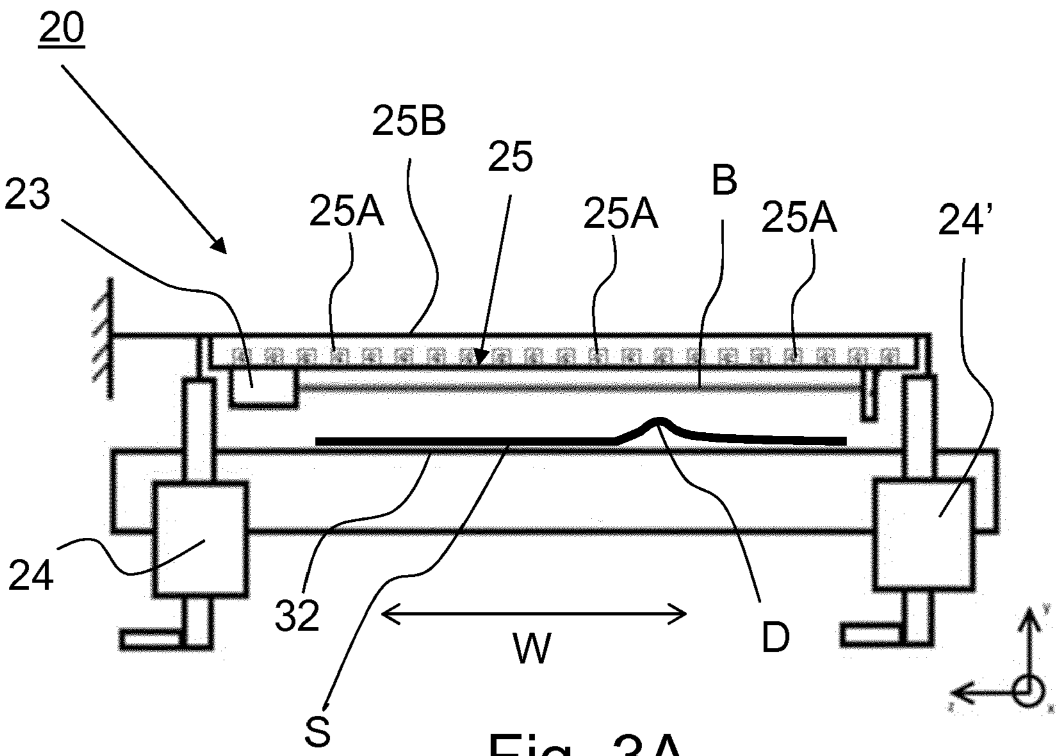
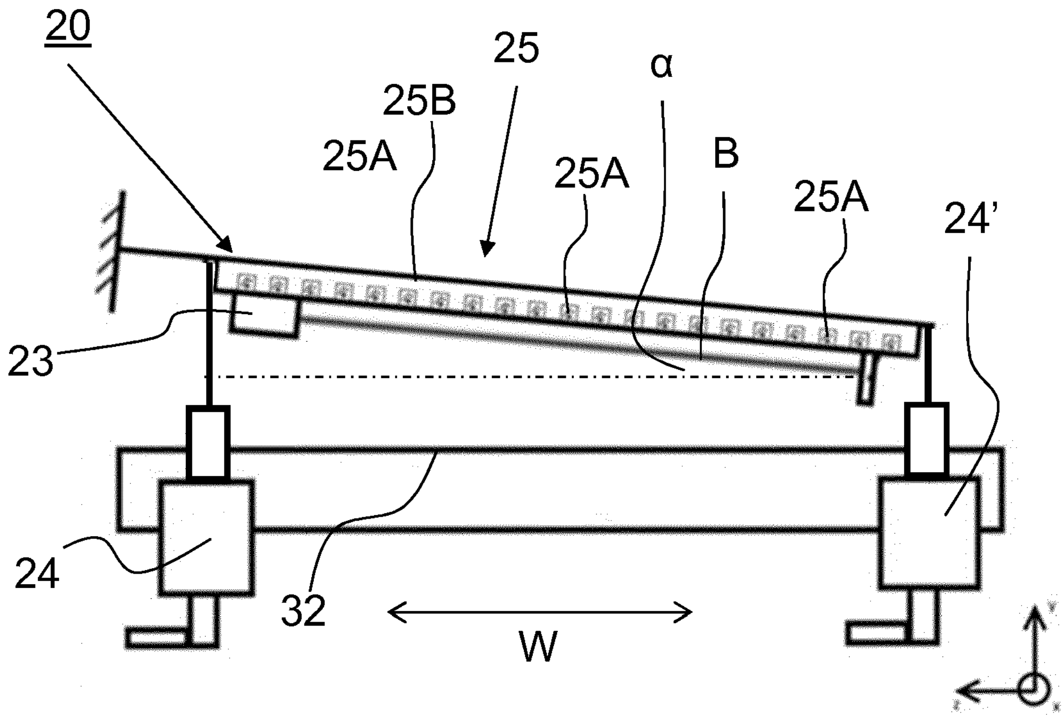

