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(54)

IMAGE FORMING DEVICE AND METHOD OF OPERATING AN IMAGE FORMING DEVICE

(57)

The invention provides an image forming device (100) for forming images on individual sheets (1) of a medium and a method for operating such a device. The device comprises: a medium transport system (10) configured to transport the individual sheets (1) of the medium along a pathway (12) within the image forming device (100), the pathway (12) including a measurement section (14) that comprises at least one bend (16) in the pathway

(12); a sensor system (20) configured to determine a passage time that each individual sheet (1) of the medium transported along the pathway (12) takes in passing through the measurement section (14); and a controlling unit (30) configured to control a processing, by the image forming device (100), of each individual sheet (1) of the medium based on the passage time measured for that individual sheet (1) of the medium.

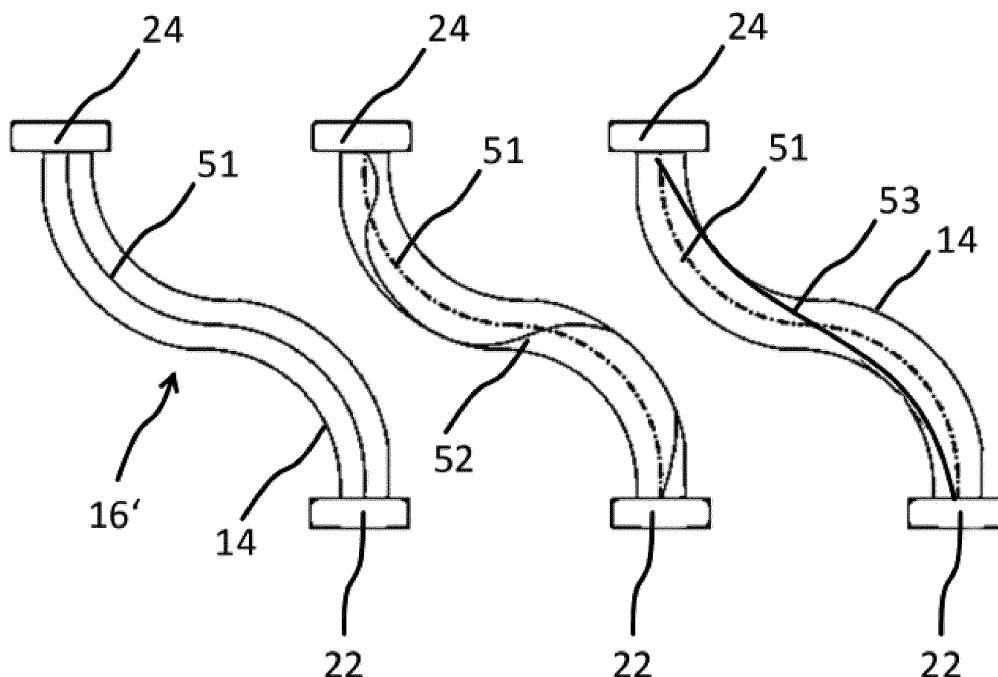


Fig. 4

Description

FIELD OF THE INVENTION

[0001] The present invention generally pertains to an image forming device for forming images on individual sheets of a medium such as sheets of paper. The image forming device may be, but is not restricted to, an inkjet printer device. The invention further pertains to a method of operating an image forming device for forming images on individual sheets of a medium such as sheets of paper.

BACKGROUND ART

[0002] Image forming devices for forming images on individual sheets of a medium are well known in the art. Such devices are usually able to process a large number of different sheets of different media. The sheets, or the media, may differ in such properties as size, thickness, friction coefficients and so on. In particular for paper as a recording medium, a sheet's mass per unit area, which is also referred to as "grammage" or as "basis weight", is an important quantity. For example, the same image forming device may be able to process both glossy paper with a grammage of 80 g/m² (g/m² is sometimes abbreviated with "gsm") as well as matte paper with a grammage of 120 g/m². However, the sheets of those two types of paper may behave rather differently when processed by one and the same image forming device.

[0003] In US 7 036 811 B2 a test registration system is described which measures a velocity of a sheet of paper with a certain grammage along a travel path. Information about the behavior of sheets of paper in general with that grammage may then be stored, based on the results of the test registration system, in a look-up table. The look-up table may then be provided to a printer. If a user inputs a stack of paper into the printer and transmits information about the grammage of that stack to the printer, that printer may then process that stack of paper based on information in the look-up table.

[0004] It is desirable to have an image forming device that is able to more accurately control its processing of sheets of a medium according to the properties of that medium.

SUMMARY OF THE INVENTION

[0005] In a first aspect of the present invention, an image forming device for forming images on individual sheets of a medium is provided. The individual sheets of the medium may in particular be individual sheets of paper.

[0006] The image forming device comprises a sheet feeder for feeding sheets from a sheet stack into a medium transport system which medium transport system is configured to transport the individual sheets of the medium along a pathway within the image forming device, the pathway including a measurement section positioned

between the sheet feeder and a printing section, such that each sheet fed from the sheet feeder passes through the measurement section before printing on said sheet, wherein the measurement section comprises at least one bend in the pathway; a sensor system configured to determine a passage time that each individual sheet of the medium transported along the pathway takes in passing through the measurement section; and a controlling unit configured to control a processing, by the image forming device, of each individual sheet of the medium based on the passage time measured for that individual sheet of the medium.

Determining the passage time includes, among other possibilities, directly measuring the passage time as well as calculating the passage time based on other, directly measured, quantities, for example, a velocity.

[0007] It is to be understood that the passage time is a time that each individual sheet of the medium requires to pass through the measurement section, all other things being equal (*ceteris paribus*). For example, all of the sheets of the medium should be propelled to traverse the measurement section by application of the same forces and/or torques with the same magnitudes.

[0008] For the present invention, it has been noticed that, depending on the properties of the medium, e.g. on the medium's stiffness, the sheets of the medium will take different amounts of time (that is, different passage times) to pass through at least the bend in the pathway in the measuring section.

[0009] As will be explained in more details below and with reference to the drawings, sheets of media with comparatively higher stiffness tend to take shorter paths through bends resulting in comparatively shorter passage times while sheets of media with comparatively lower stiffness tend to take longer paths through the same bends, resulting in comparatively longer passage times. By purposefully designing and providing the at least one bend in the pathway, a sufficient difference in the passage times can be achieved such that reliable measurements are possible.

[0010] By positioning the measurement section between the sheet feeder and the printing section, each sheet is sensed effectively before passing through the majority of the medium transport system. This allows the sheet's velocity or trajectory to be adjusted in accordance with each sheet's determined stiffness. It is the insight of the inventor that paper jams through erroneously input sheets can be prevented by screening all sheets on entry by means of the above described measurement section. A sheet is handled by the medium transport system in accordance with its media type as indicated in the print job. Based on said media type, the printer or operator selects a sheet stack to supply sheets from for executing said print job. In case sheets of a different media type are present in the selected sheet stack, these different sheets may be transported in a manner unsuited for the different media type. These different sheets may then move too fast or through unsuited sections of the medium

transport path, resulting in paper jams or damage to the sheets. Stiffer sheets generally require a reduced transport velocity, allowing them more time to bend or curve through turns in the medium transport path. The present invention provides a screening for identifying these deviant sheets in a sheet stack, allowing the controlling unit for example to eject these sheets from the transport path or to adjust the transport of these sheets to fit the media type of these sheets.

[0011] In the following, some examples will be presented in which the passage time indicates a thickness of the individual sheets of the media. Although thickness of sheets is an important factor, it should be understood that the passage time may indicate other important properties of the sheets or may simply be used to differentiate between different types of sheets and/or of different types of media.

[0012] A bend in the pathway may be characterized in that a direction of movement of the sheet's leading edge immediately before the bend is different from a direction of movement of the sheet's leading edge immediately after the bend. The bend may be realized as a curve, or a curvature. One way to characterize such a bend in the pathway is to say that the pathway, expressed as a function with x and y coordinates, has a nonzero curvature along the bend, i.e. a nonzero second derivative along the bend. As an alternative, the bend may be realized as a section of the pathway that has at least one kink, which may be described as a point with a non-continuous first derivative, wherein the sections immediately before and after the kink may or may not have a nonzero second derivative.

