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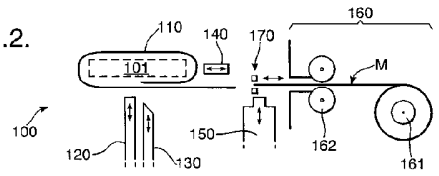
Fig.2.



(57) Abstract: A strapping apparatus (100) is provided for strapping a stack (S) of sheet documents. The apparatus comprises: a strap feeder (160) adapted to feed a length of strap material (M) into the strapping apparatus; a guide channel (110) arranged to receive the leading edge of the strap material from the strap feeder, to guide the leading edge around a stack receipt zone (101) and to overlap the leading edge with an upstream portion of the strap material, resulting in overlapping portions of strap material in an overlap region of the guide channel, so as to form a closed loop of strap material around the stack receipt zone, the stack receipt zone being configured to accommodate a stack of sheet documents in use; a sealing unit (120) adapted to join the overlapping portions of the strap material to one another at a joining point; and a cutting unit (130) for cutting the strap material upstream of the joining point. The invention also provides a stacking apparatus (50) for forming stacks of sheet documents.

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APPARATUS FOR STRAPPING STACKS OF SHEET DOCUMENTS, APPARATUS FOR FORMING STACKS OF SHEET DOCUMENTS AND CORRESPONDING METHODS

This invention relates to strapping apparatus and stacking apparatus for strapping stacks of sheet documents and forming stacks of sheet documents, respectively. The invention also encompasses corresponding methods therefor.

Document handling machines are used in many fields to process sheet documents such as banknotes, certificates, cheques, letters and other papers. Typical functions performed by a document handling machine include sorting, counting, storage, dispensing and authenticating sheet documents. An example of a document handling apparatus is disclosed in WO2005/118443, and available products of this sort include the Kalebra™, Cobra™ (also known as the De La Rue 4000) and the CPS 1200 (also known as the De La Rue 7000), all made by De La Rue International Limited of Basingstoke, UK. The primary function of the apparatus disclosed in WO2005/118443 is to sort banknotes into different denominations and/or currencies. To do so, the apparatus includes differentiation means for distinguishing one banknote type from another, and a plurality of output pockets into which notes of each type are sorted. Each output pocket includes a stacking apparatus which forms the notes directed to that pocket into a stack in which the notes are arranged face to face. The stack of notes can then be removed by a user and dealt with as necessary.

In many cases, the next step in the handling process is to "strap" the stack of banknotes: that is, to fit a band around the stack so that the notes are held together as one cohesive unit. The strapped stack may then be passed on for distribution by banks or vault storage, etc.

Conventional strapping apparatus form a strap around the stack of banknotes by use of a robotic arm which pulls a length of strap material around the notes, adjusts the tension and then joins the two ends of the strap material together, usually by means of heat sealing. Examples of such conventional strapping apparatus can be found in the aforementioned available products.

Such strapping apparatus may be provided as an extension of the document handling apparatus, with either a strapping device being located in each output pocket, or means being provided for transferring the stack of banknotes from the output pocket into a strapping apparatus, thereby achieving a level of automation.

However, the strapping procedure is inherently slow as a result of the time taken for the robotic arm to pass the strap material around the bundle of notes, and the time required for the heat sealing to take place. This has the result that, each time a stack of the correct size is formed in an output pocket, the output to that pocket has to be stopped whilst the completed stack is removed for strapping or whilst strapping takes place in the output pocket. This is unacceptable since the throughput of documents through the handling apparatus is of utmost importance. As such, this is currently dealt with by designating two (or more) output pockets for each note type that requires strapping. When the first output pocket completes a stack having the desired number of notes, the output is diverted to the second pocket. This allows the stack of notes formed in the first pocket to be strapped whilst the outputting continues in the second pocket. The stack from the first pocket is strapped and removed so that, when the second output pocket completes the next stack, output can be redirected to the first pocket whilst the newly completed stack is strapped in the second pocket. In this way, the throughput of notes through the machine can be maximised. However, this method carries with it a number of significant disadvantages including the requirement for more than one pocket for each note type that requires strapping. In most document handling machines, there is not an unlimited number of output pockets, and so the use of more than one for a single document type reduces the total number of different document types which can be sorted. Further, there is a high level of redundancy since at any one moment only one of the output pockets designated for each document type is in use.

The conventional strapping process also suffers from a number of further problems including inherent lack of reliability since the strapping apparatus includes a large number of moving mechanical parts which, in practice, are

found to suffer failure frequently. Further, different customers have different strapping requirements and, as such, the apparatus must handle a number of different types of strap material and sealing means. It has been found that the robotic arm technique is not good at handling such different requirements and this frequently results in incorrect tensioning of the strap. Further, the conventional strapping apparatus is expensive due to its high part count and requires frequent maintenance.

In accordance with a first aspect of the present invention, a strapping apparatus is provided for strapping a stack of sheet documents, the apparatus comprising:

a strap feeder adapted to feed a length of strap material into the strapping apparatus;

a guide channel arranged to receive the leading edge of the strap material from the strap feeder, to guide the leading edge around a stack receipt zone and to overlap the leading edge with an upstream portion of the strap material, resulting in overlapping portions of strap material in an overlap region of the guide channel, so as to form a closed loop of strap material around the stack receipt zone, the stack receipt zone being configured to accommodate a stack of sheet documents in use;

a sealing unit adapted to join the overlapping portions of the strap material to one another at a joining point; and

a cutting unit for cutting the strap material upstream of the joining point.

