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(54) **AN APPARATUS AND A METHOD FOR MAINTAINING SURFACE SMOOTHNESS OF A DOCUMENT DURING HIGH SPEED PROCESSING**

(57) The invention relates to an apparatus for a document sorting machine, in particular a banknote sorting machine. The apparatus (100) comprises: a first suction block (2); a second suction block (3); a first conveyor unit (50) for moving the document along a document guiding surface of the first suction block (2) and a second conveyor unit (51) for moving the document along a document guiding surface of the second suction block (3), the

first suction block (2) and the first conveyor unit (50) and the second suction block (3) and the second conveyor unit (51) being arranged on opposite sides of a conveyor belt-free gap, the belt-free gap being configured to accommodate an inspecting plate (1) of a sensor unit; wherein the length of the gap is substantially shorter than the length of the document. The invention also relates to a document sorting machine and methods.

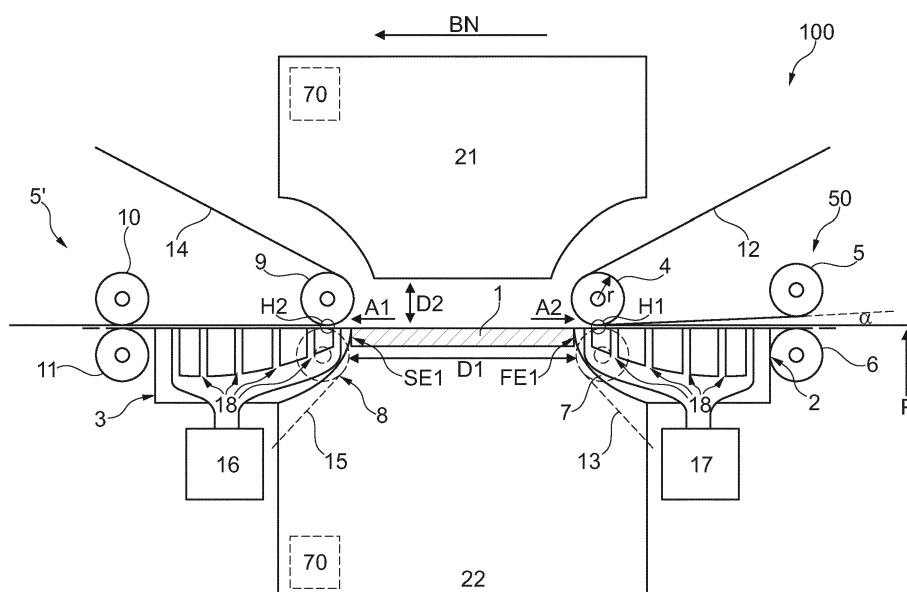


Fig. 1

Description

FIELD OF INVENTION

[0001] The invention relates to an apparatus and a method for maintaining surface smoothness of a document during high speed processing.

BACKGROUND

[0002] Automated, high- volume currency processing is an important technical field affecting numerous aspects of the distribution, collection, and accounting of paper currency. Currency processing presents unique labor task issues that are intertwined with security considerations. Currency processing requires numerous individual tasks, for example: the collection of single notes by a cashier or bank teller, the accounting of individual commercial deposits or bank teller pay-in accounts, the assimilation and shipment of individual deposits or accounts to a central processing facility, the handling and accounting of a currency shipment after it arrives at a processing facility, and the processing of individual accounts through automated processing machines. Any step in the process that can be automated, thereby eliminating the need for a human labor task, saves both the labor requirements for processing currency and increases the security of the entire process. Security is increased when instituting automated processes by eliminating opportunities for theft, inadvertent loss, or mishandling of currency and increasing accounting accuracy.

[0003] A highly automated, high-volume processing system is essential to numerous levels of currency distribution and collection networks. Several designs of high-volume processing machines are available in the prior art and used by such varied interests as national central banks, independent currency transporting companies, currency printing facilities, and individual banks. In general, currency processing machines utilize a conveyor system which transports individual notes past a series of detectors.

[0004] One of the major challenges in high-volume banknote sorting and processing consists in detecting properties of the banknote, as for example images of the banknote in order determine their authenticity or fitness. In order to obtain these properties, the banknotes have to be flat during detection/sensing. However, if the banknotes are held between conveyor belts, parts of the banknote are hidden and cannot be analyzed.

[0005] Various concepts have been developed in order to keep the banknotes flat without conveyor belts. In one of these concepts, the conveyor belts are omitted on one side while the banknote is sucked to the opposite conveyor or a plate. This, however, allows only taking images from one side of the banknote.

[0006] EP 2 081 862 A2 discloses a banknote processing machine that relies on inertia or centrifugal forces for keeping the banknotes flat during inspection. A curved

document guide is used to generate the inertia/centrifugal force. However, this solution requires too much space.

5 SUMMARY

[0007] It is an object of the present invention to provide an apparatus and methods for a valuable or security document or banknote processing machine having reduces size and costs.

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[0008] According to an aspect, an apparatus for a document sorting machine, in particular for a banknote sorting machine, is provided. The invention also provides a document sorting machine, in particular a banknote sorting machine comprising the apparatus. The apparatus can also be regarded a module.

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[0009] The apparatus or module can comprise: a first suction block (or air sucking block), a second suction block (or air sucking block), a first conveyor unit for passing the document to and/or along the first suction block and a second conveyor unit for receiving the document at second suction block and/or passing the document along the second suction block.

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[0010] As per definition, the document, while moving through the apparatus has a leading edge and a trailing edge in the direction of movement of the document.

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[0011] The apparatus can further comprise a sensor unit for determining properties of the document.

[0012] The apparatus can also comprise a processing unit for processing data from the sensor unit.