[0013] Each of the medium transport system, the sensor system and the controlling unit may comprise a plurality of individual components, or may be provided as a single component. The term "controlling unit" should not be understood to encompass only controlling units that are provided as a single component such as a microcontroller; the controlling unit may also be provided as a plurality of individual components such as microcontrollers, ASICs, FPGAs, CPUs, and similar control logics.

[0014] The image forming device according to the first aspect has the advantage that a user of the device does not have to input any particular data about the medium because the device will determine some, of, or all, of the important parameters of that medium directly using the measurement section and the sensor system. Moreover, a user does not have to switch settings of the image forming device every time that a sheet of a different type of medium is inserted, for example every time the user switches between a sheet of 80 gsm paper and a sheet of 120 gsm paper. The user of the image forming device does not have to know which of the sheets in a batch, or stack, of sheets has which properties; the user does not even have to be aware that there are any differences at all between the sheets in a batch, or stack, of sheets of media provided to the image forming device. The image forming device will always measure the passage time of

each individual sheet and will handle, or process, each individual sheet accordingly, thus ensuring optimal processing and therefore optimal printing results.

[0015] The controlling of the processing of the individual sheets of the medium may range from maintaining previous settings without any changes, e.g. when all of the sheets of the medium have the exact same properties, to changing (or adapting) some parameters of the processing for every single sheet, e.g. when all of the sheets of the medium have relevantly different properties.

[0016] In an embodiment, the controlling unit is further configured to compare the determined passage time of each sheet to a medium type parameter of a print job for verifying whether each sheet confirms to the medium type parameter prescribed by the print job. The controlling unit is configured to receive print job information via a user interface. The print job information comprises a media type identifier, input separately or directly with the remaining print job information via the user interface. The controlling unit further comprises tray media identifiers describing which media types are present on which input tray of the image forming device. The controlling unit compares the media type identifier to the tray media identifiers to determine from which input tray sheets will be supplied for the print job. Each sheet fed from the determined input tray passes through the measurement section, resulting in a passage time, which provides a means for identifying the media type of the sheet.

[0017] In another embodiment, the controlling unit is further configured to compare the determined passage time of each sheet to a medium type parameter of a print job for verifying whether each sheet confirms to the medium type parameter prescribed by the print job. The sensed passage time is compared to e.g. a pre-stored passage time for the selected media type. The controlling unit may comprise look-up means, such as a look-up table, graph, formula, or algorithm which links media types to passage times. The controller thereby compares the media type of the sensed sheet to the media type indicated in the print job information. In case the sensed sheet is determined to differ from the media type in the print job information, the controlling unit may be configured to adjust the transport of the different sheet to a manner suitable for the media type of the different sheet. Thereto, the controlling unit may take appropriate action, such as adjusting the velocity of the deviant sheet, stopping the medium transport mechanism, ejecting the deviant sheet from the transport path, or informing an operator.

[0018] Preferably, the measurement section is provided at the start of the pathway, for example directly downstream of the sheet feeder. In case the controlling unit determines a sheet to be of a different media type than prescribed in the print job information, the controlling unit can adjust the transport of the sheet along the remainder of the pathway in accordance with the determined media type parameter of said sheet. This reduces the chance

of paper jams by sheets being transported at unsuitable velocities.

In some advantageous embodiments of the first aspect, the measurement section comprises a double-bend in the pathway. The double-bend may be formed as an S-shaped portion of the pathway. In other words, the double-bend may be provided as a portion of the pathway in which the (e.g. continuous) curvature (i.e. second derivative) of the pathway changes signs. Alternatively, or additionally, the double-bend may be realized by at least two kinks in the pathway, e.g. in a zigzag shape.

[0019] A double-bend results in larger differences in the passage time for sheets of media with different bending stiffness which, in turn, is strongly correlated with the grammage of the sheets. Accordingly, the double-bend enables a more precise measurement and therefore a more precise controlling of the processing according to each individual sheet. The double bend or S-shape was to found to be particularly suited for determining the medium type parameter based on the passage time. As shown in Fig. 3, the shape of the double bend or S-shape enhances the behavioral differences in weak and stiff media types as these pass through the measurement section. Further, the double bend or S-shape allows for relatively high speed transport while still allowing significantly different behavior between different media types. Preferably, the length of the measurement section is comparable to or less than the sheet length of the used media.

[0020] In some embodiments of the first aspect, the sensor system comprises a first sensor unit configured to measure a first time associated with an entry of the individual sheet of the medium into the measurement section, and a second sensor unit configured to measure a second time associated with an exit of the individual sheet of the medium from the measurement section. The passage time may be calculated based on the measured first time and the measured second time. In this way, a very precise and very accurate determining of the passage time is possible.

[0021] In some embodiments, the first sensor unit and/or the second sensor unit comprises a photodiode. The photodiode may be coupled with a light source configured and arranged such that light generated by the light source is received and detected by the respective photodiode and that an interruption of the receiving of the light at the photodiode indicates that the sheet of the medium is currently present at the location of the photodiode and/or at the location of the light source.

[0022] The photodiode and/or the light source of the first sensor unit may be positioned at, or upstream, of the beginning of the measurement section along the pathway. The photodiode and/or the light source of the second sensor unit may be positioned at, or downstream, of the end of the measurement section along the pathway.

[0023] The first time associated with the entry of the individual sheet of the medium into the measurement section may, for example, be a time at which a leading

edge of the sheet has just entered the measurement section, or has just interrupted the receiving of light at the photodiode of the first sensor unit. The first time associated with the entry of the individual sheet of the medium into the measurement section may also be a time at which the individual sheet of the medium has fully entered the measurement section, i.e. a time at which a trailing edge of the sheet has just entered the measurement section, or has just stopped interrupting the receiving of light at the photodiode of the first sensor unit.

[0024] The second time associated with the exit of the individual sheet of the medium from the measurement section may, for example, be a time at which a leading edge of the sheet has just left the measurement section, or has just interrupted the receiving of light at the photodiode of the first sensor unit. The second time associated with the exit of the individual sheet of the medium from the measurement section may also be a time at which the individual sheet of the medium has fully left the measurement section, i.e. a time at which a trailing edge of the sheet has just left the measurement section, or has just stopped interrupting the receiving of light at the photodiode of the second sensor unit.

[0025] In some embodiments of the first aspect, said controlling of the processing of each individual sheet of the medium comprises controlling the transporting, by the medium transport system, of each individual sheet of the medium. For example, the transporting may be effected, in some area, by a pair of rolls, one driven roll and one idling roll, having a controllable distance from each other. If said distance is too small for a thick sheet, jams or delays may occur, whereas, when said distance is too large for a thin sheet, the driven roll might not be able to accelerate the sheet at all. Then, said distance may be controlled based on the measured passage time. In particular, components that function based on a predicted or actual thickness of the individual sheets of the media may be controlled to operate based on a comparatively lower thickness when the determined passage time is comparatively higher, and may be controlled to operate based on a comparatively higher thickness when the determined passage time is comparatively lower.

[0026] A comparatively shorter passage time may indicate a comparatively higher bending stiffness, thus a comparatively higher grammage and accordingly a comparatively higher thickness of the sheet so that a comparatively larger distance between the pair of rolls may be effected. Conversely, a comparatively longer passage time may indicate a comparatively lower bending stiffness, thus a comparatively lower grammage and accordingly a comparatively lower thickness of the sheet so that a comparatively smaller distance between the pair of rolls may be effected.

[0027] In some embodiments of the first aspect, said controlling of the processing of each individual sheet of the medium comprises transporting each individual sheet of the medium along one of at least two different sub-pathways based on the passage time measured for that

individual sheet of the medium. For example, the image forming device might comprise a first sub-pathway for sheets of media with a passage time up to a predetermined threshold time value (which may correspond to a predetermined threshold thickness, or grammage, value) and a second sub-pathway for sheets of media with a passage time of, and over, said predetermined threshold time value. For example, an image forming device might comprise a first sub-pathways for sheets of paper, and a second sub-pathway for sheets of cardboard.