By making use of a guide channel which is arranged to form the incoming strap material into a loop, the use of a robotic arm is done away with. Not only does this reduce the number of moving parts, thereby increasing the robustness and reliability of the apparatus, but is also inherently faster. In addition, the configuration leads to the situation where the stack of documents to be strapped need not be present in the stack receipt zone when the loop of strap material is formed (unlike in the case of the conventional apparatus where the strap is formed by the robotic arm passing the strap around the stack of documents). This permits the loop of strap material to be formed before the stack of sheet documents arrives, thus further reducing the time required to

complete the strapping procedure on receipt of a stack. In all, the strapping apparatus allows a stack of sheet documents to be strapped much faster than previously possible.

The sealing unit may be adapted to join the overlapping portions of the strap material in a number of ways. For example, the sealing unit could apply heat in order to heat seal the strap ends together. Preferably, the sealing unit is adapted to apply pressure to the overlapping portions of the strap material. In many cases, this is sufficient by itself to effect the join. For example, the strap material may be pre-glued, the application of pressure bringing the two overlapping portions into contact with one another and thereby forming a join. In other cases, the application of pressure could be used to "crimp" the two ends of the strap to one another.

In a particularly preferred embodiment the sealing unit comprises a pressure member movable between a storage position in which the passage of the strap material is not impeded, and a sealing position in which the pressure member is extended towards the stack receipt zone at which, in use, the overlapping portions of the strap material are pressed against a stack of documents in the stack receipt zone. This arrangement makes use of the stack of documents itself for opposing the pressure applied by the pressure member, thereby removing the need for any additional components. It is particularly advantageous if this arrangement is combined with the use of a strap material which is self-adhesive or has glue applied to it in the region of the sealing unit such that application of pressure by the pressure member effects a join. Adhesive joining is much faster than heat sealing since no dwell time is required and further can be used in combination with documents formed from a substrate which may be affected by heat, such as polymer banknotes, without causing any damage.

As noted above, the strap material may be self-adhesive. However, preferably, the strapping apparatus further comprises an adhesive station adapted to apply adhesive to the strap material. This permits the use of a wide range of different strap materials and selection of the most appropriate adhesive. For example, the adhesive station may comprise a glue dot cassette.

For all the reasons set out above, the use of adhesive is greatly preferred to a heat sealing technique. The adhesive station could be located anywhere that permits it to apply adhesive to one or other (or both) of the portions of the strap material which will ultimately overlap. If designed appropriately, the adhesive station could even apply adhesive between the overlapping portions once they have been overlapped. However, preferably, the adhesive station is disposed upstream of the overlap region of the guide channel. This enables adhesive to be applied to a portion of the strap material before it becomes overlapped. In particularly preferred embodiments, the adhesive station is disclosed between the guide channel and strap feeder.

In a preferred implementation, the adhesive station is configured to apply adhesive adjacent the leading edge of the strap material on its surface forming the outer surface of the loop. When the loop is formed, this portion of the strap will be located on the innermost overlapping portion, facing the outer overlapping portion. In another preferred implementation, the adhesive station is configured to apply adhesive adjacent a trailing edge position of the strap material on its surface forming the inner surface of the loop. The "trailing edge" of the strap is formed when the strap material is cut. However, prior to cutting, it is possible to calculate where the trailing edge position will be relative to the leading edge of the strap material given knowledge of the size of the stack which is to be strapped. Therefore, if adhesive is applied in this region, once the loop is formed, the adhesive will be on the inner surface of the outermost overlapping portion of the strap material, facing the inner overlapping portion.

The guide channel may be configured so as to provide a loop of strap material which is of the precise dimensions required. However, so that adjustment may be made, the strapping apparatus preferably further comprises a tensioning unit arranged to adjust the tension of the loop of strap material prior to sealing by the sealing unit.

The tensioning unit could take many forms. For example, between the strap feeder and the guide channel, the strap material could be passed around one or more tensioning rollers which are movable in a direction perpendicular to the path of the strap material, to thereby adjust the tension of the loop.

However, preferably, the tensioning unit comprises means for reversing the trailing edge of the strap material out of the guide channel. Depending on the configuration of the guide channel in relation to the stack of sheet documents, this may by itself be sufficient to effect tensioning if there is friction between the loop of strap material and the stack to hold the leading edge of the strap material more or less in place. However, preferably, the tension unit further comprises retardation means arranged to oppose the reversal of the leading edge of the strap material, preferably a brake arranged to hold the leading edge of the strap material at a fixed position. The brake could comprise a clamp or similar which is placed on the strap material at some point between the leading edge and the trailing edge to hold it in fixed relation to the guide channel while the trailing edge of the strap material is reversed. In preferred examples, the brake may comprise a brake member which can be pressed against the strap material and the stack of documents to thereby hold the stack material in place while reversal takes place. The brake is preferably arranged as close to the leading edge of the strap as possible, so that tensioning is even around the whole of the loop.

In a particularly preferred implementation, the retardation means comprises a clamp portion of the guide channel which is movable relative to the remainder of the guide channel from a guiding position, in which the clamp portion is arranged to guide the leading edge of the strap material into a closed loop, in conjunction with the remainder of the guide channel, and a clamping position, in which at least part of the clamp portion is extended toward the stack receipt zone so as to, in use, press a portion of the strap material against the stack of documents.

This configuration keeps the number of parts to a minimum and applies the retardation closer to the leading edge of the strap material than is possible with other arrangements.

Preferably, the clamp portion of the guide channel is pivotable between the guiding position and the clamping position, an end of the clamp portion extending toward the stack receipt zone when the clamp portion is in the clamping position. This enables pressure to be applied at a narrow, well

defined position such the remainder of the upstream strap material can be tensioned evenly.