20
25B
25
23
25A
25A
B
25A
24'
24
32
W
D
S

Fig. 3A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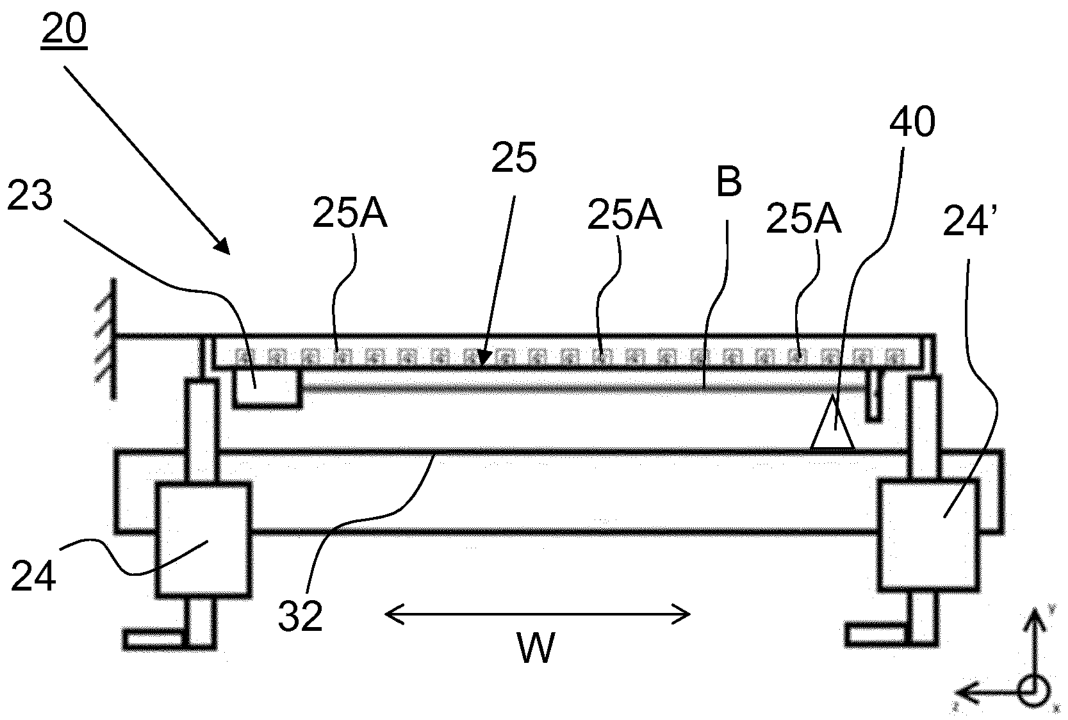
25
α
25B
25A
25A
B
25A
24'
23
24
32
W

Fig. 3B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25A
25
25A
B
25A
40
24'
24
32
W
y
z
x

Fig. 4A

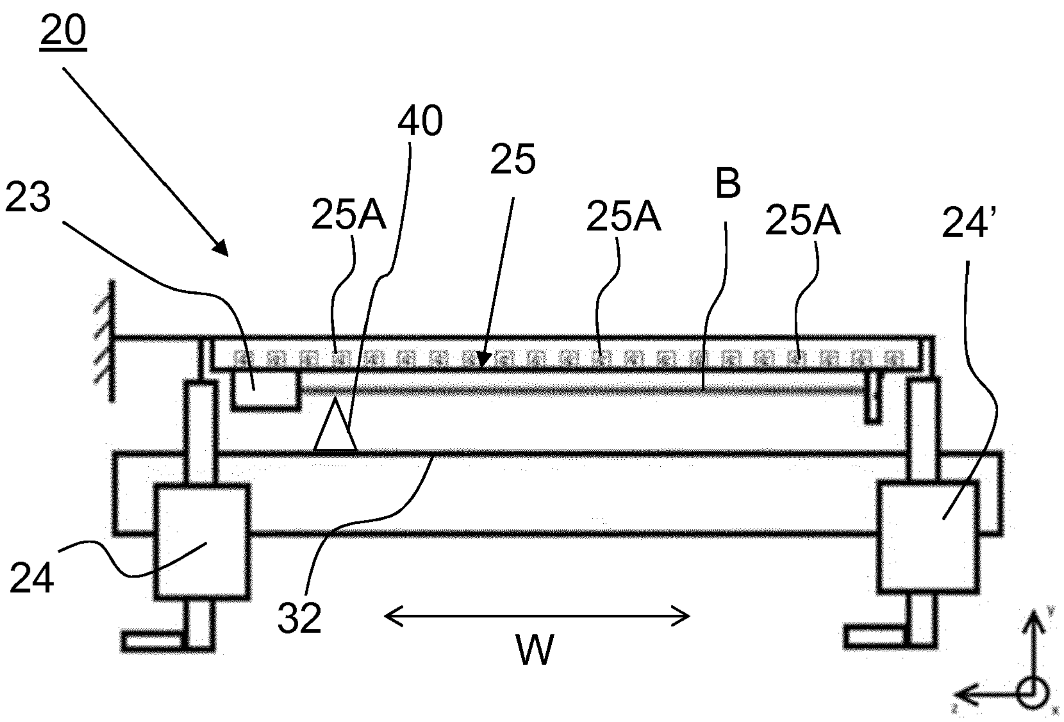
20
23
25A
40
25
25A
B
25A
24'
24
32
W
y
z
x

Fig. 4B

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EUROPEAN SEARCH REPORT

Application Number
EP 18 19 0060

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B41J
B65H
B41F
G01N

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	23 November 2018	Gaubinger, Bernhard

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