[0028] In some embodiments of the first aspect, the controlling unit is further configured to control the processing of each individual sheet of the medium further based on the difference of the passage time measured for that individual sheet of the medium to a reference time value. The reference time value may be an average value of the passage time for all of the types of sheets and/or of types of media usable in the device. The image forming device, in particular the medium transport system, might be set up to generally process sheets of the media as if their passage times would correspond to the reference time value. By calculating the difference of the actual passage times of the individual sheets of media to the reference value, the processing of the sheets may then be minimally adapted. In this way, the degree or amount of adjustments of the processing of the individual sheets may be kept to a minimum, simplifying the configuration of the image forming device and minimizing time consumption for the adjustments.

[0029] In some embodiments of the first aspect, the controlling unit is further configured to determine, e.g. calculate, a bending stiffness value for each individual sheet of the medium based on the passage time measured for that individual sheet of the medium. The bending stiffness value may be read out from a look-up table connecting each measured value of the passage time with an according stiffness value. The controlling unit may further be configured to control the processing of each individual sheet of the medium further based on the stiffness value calculated for that individual sheet of the medium.

[0030] According to a second aspect of the invention, a method of operating an image forming device for forming images on individual sheets of a medium is provided. The method comprises at least the steps of: transporting sheets of a medium along a pathway extending from a sheet feeder to a printing section within the image forming device, comprising transporting the sheets of the medium through a measurement section positioned along the pathway between a sheet feeder and a printing section of the pathway which measurement section includes at least one bend in the pathway; determining a passage time that each individual sheet of the medium transported along the pathway takes in passing through the measurement section; controlling a processing, by the image forming device, of each individual sheet of the medium based on the passage time measured for that individual sheet of the medium.

[0031] It will be understood that the method according to the second aspect may be used to operate the image forming device according to the first aspect, and that the method according to the second aspect may be modified and controlled in accordance with all modifications and variations described or implied with respect to the device according to the first aspect and vice versa.

[0032] In some embodiments of the second aspect, the method comprises the steps of: measuring a first time associated with an entry of the individual sheet of the medium into the measurement section; and measuring a second time associated with an exit of the individual sheet of the medium from the measurement section. The passage time may then be determined by a step of calculating a difference based on the first time and the second time.

[0033] In some embodiments of the second aspect, said controlling of the processing of each individual sheet of the medium comprises controlling the transporting, by the medium transport system, of each individual sheet of the medium.

[0034] In some embodiments of the second aspect, the method comprises a step of calculating a difference of the passage time measured for each individual sheet of the medium to a reference time value. The controlling of the processing of each individual sheet of the medium may then further be based on said calculated difference that individual sheet of the medium.

[0035] In some embodiments of the second aspect, the method comprises a step of determining a bending stiffness value for each individual sheet of the medium based on the passage time measured for that individual sheet of the medium; and wherein the controlling of the processing of each individual sheet of the medium is further based on the bending stiffness value calculated for that individual sheet of the medium.

[0036] In some embodiments of the second aspect, the method further comprises the steps of creating, or modifying, a predicted-time-of-arrival value for an arrival of each individual sheet of the medium at at least one component of the image forming device; providing said created, or modified, predicted-time-of-arrival value to said at least one component; and controlling said at least one component to operate based on said created, or modified, predicted-time-of-arrival value.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying schematic drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

Fig. 1 schematically shows an embodiment of image forming device according to the present invention

Fig. 2 schematically shows an image forming device

- according to an embodiment of the first aspect;
 Fig. 3 schematically shows an image forming device according to another embodiment of the first aspect;
 Fig. 4 shows schematic drawings illustrating a variant of the image forming device shown in Fig. 3;
 Fig. 5 schematically shows an image forming device according to yet another embodiment of the first aspect; and
 Fig. 6 shows a schematic flow diagram illustrating a method according to an embodiment of the second aspect.

DETAILED DESCRIPTION OF THE DRAWINGS

[0038] 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.

[0039] FIG. 1 shows schematically an embodiment of a general configuration of a printing system 100 according to the present invention. The printing system 100, for purposes of explanation, is divided into an output section 5, a print engine and control section 3, a local user interface 7 and an input section 4 or sheet feeder 4. While a specific printing system is shown and described, the disclosed embodiments may be used with other types of printing system such as an ink jet print system, an electrophotographic print system, etc.

[0040] The output section 5 comprises a first output holder 52 for holding printed image receiving material, for example a plurality of sheets. The output section 5 may comprise a second output holder 55. While 2 output holders are illustrated in Fig. 1, the number of output holders may include one, two, three or more output holders. The printed image receiving material is transported from the print engine and control section 3 via an inlet 53 to the output section 5. When a stack ejection command is invoked by the controller 37 for the first output holder 52, first guiding means 54 are activated in order to eject the plurality of sheets in the first output holder 52 outwards to a first external output holder 51. When a stack ejection command is invoked by the controller 37 for the second output holder 55, second guiding means 56 are activated in order to eject the plurality of sheets in the second output holder 55 outwards to a second external output holder 57.

[0041] The output section 5 is digitally connected by means of a cable 60 to the print engine and control section 3 for bi-directional data signal transfer.

[0042] The print engine and control section 3 comprises a print engine and a controller 37 for controlling the printing process and scheduling the plurality of sheets in a printing order before they are separated from input holder 44, 45, 46 of the sheet feeder 4.

The controller 37 is a computer, a server or a workstation, connected to the print engine and connected to the digital environment of the printing system, for example a net-

work N for transmitting a submitted print job to the printing system 100. In Fig. 1 the controller 37 is positioned inside the print engine and control section 3, but the controller 37 may also be at least partially positioned outside the print engine and control section 3 in connection with the network N in a workstation N1.

The controller 37 comprises a print job receiving section 371 permitting a user to submit a print job to the printing system 100, the print job comprising image data to be printed and a plurality of print job settings. The controller 37 comprises a print job queue section 372 comprising a print job queue for print jobs submitted to the printing system 100 and scheduled to be printed. The controller 37 comprises a sheet scheduling section 373 for determining for each of the plurality of sheets of the print jobs in the print job queue an entrance time in the paper path of the print engine and control section 3, especially an entrance time for the first pass and an entrance time for the second pass in the loop in the paper path according to the present invention. The sheet scheduling section 373 will also be called scheduler 373 hereinafter.

The sheet scheduling section 373 takes the length of the loop into account. The length of the loop corresponds to a loop time duration of a sheet going through the loop dependent on the velocity of the sheets in the loop. The loop time duration may vary per kind of sheet, i.e. a sheet with different media properties.

[0043] Resources may be recording material located in the input section 4, marking material located in a reservoir 39 near or in the print head or print assembly 31 of the print engine, or finishing material located near the print head or print assembly 31 of the print engine or located in the output section 5 (not shown).

[0044] The paper path comprises a plurality of paper path sections 32, 33, 34, 35 for transporting the image receiving material from an entry point 36 of the print engine and control section 3 along the print head or print assembly 31 to the inlet 53 of the output section 5. The paper path sections 32, 33, 34, 35 form a loop according to the present invention. The loop enables the printing of a duplex print job and/or a mix-plex job, i.e. a print job comprising a mix of sheets intended to be printed partially in a simplex mode and partially in a duplex mode.

[0045] The print head or print assembly 31 is suitable for ejecting and/or fixing marking material to image receiving material. The print head or print assembly 31 is positioned near the paper path section 34. The print head or print assembly 31 may be an inkjet print head, a direct imaging toner assembly or an indirect imaging toner assembly.

[0046] While an image receiving material is transported along the paper path section 34 in a first pass in the loop, the image receiving material receives the marking material through the print head or print assembly 31. A next paper path section 32 is a flip unit 32 for selecting a different subsequent paper path for simplex or duplex printing of the image receiving material. The flip unit 32 may be also used to flip a sheet of image receiving ma-

terial after printing in simplex mode before the sheet leaves the print engine and control section 3 via a curved section 38 of the flip unit 32 and via the inlet 53 to the output section 5. The curved section 38 of the flip unit 32 may not be present and the turning of a simplex page has to be done via another paper path section 35.

[0047] In case of duplex printing on a sheet or when the curved section 38 is not present, the sheet is transported along the loop via paper path section 35A in order to turn the sheet for enabling printing on the other side of the sheet. The sheet is transported along the paper path section 35 until it reaches a merging point 34A at which sheets entering the paper path section 34 from the entry point 36 interweave with the sheets coming from the paper path section 35. The sheets entering the paper path section 34 from the entry point 36 are starting their first pass along the print head or print assembly 31 in the loop. The sheets coming from the paper path section 35 are starting their second pass along the print head or print assembly 31 in the loop. When a sheet has passed the print head or print assembly 31 for the second time in the second pass, the sheet is transported to the inlet 53 of the output section 5.