With or without the tensioning unit, the apparatus preferably comprises means for reversing the trailing edge of the strap material out of the guide channel. This can be used after cutting of the strap material to return the new leading edge (formed by the cutting step) back to a start position, e.g. for application of adhesive or simply to space the new leading edge from the completed strapped stack while it is being removed from the apparatus. In a particularly preferred embodiment, the strap feeder is further adapted for reversal of the strap material out of the strapping apparatus. This combines the reversing means into the strap feeder.

The apparatus could be operated by timing the feeding of the strap material so that its position is known. However, preferably, the strapping apparatus further comprises at least one sensing unit for sensing the position of the leading edge of the strap material. For example, a reflective or transmissive optical sensor may be used.

Preferably, the apparatus further comprises a stack support assembly arranged outside the guide channel and configured to support the stack of sheet documents within the stack receipt zone at a position spaced from the guide channel. This ensures that a space is provided between the guide channel surface and the stack of documents, so that the strap material can be moved therebetween during loop formation and/or tensioning. For example, the stack support assembly could take the form of a clamp arrangement for gripping the stack in an elevated position, or one or more support points or platforms on which the stack can be laid. Significantly, the stack support means should not extend into the guide channel, or at least not into that section of the guide channel which will receive the strap material in use, so that the stack support assembly does not obstruct formation of the strap around the stack (alone).

Advantageously, the guide channel is configured so as to receive the strap material on the innermost surface of the guide channel in the region of the strap material, such that in use the closed loop of strap material is formed

around the stack receipt zone only (even during the initial stage of loop formation, prior to any tensioning). Here, "innermost" refers to the interior of the loop, i.e. that surface of the guide channel closest to (and facing) the stack receipt zone. The region of the guide channel which receives the strap material may comprise the full width of the channel or, if the strap material is narrower than the guide channel, only that portion of the channel covered by the strap material. In this region, the surface of the guide channel against which the outer surface of the strap material lies should be the innermost surface of the guide channel, i.e. with no further surface or other structure disposed between the strap material and the stack receipt zone. In particular it is preferred that the guide channel does not include any means or surface for guiding the interior surface of the strap material, although the guide channel could include side edges for retaining the strap material laterally therebetween by guiding the side edges of the strap material (since such protrusions would be located outside the region of the guide channel receiving the strap material). In this way, the loop of strap material formed by conveying its leading edge through the guide channel encircles only the stack receipt zone and no other structure, particularly no part of the guide channel, such that when the loop is tightened or removed from the guide channel, there is no obstruction and no damage to the strap material. The strap material should preferably be sufficiently stiff that the loop formed against the guide channel is self supporting, e.g. paper.

The guide channel preferably comprises one or more guide elements encircling the stack receipt zone, arranged to receive the leading edge of the stack material on their interior surface.

Advantageously, the one or more guide elements form a substantially closed loop, at least part of the one or more guide elements overlapping, and the overlapping portions of the guide elements being spaced from one another so as to receive the leading edge of the strap material therebetween. It should be noted that the guide channel does not itself have to be a completely continuous loop but may include gaps across which the strap material is able to pass, such as one or more apertures for interaction with the sealing and cutting units for example.

In a particularly preferred implementation, the guide channel comprises first, second and third guide elements, the second and third guide elements being movable relative to each other and to the first guide element. Portions of the guide channel can then be used to perform a number of additional functions.

Preferably, the first guide element forms a base portion of the guide channel and is in fixed relation to the stack receipt zone. The first guide element can act as a support surface on which sheet documents are placed to form a stack of documents. In this case, a lift mechanism may additionally be provided to lift the stack off the first guide element prior to strapping. Alternatively, the first guide element may be arranged underneath a stack support plate on which a stack is formed, the plate being removed prior to strapping, or having a gap therethrough with which the first guide element is aligned.

Advantageously, the second guide element constitutes the clamp portion of the guide channel and is spaced from and arranged to at least partially overlap a portion of the first guide element. As described above, utilizing a portion of the guide channel as retardation means keeps the number of parts to a minimum and enables clamping close to the leading edge.

Preferably, the third guide element forms an upper portion of the guide channel and is movable between a guiding position in which the third guide element adjoins the first and second guide elements to guide the leading edge of the strap material to form a closed loop, and an open position in which the third guide element is removed from the first and second guide elements so as to permit entry of sheet documents into the stack receipt zone. This enables the stack of documents to be formed within the stack receipt zone so that no transfer means are required for placing the stack into position for strapping.

Preferably, the stack receipt zone is configured to accommodate an edge of a stack of sheet documents in use.

The first aspect of the present invention further provides a method of strapping a stack of sheet documents positioned at a stack receipt zone, the method comprising:

a) feeding the leading edge of a length of strap material into a guide channel arranged to guide the leading edge around the stack receipt zone and to overlap the leading edge with an upstream portion of the strap material, resulting in overlapping portions of strap material in an overlap region of the guide channel, so as to form a closed loop of strap material around the stack receipt zone;

b) sealing the overlapping portions of strap material to one another at a sealing point; and

c) cutting the strap material upstream of the sealing point.

As noted above, by feeding the leading edge of the strap material into a guide channel configured to form the strap material into a loop, the speed of strapping is greatly increased, both in terms of the procedure as a whole and the fact that the loop can, if desired, be formed before the stack of sheet documents is inserted. Preferably, in step (a), the strap material is received by the innermost surface of the guide channel in the region of receipt of the stack material so as to form the closed loop around only the stack receipt zone. Depending on the particular application in question, the method preferably further comprises the step of placing a stack of sheet documents into the stack receipt zone either before, during or after step a) and prior to step b). Advantageously, the stack of sheet documents is supported at a position within the stack receipt zone spaced from the guide channel by a stack support assembly outside the guide channel.