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[0013] In an aspect, there is a belt-free gap between the first suction block and the second suction block. The first conveyor unit and the first suction block can be arranged on one side of the belt-free gap and the second suction block and the second conveyor unit can be arranged on a second side of the belt-free gap (in the direction of the movement of the document). In other words, they are arranged on opposite sides of the belt-free gap (or inspecting plate).

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[0014] The belt-free gap can be configured to accommodate an inspecting plate of a sensor unit. The length of the gap can be substantially shorter than the length of the document. This implies that the length of the inspection plate in the direction of the movement of the document is also substantially shorter than the document.

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[0015] The air suction blocks create an air flow under beneath the document (between the document guiding surfaces of suction blocks) that serves to suck the documents to the suction blocks. This keeps the document already flat. Furthermore, the air suction blocks also create an air flow in the belt-free gap and in particular between the document guiding surface of the inspecting plate and the document. This air flow towards the first and the second air suction blocks reduces or prevents air buffering in the area of the inspecting plate and keeps the document substantially flat.

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[0016] Advantageously, the apparatus also comprises the inspecting plate. The inspecting plate can be ar-

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ranged between the first suction block and the second suction block and fill the gap. The upper surface of the inspecting plate is configured as a conveyor-free area. The sensor unit may then further be configured to detect a property of the document while passing over the inspecting plate.

[0017] The suction blocks and the inspecting plate are advantageously arranged such that there is no further gap between them.

[0018] The document can advantageously always be held by at least one of the conveyor units while moving along the belt-free gap and the inspecting plate. The conveyor units are arranged outside the gap or, in other words, outside the upper surface and area of the inspecting plate. The document can always be driven by at least one of the conveyor units. In an aspect, the document is substantially held by the first and the second conveyor unit while moving over the inspecting plate. The document may then be pushed by the first conveyor unit towards the inspection plate and/or pulled by the second conveyor unit away from the inspection plate.

[0019] The first conveyor unit only releases the document when the trailing edge of the document leaves the first suction block and/or when the trailing edge enters the inspecting plate (belt-free gap). The second conveyor unit is configured such that it pulls (moves, grabs) the document when the leading edge of the document leaves the inspecting plate (belt-free gap) and/or when the leading edge of the document enters the second suction block.

[0020] The conveyor units (first and/or second conveyor unit) can be of a one-belt, two-belts or three-belts type. The document may therefore be moved through the processing machine between two (one-belt type), four (two-belts type) or six (three-belts type) conveyor belts. The respective conveyor belt systems are known in the art.

[0021] The upper surfaces (document guiding surfaces) of the first suction block, the second suction block and the inspection plate are advantageously in the same flat plane on which the document can move.

[0022] However, in an aspect the plane of the upper surface of the first suction block can also have a very small inclination with respect to the plane of the upper surface of the inspection plate.

[0023] The previous aspects support that the document remains flush on the inspecting plate. Once the document is released from any conveyor unit, an air buffer will built up between the document and the upper surface of any plate or block (suction block, inspecting plate) on which the document is supposed to move. The effect of the suction blocks is that an air buffering between the document and the upper surface of the inspecting plate is reduced or even prevented and the surface smoothness of the document during quality control by the sensor unit is maintained.

[0024] Dependent on the type of the sensor unit, the inspecting plate can be made of various suitable mate-

rials as for example metal, steel, glass, and/or ceramics.

[0025] The sensor unit can be any kind of detector of properties or features of the document. It might be a sensor for detecting magnetic properties, or properties of the document like size, authenticity or fitness in general. In an embodiment, the sensor unit may be an image capture device which is configured to determine whether the document is complete or other properties of the document. The sensor unit may also be configured to detect security features on the document. If the sensor unit is an image capture device, the inspecting plate is advantageously transparent.

[0026] The sensor unit may comprise a first (may also be referred to as upper) sensor module and a second (may also be referred to as lower) sensor module. The first sensor module and the second sensor module can be arranged on opposite sides of the inspecting plate for sensing a property of the document from both sides. This aspect provides that the document or banknote can be sensed from both sides.

[0027] If the sensor unit is an image capture device, the first and second sensor module may take an image of the document in at least reflection of one side (or both sides) and/or transmission.

[0028] In case of an image capture device, the first sensor module of the image capture device may comprise a first light source and the second sensor module of the image capture device may comprise a second light source. The two light sources are arranged on opposite sides of the inspecting plate. The document or banknote may then be checked in reflection from both sides and in transmission.

[0029] The processing unit may generally be configured to process sensor data from the sensor unit, for example an image of the document received from the sensor unit, and to determine the authenticity and/or soiling and/or fitness of the document based on the sensor data.

[0030] In an advantageous embodiment, the inspecting plate can be coupled or fixedly coupled or can even form part of the first or second sensor module. If the inspecting plate and the sensor module are coupled to each other as an integral single component, the amount of soil or dust between the inspecting plate and the portion of the sensor unit can be reduced.

[0031] The length of the inspecting plate in the direction of the movement of the document can advantageously be 7 mm to 40 mm. This means also that the gap (when the inspecting plate is absent) can advantageously be 7 mm to 40 mm. Accordingly, there is a small belt-free gap for accommodating the inspecting plate over which the document or banknote passes. While passing over the gap (inspecting plate), properties can be sensed and/or detected from both side. For example, images can be taken from both sides of the document in reflection, but additionally images can be taken in transmission. This means that many if not all necessary checks of the authenticity and/or fitness of the banknote can be made

within a single step.

[0032] Advantageously, a distance between the inspecting plate and the first or second sensor module can be between 2 mm and 12 mm, and advantageously 5 mm to 12 mm. This means that the opening through which the document moves has a limited height. This is possible as the document remains flat and flush on the plate due to the suction blocks.