[0048] The input section 4 may comprise at least one input holder 44, 45, 46 for holding the image receiving material before transporting the sheets of image receiving material to the print engine and control section 3. Sheets of image receiving material are separated from the input holders 44, 45, 46 and guided from the input holders 44, 45, 46 by guiding means 42, 43, 47 to an outlet 36 for entrance in the print engine and control section 3. Each input holder 44, 45, 46 may be used for holding a different kind of image receiving material, i.e. sheets having different media properties. While 3 input holders are illustrated in Fig. 1, the number of input holders may include one, two, three or more input holders.

[0049] The local user interface 7 is suitable for displaying user interface windows for controlling the print job queue residing in the controller 37. In another embodiment a computer N1 in the network N has a user interface for displaying and controlling the print job queue of the printing system 1

[0050] Fig. 2 schematically shows the image forming device 100 for forming images on individual sheets 1 of a medium according to an embodiment of the first aspect. In the following, the function of the image forming device 100 will sometimes be described with reference to an inkjet printer forming images on individual sheets of paper. It should be understood, however, that the functions, features, elements, and ideas expressed herein are equally applicable to any other kind of image forming device that may employ other techniques to form images and/or process other types of media.

[0051] The image forming device 100 shown in Fig. 2 comprises a medium transport system 10 configured to transport the individual sheets 1 of the medium along a defined pathway 12 within the image forming device 100. The pathway 12 may be a simple one-way pathway or

may comprise one or more forks leading to several sub-paths. The medium transport system 10 is adapted to, among other possible functions, transport the sheets 1 of the medium from an input area of the image forming device 100 to an image forming system 18 of the image forming device. The image forming system 18 is configured to form the image on the individual sheets 1 of the medium, e.g. by applying ink, toner, or heat.

[0052] The pathway 12 includes a measurement section 14 that comprises at least one bend 16 in the pathway 12. In other words, the at least one bend 16 is provided in a portion of the pathway 12 that is part of the measurement section 14.

[0053] The image forming device 100 further comprises a sensor system 20 configured to determine a passage time, or a time-of-passage, ToP, that each individual sheet 1 of the medium transported along the pathway 12 takes in, or needs for, passing through the measurement section 14. As has already been discussed before, it is to be understood that the passage time is a time that each individual sheet 1 of the medium requires to pass through the measurement section, all other things being equal (*ceteris paribus*). For example, all of the sheets of the medium should be propelled, by the medium transport system 10, to traverse the measurement section by application of the same forces and/or torques with the same magnitudes.

[0054] The image forming device 100 also comprises a controlling unit 30 which may, for example, be provided as, or comprise, a microcontroller, an ASIC, a printed circuit board, a FPGA, a CPU and/or any other type of logics circuit. The controlling unit 30 is configured to control a processing, by the image forming device 100, of each individual sheet 1 of the medium based on the passage time measured for that individual sheet 1 of the medium. Processing herein may comprise any or all actions associated with the handling of the sheets prior to and/or after the forming of the image on the sheets as well as any or all actions used for forming the image on the sheets.

[0055] Specifically, the controlling unit 30 may control, among other components of the image forming device 100, the medium transport system 10 and/or the image forming system 18 to process each individual sheet 1 of the medium based on the passage time measured for that individual sheet 1 of the medium. Controlling the medium transport system 10 may comprise controlling units configured to move, shift, grab or otherwise affect the individual sheets 1.

[0056] In Fig. 2 a signal 91 is shown in which the measured passage time, or, more precisely, a signal indicating the measured passage time, is transmitted from the sensor system 20 to the controlling unit 30. The sensor system 20 and the controlling unit 30 may be completely or partially integrated with one another; for example, a common CPU and/or memory could be shared by the sensor system 20 and the controlling unit 30.

[0057] As has been discussed in the foregoing, the

measured passage time may be used as an indicator for a bending stiffness and/or for a grammage of the individual sheets 1 of the medium, both of which are useful parameters for optimizing the processing of the individual sheets 1 of the medium by the image forming device 100.

[0058] The controlling unit 30 may be configured to determine the bending stiffness value for each individual sheet 1 of the medium based on the passage time measured for that individual sheet 1 of the medium, e.g. by reading out bending stiffness values from a predetermined look-up table connecting each measured value of the passage time with an according stiffness value. The controlling unit 30 may further be configured to control the processing of each individual sheet 1 of the medium further based on the bending stiffness value determined for that individual sheet 1 of the medium.

[0059] Similarly, the controlling unit 30 may be configured to determine the grammage value of each individual sheet 1 of the medium based on the passage time measured for that individual sheet 1 of the medium, e.g. by reading out grammage values from a predetermined look-up table connecting each measured value of the passage time with an according grammage. The controlling unit 30 may further be configured to control the processing of each individual sheet 1 of the medium further based on the grammage value determined for that individual sheet 1 of the medium.

[0060] Specifically, the controlling unit 30 may control, among other components of the image forming device 100, the medium transport system 10 and/or the image forming system 18 to process each individual sheet 1 of the medium based on the bending stiffness value and/or the grammage value determined for that individual sheet 1 of the medium.

[0061] The image forming device 100 may, for example, comprise a flipping wheel, the behavior of which may be controlled to be adapted per sheet 1 to optimize a stacking quality. The image forming device 100 may also comprise an air separation module, the behavior of which may be controlled to be adapted per sheet to improve its reliability.

[0062] As has been discussed above, depending on the properties of the medium, e.g. on the medium's bending stiffness, the sheets 1 of the medium will take different amounts of time (that is, different passage times) to pass through at least the bend 16 in the pathway 12 in the measuring section 14. Sheets 1 of media with comparatively higher bending stiffness tend to take shorter paths through bends resulting in comparatively shorter passage times while sheets of media with comparatively lower bending stiffness tend to take longer paths through the same bends 16, resulting in comparatively longer passage times.

[0063] The measurement section 14 may comprise a single bend 16 provided in the pathway 12. In that case, the single bend 16 is preferably configured such that the movement of the sheet 1 of the medium is changed, as a result of passing through the single bend 16, by at least

10° (ten degrees), preferably by at least 15° (fifteen degrees), even more preferably by at least 30° (thirty degrees), in particular by at least 45° (forty-five degrees), by at least 60° (sixty degrees) or by at least 75° (seventy-five degrees).

[0064] The measurement section 14 may also comprise more than one bend 16. In a preferred embodiment discussed in the following with respect to Fig. 3 to Fig. 5, the measurement section 14 may comprise a double-bend 16' which may also be called an S-curve or an S-shaped portion of the pathway 12.

[0065] It should be understood that the image forming device 100 may comprise additional components not shown in Fig. 1 or 2 which may still be controlled by the controlling unit 30.

[0066] Fig. 3 schematically shows the image forming device 100 comprising a double-bend 16'. Fig. 4 serves to illustrate the particular advantages of such a double-bend 16' in the measurement section 14.

[0067] On the left in Fig. 4, a measurement section 14 consisting of a double-bend 16' is shown. At the beginning of the measurement section 14, a first sensor unit 22 of the sensor system 20 is located, and at the end of the measurement section 14, a second sensor unit 24 of the sensor system 20 is located. The measurement section 14 may be defined as that section of the pathway 12 which is located between the first sensor unit 22 and the second sensor unit 24.

[0068] As has been described above and in several variants, the first sensor unit 22 is configured to measure a first time associated with an entry of the individual sheet 1 of the medium into the measurement section 14, and the second sensor unit 24 is configured to measure a second time associated with an exit of the individual sheet 1 of the medium from the measurement section 14. The controlling unit 30 and/or the sensor system 20 may be configured to calculate the passage time based on the first time and the second time, e.g. by calculating the difference between the two.

[0069] The first sensor unit 22 and the second sensor unit 24 are described herein as each comprising a photodiode and a light source, wherein the photodiode is coupled with the light source, and wherein the photodiode and the light source are configured and arranged such that light generated by the light source is received and detected by the respective photodiode. An interruption of the receiving of the light at the photodiode indicates that the sheet 1 of the medium is currently present at the location of the photodiode and/or at the location of the light source. It will be understood that also other types of sensor units 22, 24 may be used with the image forming device 100, for example mechanical sensor units employing mechanical switches, sensors based on sound and so on.