In a particularly preferred implementation, the stack is formed within the stack receipt zone before the loop of strap material is formed. This can be achieved where the guide channel comprises a plurality of guide elements movable relative to one another. The method further comprises, prior to performing step a), the steps of:

i) removing at least one of the guide elements from the guide channel, so as to provide an opening;

ii) receiving sheet documents at the stack receipt zone through the opening so as to form a stack; and

iii) returning the at least one of the guide elements to the guide channel, so as to substantially close the opening.

Preferably, step b) comprises applying pressure to the overlapping portions of strap material since, as discussed above, this can be used either alone or in combination with heat, to effect a number of different join types. In a particularly preferred embodiment, pressure is applied to the overlapping portions of strap material by pressing them against the stack of sheet documents. In a preferred implementation, at least portions of the strap material are self-adhesive. In other preferred embodiments, the method further comprises a step of applying adhesive to the strap material. The use of adhesive is preferred to heat sealing due to its speed and suitability for use with all document types, including polymer substrates.

Advantageously, adhesive is applied to the strap material at a location upstream of the overlap region of the guide channel. Preferably, adhesive is applied to the strap material at a location upstream of the entrance to the guide channel. Preferably, the adhesive is a pressure adhesive or a contact adhesive.

The method may preferably further comprise a step of tensioning the loop of strap material prior to step b). Advantageously, the tensioning step comprises reversing the trailing edge of the strap material out of the guide channel. It should be noted that this does not require the trailing edge to exit the guide channel: adequate tensioning will typically be achieved by reversing the trailing edge a suitable distance towards the exit of the guide channel. Preferably, the tensioning step further comprises retarding motion of the leading edge of the strap material while the trailing edge is reversed. Advantageously, motion of the leading edge of the strap material is retarded by moving a clamp portion of the guide channel relative to the remainder of the guide channel from a guiding position in which the clamp portion is arranged to guide the leading edge of the strap material into a closed loop, in conjunction with the remainder of the guide channel, into a clamping position, in which at least part of the clamp portion extends toward the stack receipt zone so as to press a portion of the strap material against the stack of documents.

In a particularly preferred embodiment, the method further comprises, after step c), reversing the new leading edge formed by cutting the strap material out of the guide channel. This is particularly appropriate where the new leading edge is to have adhesive applied.

The provision of a fast stacking technique, by the first aspect of the present invention, potentially makes it possible to use a single output pocket for each type of document being sorted. The time taken for a stack to be strapped in accordance with the above described technique can now be made sufficiently short that output need not be diverted to a second pocket to allow time for strapping to take place. Instead, the strapping can be completed before a new stack is completed in the same output pocket, thus allowing a continuous stream of notes to be output by each sorter pocket. However, it remains essential that each completed document stack is correctly delimited from the next when taken for strapping. In conventional systems, this requires the output module to be stopped for an instant while the completed stack is removed, so that subsequent notes are not inadvertently included with the strapped stack. However, even a short pause in output is disadvantageous for all of the reasons discussed above.

In accordance with a second aspect of the present invention, a stacking apparatus for forming stacks of sheet documents is provided, comprising:

a stacker unit adapted to receive sheet documents from a transport path and to output the sheet documents face to face;

a stack support surface for receiving the sheet documents from the stacker unit so as to form a first stack, and supporting the first stack thereon;

a separation unit adapted to deploy a separator member between a selected sheet document received by the stacker unit and the next, the separator member being movable between a home position, in which the separator member does not impede passage of the sheet documents, and a holding position between the stacker unit and the stack support surface, at which the separator member receives stacked sheet documents from the stacker unit so as to form a second stack thereon, the second stack being

spaced from the first stack such that the first stack can be removed from the stack support surface while the second stack is being formed; and

a controller adapted to control the deployment of the separator member.

By providing a separator member which can be deployed between one sheet document and the next, the first stack (completed by the selected sheet document) is kept separate from a second stack of documents which can be formed on the separator member. It should be noted that the separator member need not be horizontal in its holding position for a stack to be formed thereon, but simply presents a surface against which the documents can be stacked. The first stack of documents can then be removed from the apparatus for strapping (or other handling) without stopping or slowing the stacking apparatus, which continues to output documents throughout. Documents which are not to form part of the first stack are kept separate from the first stack by the separator member. Thus, the stacking apparatus can operate at full speed whilst allowing stacks of notes to be removed at intervals for strapping, without the possibility of additional documents being inadvertently included in the stack when strapped.

Preferably, the separation unit is further adapted to retract the separator member once the first stack has been removed from the stack support surface such that the second stack is placed on the stack support surface. The second stack therefore takes the place of the first stack and continues being formed on the stack support surface. The separator member can then be used again once the second stack is completed to separate it from the next.

Preferably, the separator member is arranged to move from the home position to the holding position along a deployment path which follows the path of a sheet document through the stacking unit. By following the path of a sheet document through the stacking unit, the movement of the separator member is entirely aligned with that of each sheet document such that its insertion into the stream of documents does not disrupt the stacking.

Advantageously, the separator member is arranged to move from the holding position to the home position along a retraction path which follows the path of a sheet document between the holding position and the stack support

plate, and does not intercept the path of sheet documents through the apparatus between the stack support plate and the home position. By following the path of a sheet document between the holding position and the stack support plate, the stack formed on the separator member is effectively allowed to continue along its original path onto the stack support plate. The stack support plate may include one or more apertures therethrough to permit passage of the separator member whilst "catching" the second stack. In other cases the separator member could pass by one or both sides of the stack support surface.

Preferably, the separator member is arranged to follow a path which is a continuous loop.

The stacker unit could be formed in a number of different ways. For example, the stacking unit could operate according to a linear deceleration principle. However, preferably, the stacking unit comprises at least one stacker wheel, the or each stacker wheel having a plurality of tines extending from a central hub, each pair of the plurality of tines defining a channel therebetween for receiving a sheet document from the transport path at a receipt position, and stacker drive means for rotating the or each stacker wheel such that, at a release position, the sheet documents exit the channel(s) facing one other to thereby form a stack, the receipt position being angularly displaced from the release position.