[0033] The first suction block and the second suction block can comprise through holes through which air is sucked by an underpressure below atmospheric pressure in a range of 0.1 bar to 0.8 bar, in particular 0.3 bar to 0.4 bar. The underpressure not only serves to keep the document close to the suction blocks. It also provides that any air buffers between the document and the flat surface of the suction blocks and/or the inspecting plate are prevented.

[0034] In an aspect, the document guiding surfaces of the first suction block, the inspecting plate and the second suction block lie in one plane. In other words, the surfaces of the three elements, suction block and inspecting plate can provide one even surface for the document.

[0035] However, in an advantageous embodiment, the upper surface of the first suction block may be slightly, and only slightly, tilted with respect to the surface of the inspecting plate. The angle of inclination of the upper surface of the first suction block may only be 0° to 4°. Such a small inclination of the upper document guiding surface of the first suction block can provide an improved aerodynamic effect for the document. The risk of air buffering below the banknote may thereby be further reduced. The angle of inclination has to be kept very small to avoid negative effects when the leading edge of the document gets in contact with the inspecting plate.

[0036] There may also be small steps between the upper surfaces of the first suction block, the inspecting plate and the second suction block. These small steps may have a height of up to 0.3 mm. This further reduces the risk of air buffering below the banknote.

[0037] The invention also provides a document or banknote sorting machine including a device in accordance with the aspects and embodiments of the invention.

[0038] The invention further provides a method of sorting documents, in particular banknotes. A document may be passed from a first conveyor unit to a first suction block. The first suction block provides an underpressure to the lower surface of the document. The document is then passed/pushed to an inspecting plate by the first conveyor unit over the upper surface of the first suction block. The document is passed over the inspecting plate while sensing properties of the document by a sensor unit. The document is moved over the conveyor-free inspecting plate by either one or both of a first conveyor unit and a second conveyor unit both being arranged outside the area of the inspecting plate. After having (partially) passed the inspecting plate, the document is received at a second suction block and a second conveyor unit opposite to the first suction block and the first con-

veyor unit with respect to the inspecting plate. The document is finally passed from the second suction block and the second conveyor unit for further processing the document.

[0039] The document can advantageously be tilted by a predetermined angle with respect to the upper document guiding surface of the inspecting plate before passing it to the inspecting plate. This further decreases air buffering between the document and the upper document guiding surface of the inspecting plate.

[0040] In the context of this description, the document or banknote is considered to be a flat sheet of material. The document or banknote is also considered to basically define a plane or extend in a single plane. If the document or banknote is described to be tilted, rotated or turned by an angle, this means that the entire plane of the flat document is tilted by the respective angle. Furthermore, the angle of tilting or inclination relates to the direction of movement in a sorting machine. With respect to this movement, the document or banknote has a leading edge and a trailing edge. The document or banknote is assumed to be flat (in a single plane). The angle of rotation or inclination is then considered to occur around an axis that is parallel to the leading edge and/or trailing edge of the document or banknote.

[0041] The invention generally provides methods and devices for sorting machines for valuable documents, in particular banknotes. The invention ensures surface smoothness of the document during quality control by sensor evaluation. A belt-free support for the document is provided, along which properties of the document are detected and determined. In case of an image capture device, images (be it by any kind of camera or scanning device) can be taken from the document in reflection from both sides and in transmission (through the document). The document is kept flat on the inspecting plate (for example glass, metal, steel, or ceramics etc.) and is driven by at least one conveyor unit which is arranged outside the inspecting plate (conveyor free area). Underpressure is provided below the document by vacuum suction. However, the respective suction blocks remain outside the inspecting plate. Furthermore, the upper document guiding surface of a device along which the document is guided towards the inspecting plate can have a (small) angle of inclination in order to further reduce any risk of air buffering between the document and the inspecting plate. Still further, small steps may be provided between the upper surface of the inspecting plate and the upper surfaces of the suction blocks.

BRIEF DESCRIPTION OF DRAWINGS

[0042] Further aspects, characteristics and advantages of the invention will ensue from the following description of the embodiments with reference to the accompanying drawings, wherein

FIG. 1 is a simplified cross-sectional view of an em-

bodiment of the invention,

FIG. 2 is a simplified top view on the embodiment of FIG. 1,

FIG. 3A-C are simplified cross-sectional side views on possible details of the embodiments shown in FIG. 1 and FIG. 2, and

FIG. 4 is a simplified block diagram of a document processing and/or sorting machine according to an embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0043] FIG. 1 is a simplified cross-sectional view of an embodiment of the invention. There is a module or apparatus 100 for a document or banknote sorting machine. The apparatus comprises an inspecting plate 1 which is arranged between a first suction block 2 and a second suction block 3. The apparatus 100 further comprises a first conveyor unit 50 and a second conveyor unit 51 and a sensor unit (for example, image capture device) comprising a first sensor module 21 and a second sensor module 22. The document or banknote moves along the direction indicated by the arrow BN. The first conveyor unit 50 is only represented in a simplified manner and comprises conveyor belt 12 and rollers 4, and 5 as well as the opposite or complementary conveyor belt 13 and respective rollers 7 and 6. The opposite conveyor belt 13 and in particular roller 7 of the first conveyor unit 50 are within the first suction block 2 (illustrated by dashed lines). The second conveyor unit 51 is also only represented in a simplified manner and comprises conveyor belt 14 and rollers 9, and 10 as well as the opposite or complementary conveyor belt 15 and respective rollers 8 and 11. The opposite conveyor belt 15 and in particular roller 8 of the second conveyor unit 51 are within the second suction block 3 (illustrated by dashed lines). The document is initially held and transported between the first conveyor belt 12 and the second (complementary) conveyor belt 13 of the first conveyor unit 50. After the document has passed with a leading edge the inspecting plate 1 and reaches or passes the second end SE1 of the inspecting plate 1 to reach the second conveyor unit (point H2 between the rollers 9 and 8), the document is also held and transported between the first conveyor belt 14 and the second conveyor belt 15 of the second conveyor unit 51. When the trailing edge of the document leaves the first conveyor unit 50 and/or reaches or passes the first end of the inspecting plate 1 (point H1 between the rollers 4 and 7 / release point), the document is only moved/transported by the second conveyor unit 51.