[0070] On the left-hand side of Fig. 4, a reference path 51, or average path, is shown which a pre-defined reference sheet, or average sheet, takes, and/or which is arranged in parallel with the curvature of the measurement

section 14 itself. The reference path 51 may correspond to a reference passage time, e.g. in that said average sheet would take that reference passage time value to pass the measurement section 14 along the reference path 51. In all three sections of Fig. 4 (left, middle, and right), the sheet 1 will travel in such a way through the measurement section 14 that only its profile is visible; in other words, the profile of the sheet 1 will travel along the described paths, e.g. the reference path 51.

[0071] The middle of Fig. 4 shows a situation wherein a sheet 1 with a lower bending stiffness (e.g. caused by a lower grammage) than the reference sheet is passing the measurement section 14. As is shown by a first deviant path 52 (in a slightly exaggerated manner), such a sheet 1 will bend strongly and/or often within the measurement section 14 such that the first deviant path 52 is longer than the reference path 51, resulting in, *ceteris paribus*, a passage time for that sheet 1 that is longer than the reference passage time. The same effect will occur even when there is only a single bend 16 in the measurement section 14.

[0072] The right-hand side of Fig. 4 shows a situation wherein a sheet 1 with a higher bending stiffness (e.g. caused by a higher grammage) than the reference sheet is passing the measurement section 14. As is shown by a second deviant path 53 (in a slightly exaggerated manner), such a sheet 1 will bend only little and/or rarely within the measurement section 14 such that the second deviant path 53 is shorter than the reference path 51, resulting in, *ceteris paribus*, a passage time for that sheet 1 that is shorter than the reference passage time. The same effect will occur even when there is only a single bend 16 in the measurement section 14.

[0073] Thus, Fig. 4 illustrates how different properties of the sheet 1 (for example, bending stiffness and/or grammage) result in measurably different passage times as a result of the measurement section 14 comprising at least one bend 16, and preferably a double-bend 16'.

[0074] It should be noted that, although in Fig. 4 the two individual bends, or curves, of the double-bend 16' are shown as equal to each other in both length and degree of curvature, this need not necessarily be the case. One of the two individual bends may be longer than the other, and one of the two individual bends may be more strongly curved than the other. An example is given in Fig. 5 and will be described in the following. Of course, the measurement section 14 may comprise more than two bends as well, e.g. a triple-bend, quadruple-bend and so on, wherein each of the individual bends may be configured with their own individual length and/or curvature.

[0075] Fig. 5 schematically shows a cross-section through an image forming device 100 according to a variant of the device 100 of Fig. 3 and Fig. 4.

[0076] In Fig. 5, a sheet 1 of the medium follows the following pathway 12: The sheet 1 is inserted at point A and transported, by the medium transport system (only shown schematically and partially), through point B to

point C. After having arrived at point C, the direction of movement of the sheet 1 is reversed; it is now transported upwards in Fig. 5, through sections D, E and F in that order. In Fig. 5 it is evident that the measurement section 14 (roughly shown by the trapezoid) starts with section D and ends with section E such that it comprises a double-bend 16': one bend, with a first curvature (to the left in Fig. 5), in section D and one bend, with a second curvature opposite of the first curvature (upwards in Fig. 6) in section E.

[0077] The first sensor unit 22 (not shown in Fig. 5) of the sensor system 20 is therefore preferably arranged before (or in) section D (e.g. where the trapezoid crosses the pathway 12), especially preferably at the beginning of section D. The second sensor unit 24 (not shown in Fig. 5) of the sensor system 20 is, accordingly, preferably arranged after section E (e.g. where the trapezoid crosses the pathway 12), especially preferably at the end of section E and/or at the beginning of section F which is arranged downstream in the pathway 12 of section E.

[0078] Fig. 6 shows a schematic flow diagram illustrating a method of operating an image forming device 100 for forming images on individual sheets of a medium according to an embodiment of the second aspect. The method described with reference to Fig. 6 may be used to operate the image forming device 100 described with reference to any one of Fig. 1 to 5, and may be modified and adapted in accordance with all modifications and variations described or implied with respect to the image forming device 100 described with reference to any one of Fig. 1 to 5.

[0079] In a step S10, at least one sheet 1 of a medium, preferably a plurality of sheets 1 of the medium, are transported along a pathway 12 within the image forming device 100. The step S10 comprises transporting the sheets 1 of the medium through a measurement section 14 of the pathway 12 which includes at least one bend 16 in the pathway 12, and preferably more than one bend, e.g. a double-bend 16'. The step S10 may be performed e.g. by a medium transport system 10 as described in the foregoing.

[0080] In a step S20, a passage time that each individual sheet 1 of the medium transported along the pathway 12 takes in passing through the measurement section 14 is determined, e.g. directly measured or calculated. The step S20 may be performed e.g. by a sensor system 20 as described in the foregoing.

[0081] The step S20 may comprise the optional sub-steps S21 to S23: in step S21, a first time associated with an entry of the individual sheet 1 of the medium into the measurement section 14 is measured. The first time may, e.g., be a time at which the leading edge of the sheet 1 starts leaving the measurement section 14, or a time at which the trailing edge leaves the measurement section 14. In step S22, a second time associated with an exit of the individual sheet 1 of the medium from the measurement section 14 is measured. The second time may, e.g., be a time at which the leading edge of the sheet starts

entering the measurement section 14, or a time at which the trailing edge enters the measurement section 14. In step S23, the passage time is determined by calculating a difference based on, more precisely between, the first time and the second time.

[0082] In a step S30, a processing, by the image forming device 100, of each individual sheet 1 of the medium is controlled based on the passage time measured for that individual sheet 1 of the medium. The controlling S30 may be performed e.g. as described in detail in the foregoing with reference to the controlling unit 30. The controlling of the processing of each individual sheet 1 may comprise an adapting or maintaining, based on the passage time, of at least one parameter of a component of the image forming device 100. The controlling S30 may be based on a difference of each of the measured passage times to a pre-set or pre-determined reference passage time.

[0083] The step S30 may comprise the optional sub-steps S31 to S33. In step S31, a predicted-time-of-arrival value for an arrival of each individual sheet 1 of the medium at at least one component of the image forming device 100 is created or modified (e.g. from a pre-set standard value). In step S32, said created, or modified, predicted-time-of-arrival value is provided to said at least one component. In step S33, said at least one component is controlled to operate based on said created, or modified, predicted-time-of-arrival value.

[0084] As a part of step S20 and/or as a part of step S30, a step of determining a bending stiffness value and/or a grammage value for each individual sheet 1 of the medium based on the passage time measured for that individual sheet 1 of the medium (e.g. using a look-up table) may be performed, and the controlling S30 of the processing of each individual sheet 1 of the medium may further be based on the bending stiffness value and/or grammage value calculated for that individual sheet 1 of the medium.

[0085] While detailed embodiments of the present invention are disclosed herein, 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.

[0086] 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).

[0087] It will be evident that the described embodiments may be varied in many ways. All such modifications as would be evident to one skilled in the art starting from what is explicitly described are intended to be included.

10 Claims

1. An image forming device (100) for forming images on individual sheets (1) of a medium, comprising:

a sheet feeder (4) for feeding sheets from a sheet stack (44-46) into a medium transport system (10), which medium transport system (10) is configured to transport the individual sheets (1) of the medium along a pathway (12) within the image forming device (100), the pathway (12) including a measurement section (14) positioned between the sheet feeder and a printing section, such that each sheet fed from the sheet feeder passes through the measurement section (14) before printing on said sheet, wherein the measurement section (14) comprises at least one bend (16; 16') in the pathway (12);
a sensor system (20) configured to determine a passage time that each individual sheet (1) of the medium transported along the pathway (12) takes in passing through the measurement section (14); and
a controlling unit (30) configured to control a processing, by the image forming device (100), of each individual sheet (1) of the medium based on the passage time measured for that individual sheet (1) of the medium.

2. The image forming device (100) according to claim 1, wherein the controlling unit (30) is further configured to compare the determined passage time of each sheet to a medium type parameter of a print job for verifying whether each sheet confirms to the medium type parameter prescribed by the print job.