Advantageously, the separator member is arranged to follow a path which includes an arcuate portion concentric with the at least one stacker wheel such that the separator member follows the path of a sheet document carried by a channel of the at least one stacker wheel between the receipt and release positions. As mentioned above, by following the path of a sheet document through the stacker unit, stacking is not disrupted.

Preferably, in the home position, the separator member is disposed in line with or behind the trailing tine of a channel of the stacker wheels at the receipt position, such that a sheet document arriving at the stacker wheel is not prevented from entering the channel.

The separator member could be driven using any suitable mechanical arrangement. Preferably, the separator member is moved between its home and holding positions by a timing belt driven by a motor, preferably a stepper motor.

The separator member could be directly mounted to the timing belt. However, preferably, the separator member is supported by a carriage mounted on the track along which the separator member is movable between its home and holding positions. This improves the accuracy of the separator member's positioning.

Preferably, the separator unit further comprises a home sensor configured to detect when the separator member is at its home position. This may typically comprise an optical detector, for example.

Preferably, the separation unit is configured to stop the separator member at the holding position when a predetermined duration has elapsed since the separating member left the home position. In alternative embodiments, a further sensor may be provided at this location to identify when the separator member arrives.

Preferably, the separator unit further comprises a stack sensor configured to detect when the first stack has been removed from the stack support plate. Again, this may comprise an optical detector.

Advantageously, the separator member comprises an elongate member having an arcuate shape, preferably of substantially the same form as a tine of the stacker wheel(s).

Preferably, the separator member is hinged so as to provide a substantially flat surface forming the second stack thereon. That is, the separator member includes at least one hinge along its length. In a particularly preferred example, the separator member is hinged at approximately its mid-point. The separator member can thus maintain an arcuate shape as it rotates in line with the stacker wheels and then adopt a flatter profile (i.e. closer to rectilinear) for receipt of the notes forming the second stack. The opening of the hinge(s) can be caused by gravity, the receipt of the notes forming the second stack, or a combination of the two.

The stacking apparatus of the second aspect of the invention could be used alone, or in combination with any other document handling apparatus including conventional strapping devices. However, preferably, a document handling apparatus comprises a stacking apparatus in accordance with the second aspect of the invention and a strapping apparatus in accordance with the first aspect of the present invention. The stack support plate may be configured so as to form the first stack within the stack receipt zone. Alternatively, a transport unit may be provided for transporting the first stack from the stack support plate of the stacking apparatus to the stack receipt zone of the strapping apparatus. For example, the stack support plate may be movable between a stacking position and a strapping position in which the stack is positioned in the stack receipt zone. Combining the two disclosed apparatus is particularly advantageous since a single output pocket can be used for each document type, whilst achieving high throughput and fast strapping.

The second aspect of the present invention further provides a method of stacking sheet documents, comprising

receiving documents from a transport path into a stacker unit;

outputting the received documents face to face from the stacker unit;

receiving the outputted documents on a stack support surface so as to form a first stack;

when a selected sheet document is received into the stacker unit, deploying a separator member between the selected sheet document and the next, by moving the separator member from a home position in which the passage of sheet documents is not impeded, to a holding position disposed between the stacker unit and the stack support surface;

receiving the outputted documents on the separator member so as to form a second stack spaced from the first stack; and

removing the first stack from the stack support surface.

The deployment of the separator member between the selected sheet document and the next makes it possible to continue forming a second stack of sheet documents while the first stack is isolated for handling.

When the separator member reaches the holding position at which it receives the sheet documents forming the second stack, the separator member need not be halted entirely but could be decelerated such that a gap is formed between it and the selected sheet document which completes the first stack. However, in preferred embodiments, the method further comprises halting the separator member at the holding position until the first stack is removed from the stack support surface. This simplifies the control of the apparatus.

Preferably, the method further comprises retracting the separator member once the first stack is removed such that the second stack is placed on the stack support surface. The second stack can then be completed and the separator member reused to allow a third stack to be formed and the second stack moved on for handling.

The separator member is preferably moved from the home position to the holding position along a deployment path which follows the path of a sheet document through the stacking unit. Preferably, the separation member is moved from the holding position to the home position along a retraction path which follows the path of a sheet document between the holding position and the stack support plate, and does not intercept the path of sheet documents through the apparatus between the stack support plate and the home position. Advantageously, the movement of the separator member from the home position to the holding position and back to the home position follows a path which is a continuous loop.

Preferably, the method further comprises detecting when the separator member is at its home position. This permits accurate control and timing. Advantageously, the separator member is decelerated or halted at the holding position when a predetermined duration has elapsed since the separator member left the home position. Alternatively, a further detector may be employed to determine when the separator member reaches the holding position. Preferably, the method further comprises detecting when the first stack has been removed from the first support plate.

Advantageously, the first stack is removed from the first stack support surface while the second stack is being formed.

The method of the second aspect of the present invention is particularly advantageous when used in combination with that of the first aspect of the present invention and hence the method preferably further comprises transporting the first stack to a strapping apparatus and strapping the first stack in accordance with the method of the first aspect of the invention.