[0044] The distance between the first end FE1 of the inspecting plate 1 and the touching point/release point H1 of the last complementary rollers 4, 7 of the first conveyor unit 50 can be between 0 and 2 times r , wherein r is the radius of the rollers 4, 7. The radius r of the rollers

in this embodiment is typically 7.5 mm and 12.5 mm.

[0045] The distance between the second end SE1 of the inspecting plate 1 and the touching point/pick-up point H2 of the first complementary rollers 9, 8 of the second conveyor unit 51 can be between 0 and 2 times r , wherein r is the radius of the rollers 9, 8. The radius r of the rollers in this embodiment is typically 7.5 mm and 12.5 mm.

[0046] The distance X between the release point H1 and the pick-up point H2 can therefore be between the length $D1$ of the inspecting plate 1 (which is also the length of the belt-free gap) and the length $D1$ of the inspecting plate 1 plus 4 times r , where r is the radius of the rollers ($D1 \leq X \leq D1 + 4 \cdot r$).

[0047] There can be one two or three first and respective second belts arranged side-by-side (meaning two, four or six conveyor belts all together) dependent on the type of conveyor system.

[0048] Both conveyor units 50 and 51 are only represented in a very simplified manner. The document or banknote passes from the first conveyor unit 50 along the first suction block 2. The first suction block 2 comprises though holes 18 through which air can be sucked by an underpressure which is created in a suitable suction device 17. The second suction block 3 also comprises though holes 18 through which air can be sucked by an underpressure which is created in a suitable suction device 16. Suction devices 16 and 17 may of course be a single device.

[0049] The suction blocks 2 and 3 suck the parts of the document down which are not held between the complementary conveyor belts 12, 13 and 14, 15, respectively. Another important air flow due to the suction blocks (the underpressure) is indicated by arrows A1 and A2. In fact, the suction blocks 2, 3 also prevent air from buffering between the document and the upper surface (document guiding surface) of the inspecting plate 1. As a consequence, the document remains flush on the inspecting plate 1 and the properties of the document can be well sensed. For example, images can be taken in reflection from both sides of the document and in transmission.

[0050] Accordingly, the first and second sensor modules 21, 22 of the sensor unit, for example two image capture devices can be configured to sense or detect a property (for example images) of the document while passing over the inspecting plate 1. The sensed or detected property (for example captured images) may then be further processed and evaluated in a processing unit 70.

[0051] The first sensor module 21 and the second sensor module 22 are arranged on opposite sides of the inspecting plate 1. In case of image capture devices, the image capture devices take a picture or scan of both sides of the document in reflection and also one scan or picture in transmission.

[0052] In case of an image capture device, the first sensor module 21 of the image capture device may comprise a first light source and the second sensor module 22 of the image capture device may comprise a second

light source. The two light sources can be arranged on opposite sides of the inspecting plate 1. The first sensor module 21 of the image capture device may also comprise a first image capture unit, for example a camera or scanner, and the second sensor module 22 of the image capture device may comprise a second image capture unit, for example a camera or a scanner. The two light sources can be arranged on opposite sides of the inspecting plate 1. The document or banknote may then be checked in reflection from both sides and in transmission.

[0053] The processing unit 70 can be configured to process any sensor data, for example an image, of the document received from the sensor modules 21, 22 and to determine the authenticity and/or soiling and/or fitness of the document.

[0054] In an advantageous embodiment, the inspecting plate 1 can be coupled (or fixedly coupled) or can even form part of the first or second sensor module. If the inspecting plate 1 and one of the sensor modules 21, 22 are coupled to each other as an integral single component, the amount of soil or dust between the inspecting plate 1 and the portion of the sensor modules 21, 22 can be reduced. In this embodiment, the inspecting plate 1 forms part of the second sensor module 22.

[0055] The length D1 of the inspecting plate 1 in the direction BN of the movement of the document can advantageously be 7 mm to 40 mm. There is a small belt-free gap formed by the inspecting plate 1 over which the banknote passes. While passing over the belt-free gap, i.e. over the inspecting plate 1, sensor data, as for example images can be taken from both sides of the document in reflection and also in transmission. Dependent on the type of the sensor unit, other properties of the document may be determined. This means that many or all necessary checks of the authenticity and/or fitness of the banknote can be made within a single step.

[0056] The first suction block 2 and the second suction block 3 comprise through holes 18 through which air is sucked by an underpressure below atmospheric pressure in a range of 0.1 bar to 0.8 bar, in particular 0.3 bar to 0.4 bar. The underpressure not only serves to keep the document close to the suction blocks 2, 3 (outside the conveyor belts). It also provides that any air buffers between the document and the flat upper surface of the suction blocks 2, 3 and/or the inspecting plate 1 are prevented.

[0057] The volume of sucked air is advantageously in relation to the amount of underpressure. The volume may be in the range from 1 m³ to 100 m³ per hour.

[0058] The volume of the sucked air can be a function of the amount of underpressure. The volume of sucked air can be determined as a function (or in relation to) the size (for example diameter) of the holes 18. The holes 18 may have a diameter in the range of 0.5 mm to 2 mm, in particular, the holes 18 may have a diameter of 1.2 mm. The volume of sucked air and/or the amount of underpressure can also be a function of the number per

area or density of the holes 18. The holes 18 may be arranged in a regular grid. The distance of the holes 18 may then be in the range of 1 mm to 20 mm, and in particular 5 mm.