3. The image forming device (100) according to claim 1, wherein the controlling unit (30) is further configured to compare the determined passage time of each sheet to a medium type parameter of a print job for verifying whether each sheet confirms to the medium type parameter prescribed by the print job.

4. The image forming device (100) according to any of the preceding claims,
wherein the measurement section (14) comprises a double-bend in the pathway (12).

5. The image forming device (100) according to any of

the preceding claims,

wherein the sensor system (20) comprises a first sensor unit (22) configured to measure a first time associated with an entry of the individual sheet (1) of the medium into the measurement section (14), and a second sensor unit (24) configured to measure a second time associated with an exit of the individual sheet (1) of the medium from the measurement section (14); and wherein the passage time is calculated based on the first time and the second time.

6. The image forming device (100) according to any of claims 1 to 4, wherein said controlling of the processing of each individual sheet (1) of the medium comprises controlling the transporting, by the medium transport system (10), of each individual sheet (1) of the medium.
7. The image forming device (100) according to any of the preceding claims, wherein the controlling unit (30) is further configured to control the processing of each individual sheet (1) of the medium further based on the difference of the passage time measured for that individual sheet (1) of the medium to a reference time value.
8. The image forming device (100) of any according to claims 1 to 7, wherein the controlling unit (30) is further configured to determine a bending stiffness value for each individual sheet (1) of the medium based on the passage time measured for that individual sheet (1) of the medium; and wherein the controlling unit (30) is further configured to control the processing of each individual sheet (1) of the medium further based on the bending stiffness value calculated for that individual sheet (1) of the medium.
9. The image forming device (100) of any according to claims 1 to 8, wherein the controlling unit (30) is configured to create, or modify, a predicted-time-of-arrival value for an arrival of each individual sheet (1) of the medium at at least one component of the image forming device (100) and to provide said created, or modified, predicted-time-of-arrival value to said at least one component; wherein said at least one component is configured to operate based on said created, or modified, predicted-time-of-arrival value.
10. A method of operating an image forming device (100), comprising the steps of:

- transporting (S10) sheets (1) of a medium along a pathway (12) extending from a sheet feeder to a printing section within the image forming device (100), comprising transporting the sheets (1) of the medium through a measurement section (14) of the pathway (12) positioned along the pathway (12) between a sheet feeder and a printing section, which measurement section (14) includes at least one bend (16; 16') in the pathway (12);
- determining (S20) a passage time that each individual sheet (1) of the medium transported along the pathway (12) takes in passing through the measurement section (14);
- controlling (S30) a processing, by the image forming device (100), of each individual sheet (1) of the medium based on the passage time measured for that individual sheet (1) of the medium.

11. The method according to claim 10, comprising the steps of measuring (S21) a first time associated with an entry of the individual sheet (1) of the medium into the measurement section (14); measuring (S22) a second time associated with an exit of the individual sheet (1) of the medium from the measurement section (14); and wherein the passage time is determined by calculating (S23) a difference based on the first time and the second time.
12. The method according to claim 10 or claim 11, wherein said controlling (S30) of the processing of each individual sheet (1) of the medium comprises controlling the transporting, by the medium transport system (10), of each individual sheet (1) of the medium.
13. The method of any according to claims 10 to 12, comprising a step of calculating a difference of the passage time measured for each individual sheet (1) of the medium to a reference time value; and wherein the controlling (S30) of the processing of each individual sheet (1) of the medium is further based on said calculated difference that individual sheet (1) of the medium.
14. The method of any according to claims 10 to 13, comprising a step of determining a bending stiffness and/or a grammage value for each individual sheet (1) of the medium based on the passage time measured for that individual sheet (1) of the medium; and wherein the controlling (S30) of the processing of each individual sheet (1) of the medium is further based on the bending stiffness value and/or grammage value calculated for that individual sheet (1) of the medium.

15. The method of any according to claims 10 to 14, further comprising the steps of:

creating (S31), or modifying, a predicted-time-of-arrival value for an arrival of each individual
sheet (1) of the medium at at least one component of the image forming device (100);
providing (S32) said created, or modified, predicted-time-of-arrival value to said at least one
component; and
controlling (S33) said at least one component to operate based on said created, or modified, predicted-time-of-arrival value.

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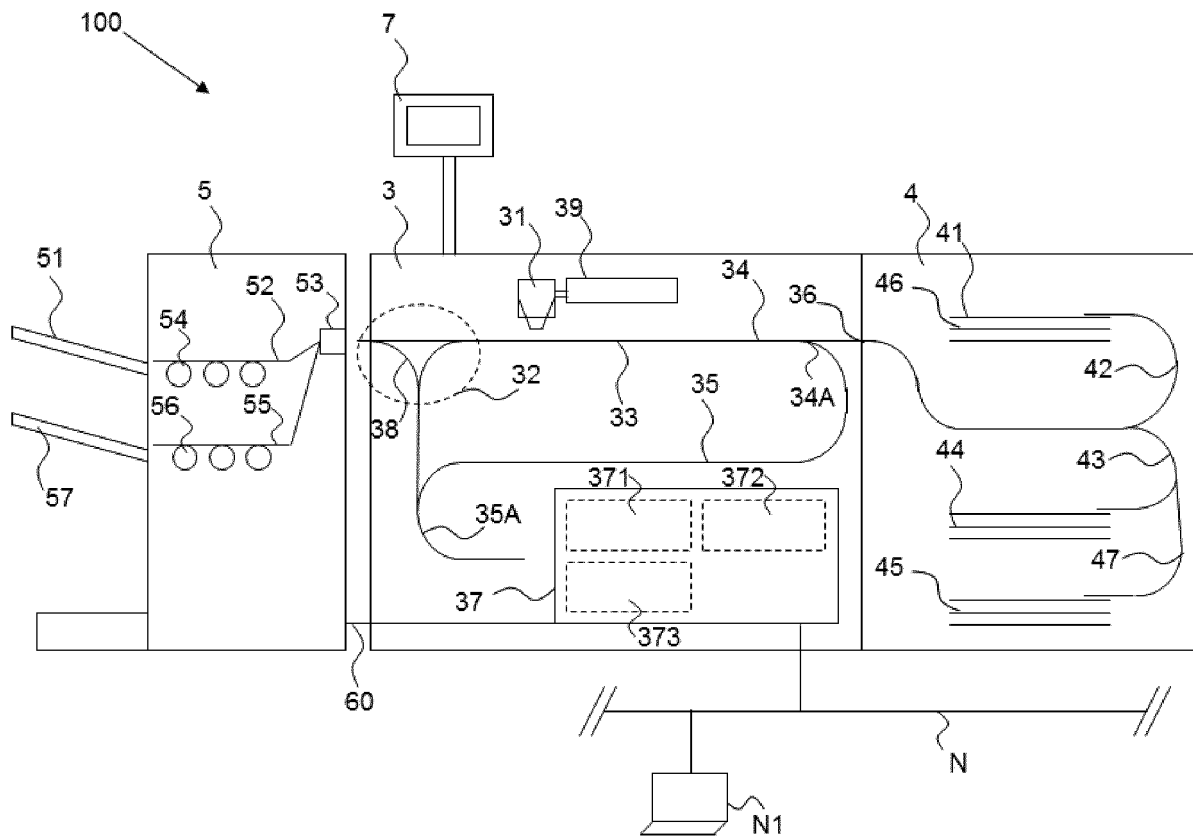