Examples of strapping apparatus, stacking apparatus and corresponding methods will now be described with reference to the accompanying drawings, in which:-

Figure 1 schematically detects an exemplary document handling apparatus in terms of its functional parts;

Figure 2 shows a first embodiment of a strapping apparatus;

Figure 3 shows in more detail a guide channel which may be used in the strapping apparatus of Figure 2;

Figure 4 shows the same guide channel from underneath to show further details thereof;

Figure 5a, b, c, d, e, f, and g depict selected components of the strapping apparatus of Figure 2 and show steps in the strapping operation;

Figure 6 shows a second embodiment of a strapping apparatus;

Figure 7 shows in more detail selected guide elements of a guide channel which may be used in the strapping apparatus of Figure 6;

Figure 8a, b, c and d depict selected components of the strapping apparatus of Figure 6 and steps in the strapping operation;

Figure 9 schematically depicts a portion of the document handling apparatus of Figure 1 in more detail, including a stacking apparatus;

Figure 10 shows components of an exemplary stacking unit which may be used in the stacking apparatus;

Figure 11 shows schematically components of a first embodiment of the stacking apparatus;

Figures 12, 13, and 14 show the stacking apparatus of Figure 11 at different stages during the stacking operation;

Figure 15 shows in more detail a separator member which may be used in the stacking apparatus of Figure 11;

Figure 16 shows the stacking apparatus of Figure 11 in perspective view;

Figure 17 depicts components a second embodiment of the stacking apparatus; and

Figures 18a and 18b show exemplary separator members which may be used in the stacking apparatus of Figure 17.

As mentioned above, document handling apparatus, including stacking apparatus and strapping apparatus, may be used to handle many different types of sheet document, including currency, certificates, cheques, letters and paperwork. Typically, the sheet documents will be flexible sheet documents but, depending on the handling techniques used, this need not be the case. The following discussion will focus on the example of banknote handling, but it will be appreciated that the invention is not so limited.

An exemplary document handling apparatus 10 is depicted schematically in Figure 1. The document handling apparatus 10 may be capable of a number of functions, including authenticating and discriminating documents. Its primary function is to sort banknotes of different denominations and/or currencies from a mixed input. A mixed bundle of banknotes B is fed into the apparatus by an input module 20. This typically comprises means for taking one note at a time from the input bundle and feeding them into a transport path. As each banknote B is conveyed along the transport path, a number of checks may be carried out by a series of sensors, detectors and controllers, represented by block 30. This may include imaging of printed patterns on the banknote, reading of codes such as serial numbers, checking of security features such as holograms and/or magnetic threads and measurement of IR or UV response, for example. The position of each note in the system is kept track of by a series of sensors such as transmissive optical sensors which can detect the arrival or departure of a note at each sensor position.

All of the information about each banknote is processed by a controller 31 to determine into which of a series of categories each banknote falls. Typically, the categories may include different denominations or currencies as

well as potential counterfeit notes, and notes which are unfit for reuse. The categories may include mixed note type categories, if desired.

The notes are then passed via another transport path 40 to the output modules 50. A plurality of output modules are provided, preferably one for each of the categories to be discriminated. For example, a first module may be designated for the output of 5 Euro notes, a second for 10 Euro notes, a third for 20 Euro notes, and so on. Figure 1 shows three exemplary output modules 50a, 50b and 50c, but in practice there may be more or fewer.

The destination of each banknote is determined by one or more diverters 45a, 45b provided in the transport path 40. The diverters 45 are controlled by controller 31 as represented by dashed lines 35. The diverters can be switched from one position to another between the passage of each note so that each note in the stream can be individually directed to the appropriate output module.

The output modules 50 each comprise stacking means for forming the notes output by that module into a stack S, in which the notes are arranged face to face. The apparatus 10 is generally programmed with a desired stack size: that is, the number of banknotes to be included in each stack. For example, the customer may require stacks of 100 banknotes in each.

The completed stacks S are then transferred to a strapping apparatus 100, of which three (100a, 100b, and 100c) are depicted in Figure 1, one for each of the output pockets 50a, 50b, and 50c. However, this one-to-one arrangement is not essential, since it may be possible for one strapping apparatus to serve more than one output pocket. Nonetheless, for consistent throughput it is generally preferred that each output pocket 50 has a dedicated strapping module 100.

It should be noted that the transfer of the stack from the output pocket 50 to the strapping module 100 could be performed in a number of ways. In the simplest case, the stack S could be presented to a user by the output pocket, the user then taking the stack from the output pocket and placing it in the strapping module. However, it is generally preferred that this transfer should be automated and therefore transfer means may be provided between the output

pocket and the strapping module, or the strapping module may be located within the output pocket itself. If the stack S is to be moved into a separate strapping apparatus, this can be achieved by use of a clamp arrangement for grabbing the completed stack S and transferring it into the strapping module 100. Such transfer means are well known in the art.

Both the output pockets 50 and the strapping modules 100 may also be controlled by controller 31, as represented by dashed line 36.

The operation of a strapping module 100 will now be considered in more detail. Figure 2 shows components of an embodiment of the strapping apparatus 100.

In the strapping apparatus, a guide channel 110 is arranged to encircle a stack receipt zone 101. The guide channel 110 is configured so as to receive a length of strap material M from a strap feeding unit 160 and to form the strap material M into a loop. The manner in which this is achieved will be described in more detail below.

The apparatus also comprises a sealing unit 120 which is arranged to join the two ends of the loop of strap material M to one. A cutting unit 130 is provided to separate the completed strap from the remainder of the length of strap material.

Optionally, the apparatus may additionally comprise retardation means such as a brake 140 to assist in tensioning the loop of strap material.

Depending on the nature of the strap material M and the desired seal type to be effected by the sealing unit 120, the apparatus may also include an adhesive station 150 for applying adhesive to the strap material M.

For accurate control of the apparatus, one or more sensors such as 170 may be provided for detecting the position of the strap material M in the system. For example, optical transmission or reflection sensors may be suitable.