[0059] In an aspect, the document guiding surfaces of the first suction block 2, the inspecting plate 1 and the second suction block 3 lie in one plane. In other words, the surfaces of the three elements, suction blocks 2, 3 and inspecting plate 1 can provide one even guiding surface for the document.

[0060] However, in the present advantageous embodiment, the upper surface of the first suction block 2 can also be slightly tilted with respect to the surface of the inspecting plate 1. The angle of inclination of the upper surface of the first suction block 2 with respect to the document guiding surfaces of the inspecting plate 1 and/or the second suction block 3 may only be 0° to 4°, i.e. the angle may have a maximum of 4°. Such a small inclination of the upper document guiding surface of the first suction block 2 can provide an improved aerodynamic effect for the document. The risk of air buffering below the banknote is thereby further reduced. The angle of inclination has to be kept very small to avoid negative effects when the leading edge of the document gets in contact with the inspecting plate 1.

[0061] The distance D2 between the upper document guiding surface of the inspecting plate 1 and the surface of the first sensor module 21 can be 2 mm to 12 mm.

[0062] The speed of the documents or banknotes in moving direction BN can be about 8 m/s or faster (an advantageous value is also 10 m/s).

[0063] The inspecting plate 1 can be made of any smooth (and transparent) material, as for example glass, metal, steel or ceramics.

[0064] FIG. 2 is a simplified top view on the embodiment of FIG. 1. The document moves in the direction indicated by the arrow BN (from right to left). There is only one conveyor belt 12, 14 per conveyor unit 50, 51. The respective belts 12, 14 hold the document. The document, in particular a banknote can have a width between 50 mm and 90 mm. In this embodiment, the suction blocks 2, 3 can have a width of 110 mm. Some of the upper rows RU and/or lower rows RL of the holes 18 may not be covered when the document has a smaller width.

[0065] From this perspective, it becomes apparent that the conveyor units 50, 51 advantageously end before the inspecting plate 1. The last roller 4 of the first conveyor unit 50 is arranged such that document is only released from the conveyor belt 12 when the trailing edge of the document leaves the first suction block 2 (or the previously described touching point/release point H1, see FIG. 1). The first roller 9 of the second conveyor unit 51 is arranged such that document is grabbed by the conveyor belt 14 when the leading edge of the document leaves the inspecting plate and/or arrives at the second suction block 3 (or the previously described touching point/pick-up point H2, see FIG. 1). The rollers 9 and 4 (and also the respective complementary or opposite rollers 8 and

7) are arranged as close as possible to the inspecting plate 1 but still outside the inspecting area of the inspecting plate 1. There are advantageously no holes 18 between the end of the rollers 4, 9 and/or the touching or holding points H1 (also release point), H2 (also pick-up point) as shown in FIG. 1 and the opposite ends FE1, SE1 of the inspecting plate 1. However, there can advantageously be holes 18 in the suction blocks which do not have a greater distance from the respective outer edges of the inspection plate 1 than 1 cm, in particular 0.5 cm.

[0066] The through holes 18 in the suction blocks 2, 3 may be evenly distributed over the entire upper surface of the suction blocks 2, 3. They may be arranged in a regular orthogonal grid. However, other arrangements are also possible. The inspecting plate 1 does not have through holes. The inspecting plate 1 is closed and firmly sealed against soil and/or dust.

[0067] The lower or complementary conveyor belt 13 of the first conveyor unit 50 is not shown, but divides the first suction block 2 in an upper part UP2 (first part) and a lower part LW2 (second) on each side of the conveyor belt 13. The lower or complementary conveyor belt 15 of the second conveyor unit 51 is not shown, but also divides the second suction block 3 in an upper part UP3 (first part) and a lower part LW3 (second part) on each side of the conveyor belt 15. In the area of the belts 13 and 15 of the first and second conveyor unit 50, 51, there are no holes 18 in the suction blocks 2, 3. However, other more complex embodiments may even use suction holes in the conveyor belts.

[0068] FIG. 3A, 3B and 3C are simplified cross-sectional side views on possible details of the embodiments of the invention. The upper surfaces O2, O1 and O3 of the first suction block 2, the inspecting plate 1 and the second suction block 3 serve as the document guiding surfaces for the document DOC, which can be a banknote. The document moves in the direction indicated by the arrow BN (from right to left). In the first embodiment shown in FIG. 3A, the three upper surfaces O1 to O3 of the inspecting plate 1 and the two suction blocks 2, 3 are all on the same level and provide a smooth and flat document guiding surface. Air is sucked through holes 18 which are provided in the two suction blocks 2, 3. The air flows indicated by arrows A1 and A2 provide that air buffering between the document DOC and the upper air guiding surfaces O1, O2 and O3 is prevented. The document DOC has a forward momentum provided by the first conveyor unit 50 which is not shown.

[0069] In the second embodiment shown in FIG. 3B, the upper surface O2 (plane of the surface) of the first suction block 2 is slightly tilted with respect to the upper surface (plane of the surface) of the inspecting plate 1 by an angle α . This angle should be very small and not be greater than 4° . This angle provides that the document DOC is slightly tilted with respect to the upper surface O1 of the inspecting plate. The tilting or slight rotation of the plane of the document DOC provides that the document

DOC is pressed to the inspecting plate 1 and air buffering between the document DOC and the inspecting plate is reduced or prevented.

[0070] In the third embodiment shown in FIG. 3C, there may also be small steps S1, S2 between the upper surfaces O1, O2, O3 of the first suction block, the inspecting plate and the second suction block. These small steps S1, S2 may have a height of up to 0.3 mm. This can further reduce the risk of air buffering below the document DOC.