Fig. 1

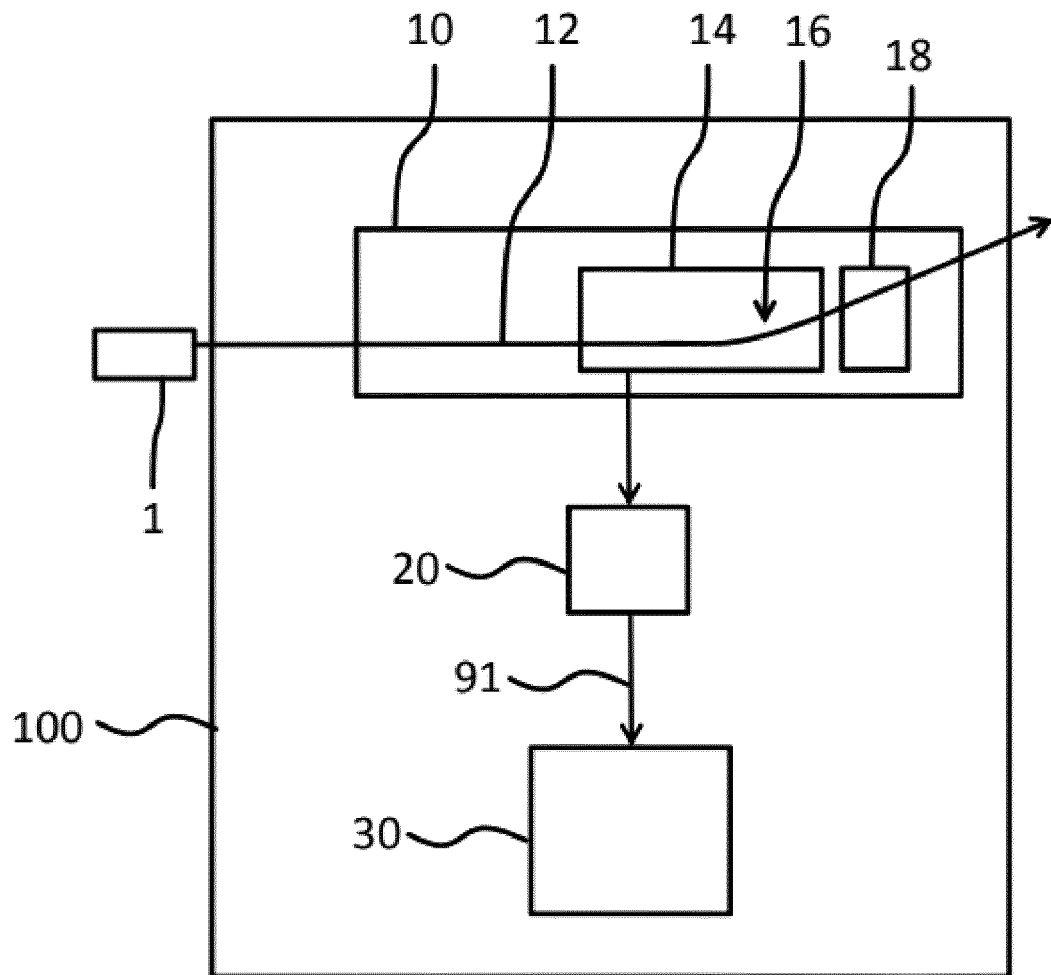


Fig. 2

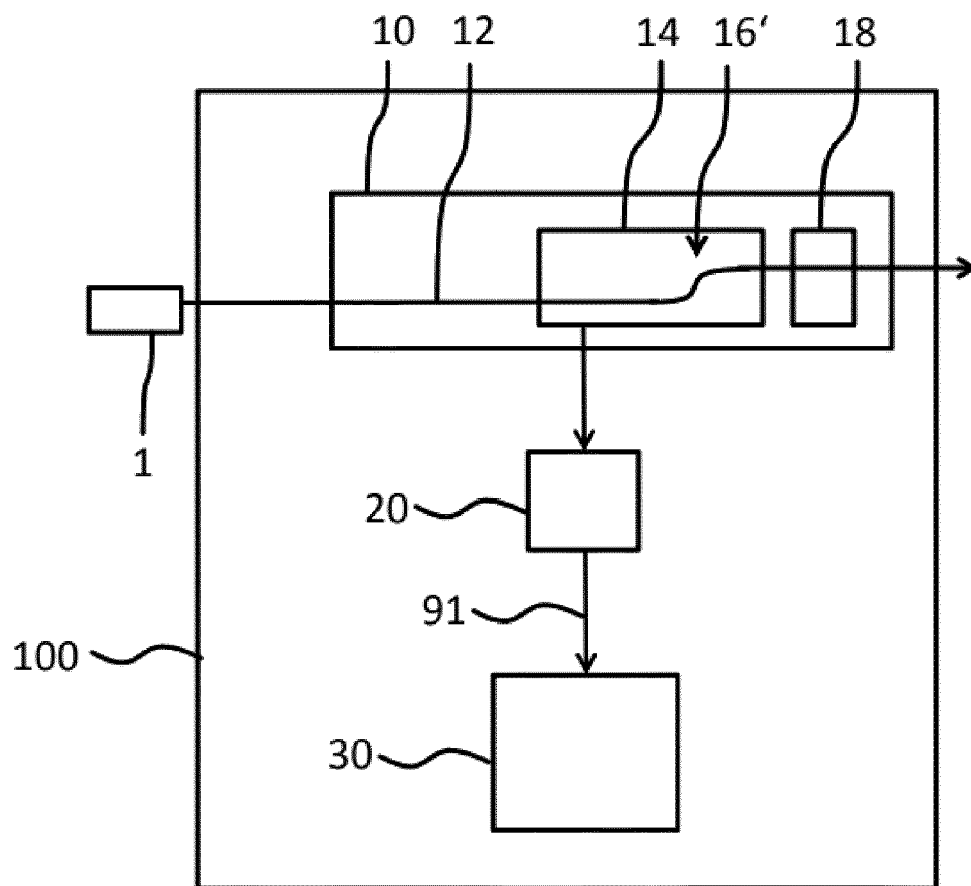


Fig. 3

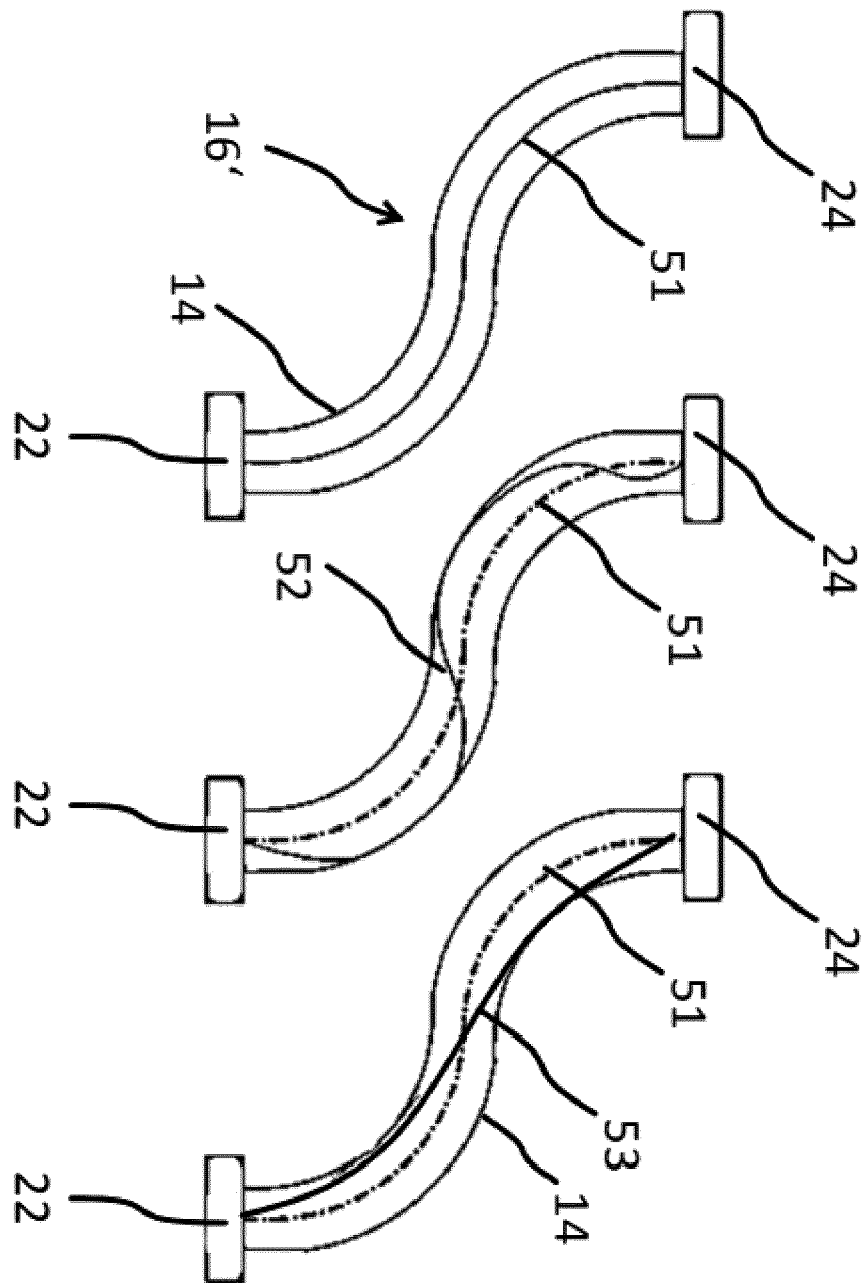


Fig. 4

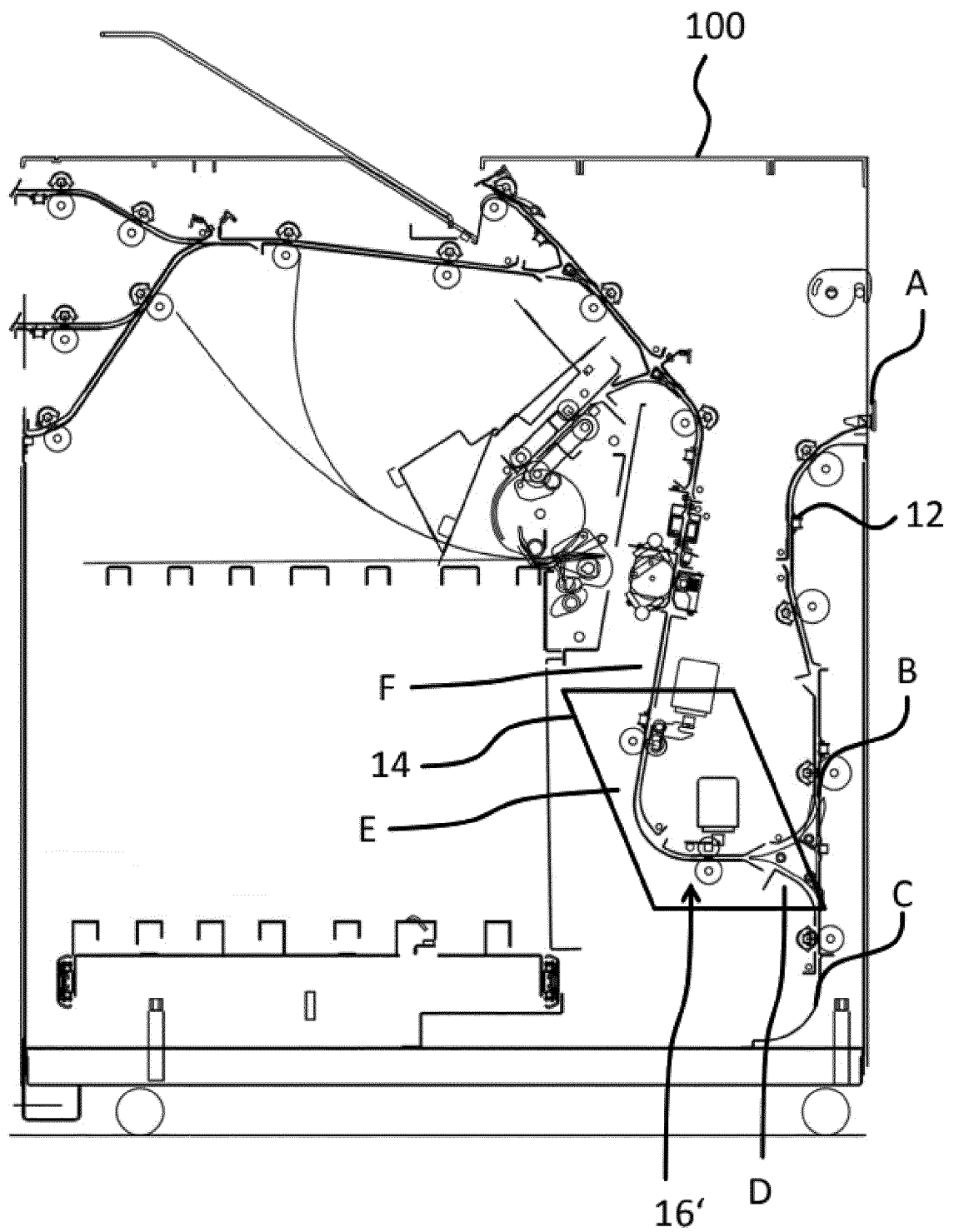


Fig. 5

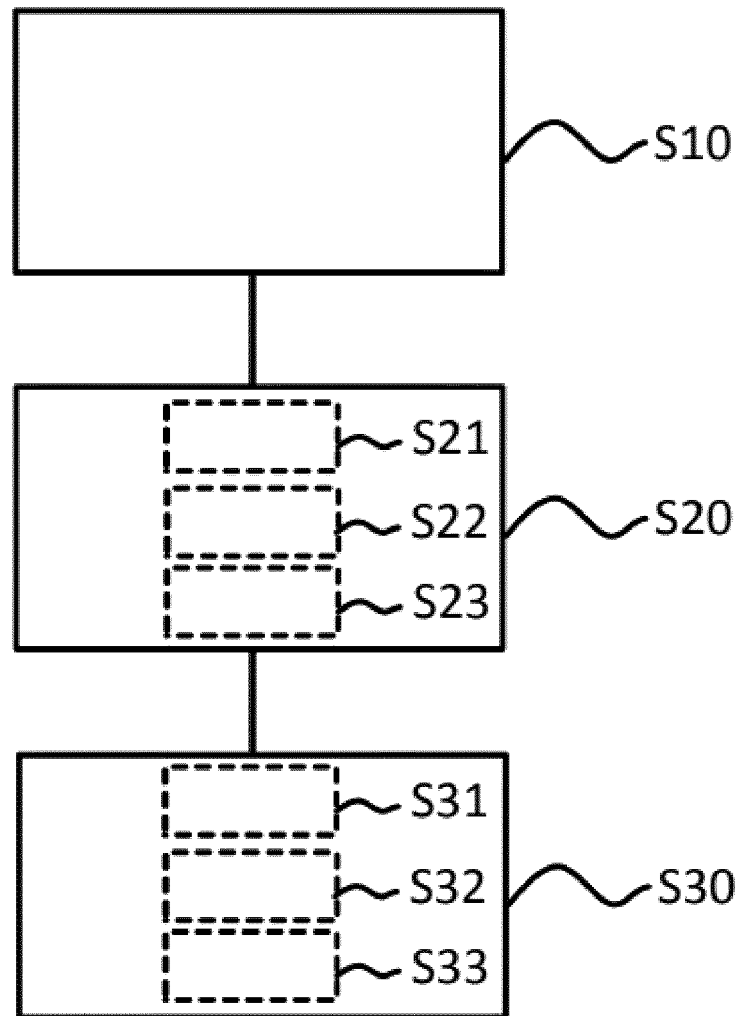


Fig. 6



EUROPEAN SEARCH REPORT

 Application Number
 EP 18 17 5329

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	US 7 036 811 B2 (XEROX CORP [US]) 2 May 2006 (2006-05-02) * the whole document *	1-15	INV. B65H5/06 B65H7/02 B65H7/20
A	EP 0 902 332 A1 (HEWLETT PACKARD CO [US]) 17 March 1999 (1999-03-17) * the whole document *	1,10	
A	US 2015/296091 A1 (ATAY STEFAN M [US] ET AL) 15 October 2015 (2015-10-15) * the whole document *	1,10	
A	EP 2 354 064 A1 (SICK INC [US]) 10 August 2011 (2011-08-10) * the whole document *	1,10	
			TECHNICAL FIELDS SEARCHED (IPC)
			B65H G03G
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 28 September 2018	Examiner Athanasiadis, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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 EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 17 5329

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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28-09-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7036811	B2	02-05-2006	NONE
EP 0902332	A1	17-03-1999	DE 69819096 D1 27-11-2003 DE 69819096 T2 22-07-2004 EP 0902332 A1 17-03-1999 JP H11147630 A 02-06-1999 US 6028318 A 22-02-2000
US 2015296091	A1	15-10-2015	US 2015185673 A1 02-07-2015 US 2015296091 A1 15-10-2015
EP 2354064	A1	10-08-2011	EP 2354064 A1 10-08-2011 JP 2011161436 A 25-08-2011 US 2011192703 A1 11-08-2011

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 7036811 B2 [0003]