Figures 3 and 4 show the guide channel 110 in more detail from upper and lower perspectives. The guide channel 110 is formed so as to define an approximately rectangular space therein which can accommodate an edge of the stack S in use. In other words, the stack S can pass through the area defined by the guide channel. This region is referred to, for convenience, as the

stack receipt zone 101. A stack of banknotes S is represented in dashed lines to indicate its position relative to the guide channel during the strapping procedure. As will be described below, the stack S could be inserted into the stack receipt zone 101 either before the loop of strap material M is formed, during or after.

Advantageously, at whichever stage the stack of banknotes is supplied, it is supported in a position spaced from the guide channel (as shown in the Figures) by a support assembly located outside the guide channel (and not extending into the guide channel at least in the region where the loop of strap material will be formed). This allows the strap material to be moved around and, particularly, underneath the stack during loop formation and (optional) tensioning. The strap is therefore formed around only the stack of banknotes, without incorporating any components of the strapping apparatus.

The guide channel 110 has a substantially flat base portion 111 which receives the strap material M on its upper surface (which becomes the inner surface in the region of the stack receipt zone). The base portion 111 extends underneath the stack receipt zone 101 and then traverses an approximate U-bend shape 112 before emerging into a substantially flat upper portion 113. The upper portion 113 is substantially aligned vertically with the base portion 111 in the region of the stack receipt zone. The guide channel 110 is closed by a second U-bend portion 114 which brings the guide channel adjacent base portion 111 again. The guide channel continues for a distance parallel but spaced from the base portion 111 underneath the stack receipt zone, thereby forming an overlapping region 118 of the guide channel. The two overlapping parts of the guide channel are designated 118a and 118b in Figures 3 and 4. It should be noted that, whilst this shape has proved convenient and successful, in fact the guide channel could take any shape which encircles the second insertion zone 101. For example, the guide channel could be substantially circular, square or otherwise. Preferably, any corners of the guide channel are curved to assist the passage of the strap material M therethrough.

As shown in the Figures, the strap material M is received on the innermost surface of the guide channel and as such there is nothing between it

and the stack receipt zone 101. The strap material is sufficiently stiff that the loop formed within the guide channel is self-supporting. As such, there is nothing to obstruct movement of the strap material away from the guide surface during (optional) tensioning of the loop or removal of the completed strap from the apparatus. The "innermost" surface of the guide channel is its surface nearest to (and facing) the stack receipt zone in the region where the guide channel receives the strap material in use. Outside this region, there could be portions of the guide channel which protrude further towards the interior of the guide channel than the surface which receives the strap material, such as side edges of the guide which retain the strap material laterally.

It should further be noted that the guide channel 110 need not be formed of a continuous component, as in the present example, but rather may be formed of a number of discrete guide elements. For example, the base portion 111 and first U-bend 112 may be detachable from the upper portion 113 and second U-bend 114 for easy access to the stack receipt zone should maintenance be required. Further, such guide elements need not adjoin one another precisely but may have gaps therebetween, provided the gaps are not so large that the strap material M escapes the guide channel.

Finally, it will be appreciated that references to "upper" portions and "base" portions (and similar) above should not be taken to imply that the apparatus need be orientated in this way: it may be preferred, for example, that the guide channel be disposed such that the stack is passed into the stack receipt zone vertically rather than horizontally (or indeed in any other orientation).

In this embodiment, the guide channel 110 includes a number of apertures 115, 116, 117 therethrough for interaction with the sealing means 120, cutting unit 130 and brake 140. In other implementations of the guide channel, such apertures may not be necessary. For example, the guide channel need not extend across the full width of the strap material, allowing the sealing, cutting and/or braking components to access the strap material at either side. Alternatively, in embodiments where the guide channel 110 is made up of multiple elements with spaces therebetween, the sealing, cutting and/or braking

components may make use of such spaces. The guide channel may also be provided with a recess along its length, arranged to coincide with an adhesive portion of the strap material, to avoid contact between the adhesive and the guide channel, so preventing sticking. This is not shown in the Figures, for clarity. Alternatively or in addition, the guide channel could have a non-stick coating.

A sealing aperture 115 is disposed through the base portion 110 of the guide channel just outside the overlapping portion 118. The aperture 115 is arranged to receive a pressure member in use, as will be described below. A cutting aperture 116 is provided in the base portion 110 at a position upstream of the sealing aperture 115 (i.e. between the sealing aperture 115 and the strap feeder 160 supplying the strap material M). In this example, the cutting aperture 116 is provided adjacent the sealing aperture 115, just within the overlapping region 118 of the guide channel so that the inner overlapping part of the guide channel 118a prevents the cutting means 130 cutting through both layers of the strap. However, the cutting means could be located further upstream, for example upstream of the whole overlapping region 118, which would also avoid this problem. Nonetheless, positioning the sealing unit and cutting unit adjacent one another is preferred to avoid wastage of the strap material.

In this example, the apparatus makes use of a retardation means in the form of brake 140. As described below this is used to hold the loop of strap material in position while it is tensioned. In other examples, a brake 140 may not be necessary if there is sufficient friction between the strap material and the inserted stack S, which will depend on the dimensions of the guide channel 110 relative to the stack S.

The brake 140 is arranged to intersect the guide channel 110 in the region of the second U-bend 114, through a brake aperture 117. The retardation means is preferably arranged as close to the leading edge of the strap material as possible, in order to ensure even tensioning of the loop. In practice, positioning the brake as shown in the Figures is therefore advantageous since it is close to the leading edge of the strap material whilst

not encountering the overlapping region. However, the braking position could be located further upstream if desired.

An exemplary strapping process using the apparatus shown in Figures 2 3 and 4 will now be described with reference to Figure 5. In Figure 5, only selected components of the apparatus are shown for clarity.