[0071] The sensor unit, in particular the sensor modules 21, 22 are advantageously independent from the suction blocks 2, 3. The suction blocks 21, 22 and the conveyor units 50 are advantageously part of the general transport system of the document processing/sorting machine. The sensor modules 21, 22 are then fitted into the gap between the suction blocks 2, 3. The second sensor module 22 advantageously includes the inspecting plate 1.

[0072] FIG. 4 is a simplified block diagram of a document sorting/processing machine 200 according to an embodiment. The document sorting/processing machine 200 (or paper currency processing apparatus) comprises the apparatus 100 according to the herein described aspects and embodiments. The machine 200 is generally configured to process documents, for example paper currency (banknotes). The machine may comprise a supply section 301 in which a large number of documents/banknotes can be placed (stacked). There is also a pick-up stage 302 which is configured to pick up the documents from the supply section 301. The documents are then transferred on a transfer path 303 comprising a plurality of endless conveyor units (not shown). The documents are transferred (moved, transported) by the conveyor units by holding the documents between conveyor belts. The documents are transferred to a general auditing device 303 one by one.

[0073] The auditing device 303 may comprise various stages among which the apparatus 100 according to the embodiments and aspects of the invention may be located. The auditing device 303 may generally be configured to perform one or more of the following tasks: determining the denomination, shape thickness, top/back genuineness, normality or defacement and the like. Some or all of these tasks may then be performed by and in the apparatus 100 according to the aspects and embodiments of the invention. According to the result of the auditing, the documents/banknotes are either rejected and transferred to a rejection stage 304 or approved and transferred to section 305 for being re-circulated.

[0074] The apparatus 100 according to the aspects and embodiments of the present invention provides, among others, a fitness sensor (sensor unit), for example including a camera system having a clear view to the document from both sides (reflection) and in transmission without disturbing elements like belts or support fences. The belt-free gap in the transport system does not increase the jam-rate in that particular part of the transport

system. The length of the belt-free gap or length of the inspecting plate 1 in the direction of the movement of the document is kept very small. It may range up to 40 mm, and advantageously ranges from 7 mm to 40 mm, while 7 mm is also an advantageous value.

[0075] While various embodiments have been described, the description is intended to be exemplary, rather than limiting and it will be apparent to those of ordinary skill in the art that many more embodiments and implementations are possible that are within the scope of the embodiments. Accordingly, the embodiments are not to be restricted except in light of the attached claims and their equivalents. Also, various modifications and changes may be made within the scope of the attached claims.

LIST OF REFERENCE SIGNS

[0076]

200: Document sorting/processing machine
 100: Module/Apparatus
 1: Inspecting plate
 2: First suction block
 3: Second suction block
 4-11: Rollers
 12-15: Belts
 16, 17: Vacuum/Underpressure Generator
 18: Holes in suction blocks
 21: First sensor module
 22: Second sensor module
 50, 51: first and second conveyor
 70: image processing unit
 BN: Direction of movement of document/banknote
 A1: First Airflow
 A2: Second Airflow
 D1: Length of Inspecting plate 1 = Width of Gap
 D2: Distance between inspecting plate 1 and First Imaging Block 21
 01, 02, 03: Upper surfaces (planes) of vacuum blocks 2, 3 and inspecting plate 1
 S1, S2: steps between inspecting plate 1 and vacuum blocks.

Claims

1. An apparatus (100) for a document sorting machine, in particular a banknote sorting machine, comprising: a first suction block (2); a second suction block (3); a first conveyor unit (50) for moving the document along a document guiding surface of the first suction block (2) and a second conveyor unit (51) for moving the document along a document guiding surface of the second suction block (3), the first suction block (2) and the first conveyor unit (50) and the second suction block (3) and the second conveyor unit (51) being arranged on opposite sides of a conveyor belt-free gap, the belt-free gap being configured to ac-

commodate an inspecting plate (1) of a sensor unit; wherein the length of the gap is substantially shorter than the length of the document.

- 5 **2.** The apparatus according to claim 1, wherein the first conveyor unit is configured to only release the document when a trailing edge of the document leaves the first suction block and/or the second conveyor unit is configured to only pull the document when a leading edge of the document leaves the belt-free gap and/or when or after the leading edge of the document enters the second suction block.
- 10 **3.** The apparatus according to claim 1 or 2, further comprising a sensor unit and the inspecting plate (1), the inspecting plate being arranged between the first suction block (2) and the second suction block (3) as a conveyor-free area and the sensor unit comprises the inspecting plate (1).
- 15 **4.** The apparatus according to claim 3, wherein the sensor unit comprises a first sensor module (21) and a second sensor module (22), the first sensor module and the second sensor module being arranged on opposite sides of the inspecting plate (1).
- 20 **5.** The apparatus according to claim 4, wherein a distance between the inspecting plate and the first sensor module is between 2 mm and 12 mm, in particular between 5 mm and 12 mm.
- 25 **6.** The apparatus according to claim 4 or 5, wherein the inspecting plate (1) forms an integral part of the second sensor module (22).
- 30 **7.** The apparatus according to anyone of the previous claims, wherein the length of the belt-free gap and/or the length (D1) of the inspecting plate (1) in the direction of the movement of the document is in a range from 7 mm to 40 mm.
- 35 **8.** The apparatus according to anyone of the previous claims, wherein the first suction block (2) and the second suction block (3) comprise through holes (18) through which air is sucked by an underpressure below atmospheric pressure in a range of 0.1 bar to 0.8 bar, in particular 0.3 bar to 0.4 bar.
- 40 **9.** The apparatus according to anyone of the previous claims, wherein the sensor unit is configured as an image capture device for taking images of the document in reflection from both sides of the document and in transmission while the document moves over the inspecting plate (1).
- 45 **10.** The apparatus according to claim 9, further comprising a processing unit (70), wherein the processing unit is configured to process an image of the docu-
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ment received from the sensor unit and to determine the authenticity and/or soiling and/or fitness of the document.

11. A document/banknote sorting machine (200) comprising an apparatus according to anyone of the previous claims.

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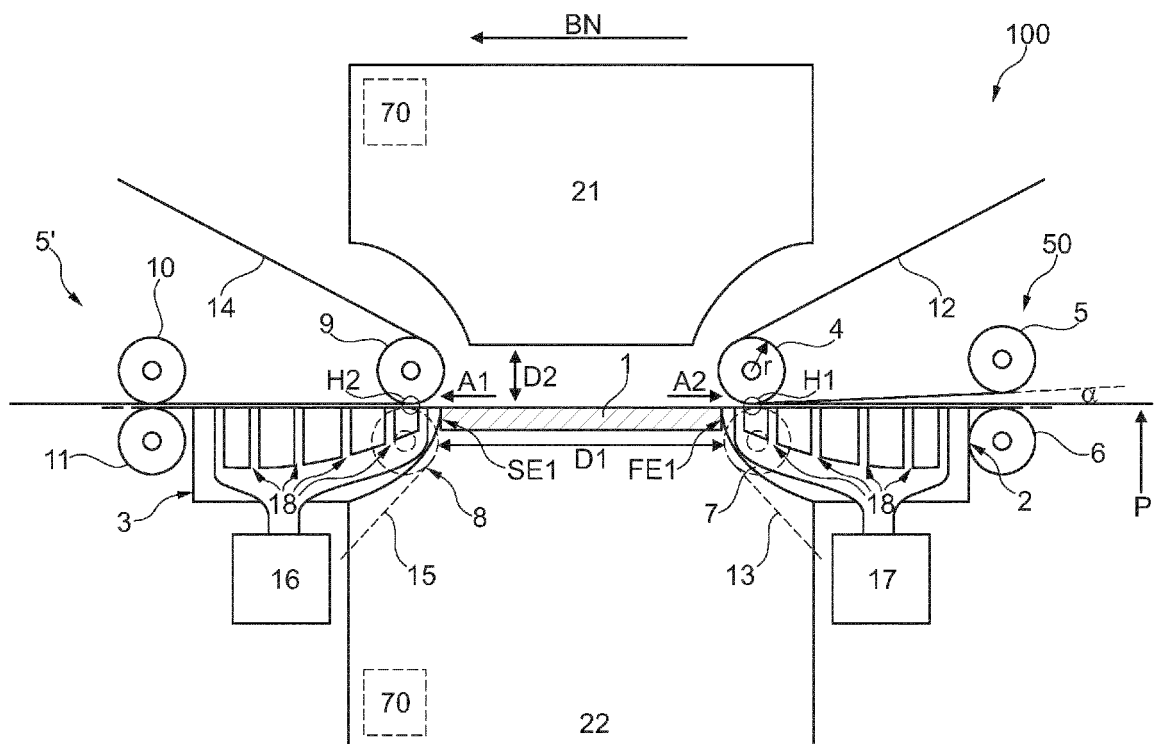


Fig. 1

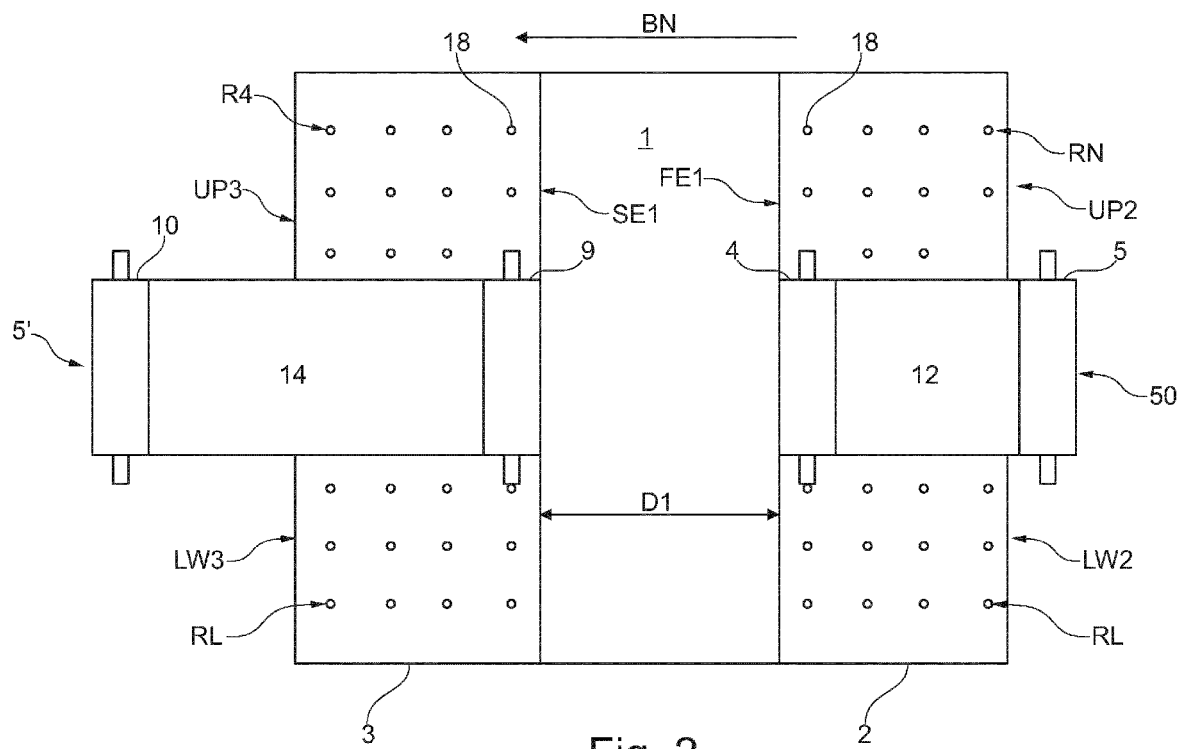


Fig. 2

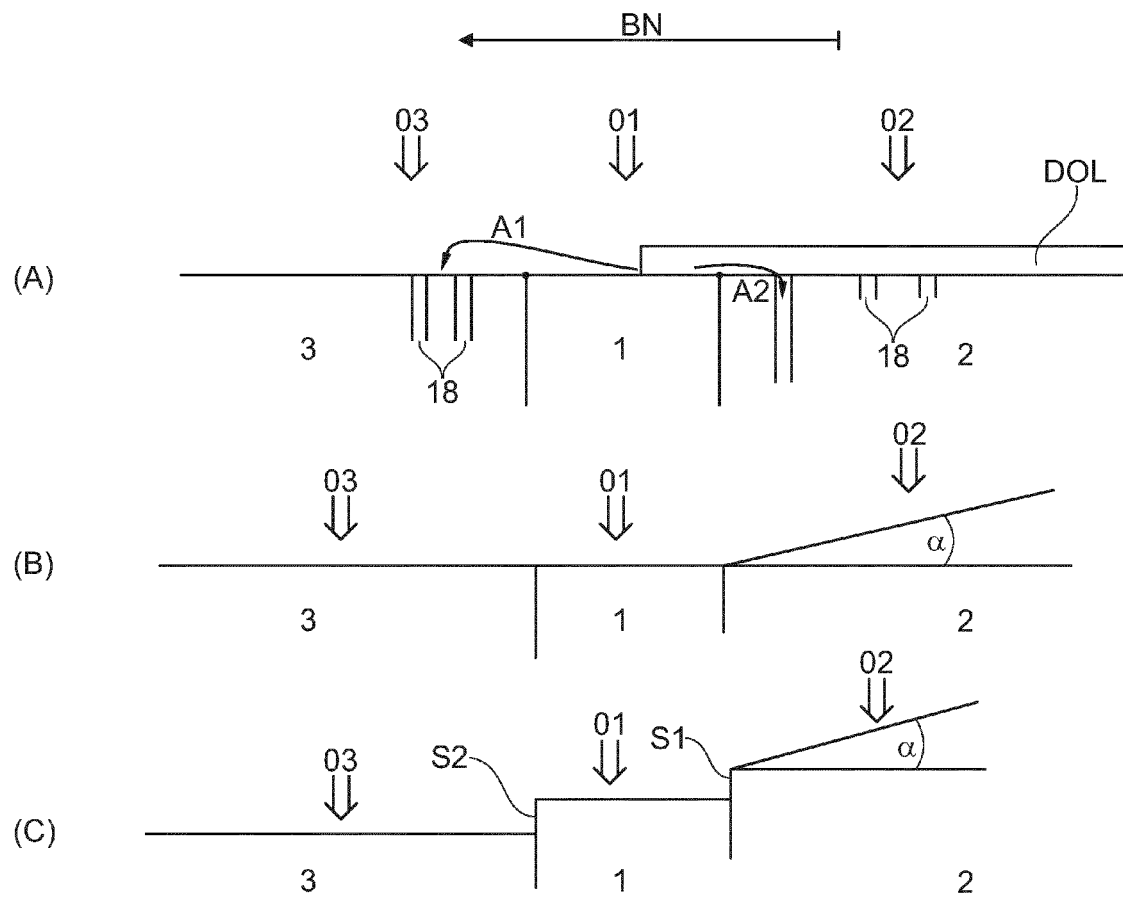


Fig. 3

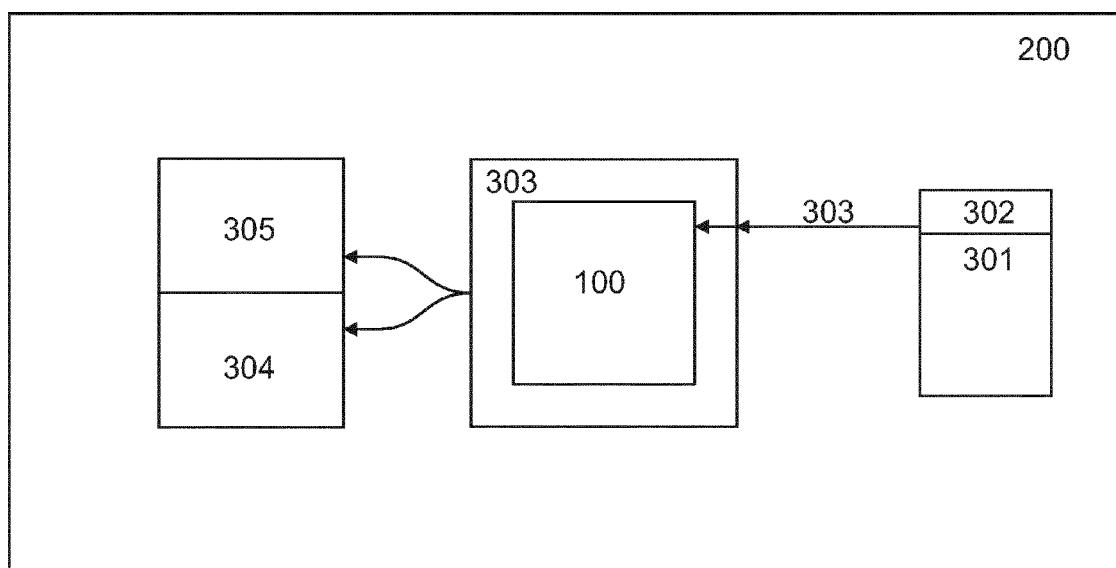


Fig. 4



EUROPEAN SEARCH REPORT

Application Number
EP 15 17 1743

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 4 November 2015	Examiner Bauer, Sebastian
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