Figure 5a shows the strap material M in a starting position prior to strapping. The leading edge, LE, of the strap material M is at a known position, determined for example by the use of sensors 170 as shown in Figure 2. In other examples, the use of sensors may be avoided by timing the feeding of the strap material. The motion of the strap material M is controlled by feeder 160 which may comprise for example a storage roll 161 containing a supply of strap material M and one or more driven roller pairs 162 which can be controlled to convey the strap material off the storage roll 161 and toward the guide channel 110. The guide channel 110 may extend all the way to the feeder 160, or additional guiding means may be provided to deliver the strap material from the feeder unit 160 into the guide channel. As described below, the feeder unit 160 is preferably also able to reverse the strap material M back onto the storage roll 161 by reversing drive to the feeder rollers 162. In other embodiments it is conceivable that the feeder unit could be arranged to move the guide channel towards a length of strap material M: the relative motion between the channel 110 and the strap material M is analogous.

In the examples shown in Figure 5, the strap material is to be sealed by adhesive and is not pre-glued, so an adhesive A is applied to the surface of the strap material M at an adhesive station 150. This could comprise, for example, a roller supplied with adhesive which is movable toward and away from the strap material M at this position. In the example shown, the adhesive A is applied adjacent the leading edge LE of the strap material M on what will become the outer surface of the loop. In other examples, the adhesive A could be applied onto the opposite surface of the strap material M in the vicinity of what will become the trailing edge TE of the loop. In this case, the adhesive station 150 will be situated on the opposite side of the strap material path to that

shown. Adhesive could be applied in both of the aforementioned locations, if desired, in which case two adhesive stations may be provided.

The strap material M then continues to be fed into the guide channel 110 by the feeder 160 as shown in Figure 5b). It will noted that this depicts the adhesive station 150 as having moved away from the strap material M such that only a portion of the strap material M adjacent the leading edge carries adhesive. In other cases, the adhesive station 150 could apply a continuous stream of adhesive to the strap material, e.g. for use with a contact adhesive which will bond only to like adhesive, but this is not preferred due to the use of unnecessary quantities of adhesive.

Continued feeding of the strap material M into guide channel 110 causes the leading edge LE of the strap material M to come into contact with the first U-bend 112 of the channel 110, which guides the strap material up and around the stack receipt zone 101. The strap material is sufficiently stiff so as to follow the curvature of the channel without collapsing and no support or guidance of the interior surface of the strap material M (i.e. that facing the stack receipt zone) is required. The overlapping region 118 of the guide channel then carries the leading edge of the strap material over the incoming upstream strap material, resulting in a portion of the strap material including the leading edge LE overlapping an upstream portion of the strap material M. The resulting loop of strap material encloses the stack receipt zone only, with nothing else therebetween, particularly no portion of the guide channel or other component of the strapping apparatus. The leading edge is moved past the overlapping region 118 of the guide channel by a distance so that at least part of the adhesive portion A faces the upstream overlapping portion of the strap material M without anything else in between.

In this example, the next step is to tension the loop of strap material that has been formed as has been described with reference to Figure 5d). However, this is an optional step since in some cases the formed loop may already be of the desired dimension.

Before tensioning can occur, the stack S of documents to be strapped must be inserted into the stack receipt zone, as represented by the cross-

hashed area S in Figure 5d). In practice, the insertion of the stack can occur before, during or after formation of the strap material loop as depicted in Figures 5a), b) and c). For the fastest strapping procedure, it is generally preferred for the loop of strap material M to be formed before the stack of documents is received.

With the stack of documents S in position, encircled by the guide channel 110 and the loop of strap material M on its interior surface, the leading edge LE of the strap material is held substantially in place by pressing a portion of the strap material against the stack S in a non-overlapped region. This is achieved using a brake member 140 which passes through aperture 117 in the guide channel 110 to sandwich the strap material M between it and the stack S. The loop of strap material can then be pulled taut around the stack S by reversing the trailing edge region of the strap material M out of the guide channel. Since there is nothing restraining the strap material M against the guide channel, the size of the loop can be reduced without difficulty. The trailing edge is that portion of the strap material upstream of the leading edge which overlaps the leading edge region. The trailing edge itself will not be formed until the loop is cut from the remaining length of strap material by cutting unit 130. However, the approximate location of the trailing edge relative to the leading edge can be deduced from knowledge of the size of the stack S.

The trailing edge is typically not reversed all the way out of the guide channel 110, but rather is pulled a distance towards the exit so as to achieve tensioning. The reversal of the strap material M may be achieved by reversing the feeder unit 160. In alternative embodiments, one or more tensioning rollers can be provided between the feeder unit 160 and the guide channel which are arranged to move perpendicularly to the path of the strap material to thereby apply the appropriate tension.

Figure 5e) shows the loop of strap material M having been pulled taut around the stack S. At this point, the brake 140 may be released, or as in the case shown, it may stay in position whilst the final steps are completed.

In the next step, the overlapping portions of the strap material M are joined to one another by the sealing unit 120. In the present example, this

comprises a pressure member which is extendable through the sealing aperture 115 to contact the overlapping portion of strap material and press it against the stack S, as shown in Figure 5e). In doing so, the adhesive A forms a bond between the two overlapping portions of strap material. In other examples, the sealing unit could alternatively or additionally apply heat to the overlapping portions either to activate an adhesive or to perform a heat seal. In further examples, the sealing unit could comprise a clamp, inserted from one of the open sides of the guide channel to apply pressure to both sides of the overlapping strap material, or to perform crimping for example.

The sealed loop can now be detached from the supply of strap material and this is performed by cutting unit 130 which includes typically a blade. The cutting unit is extended through aperture 116 and applies a high pressure to the trailing edge region of the strap material, thereby detaching the completed strap and forming a new leading edge, as shown in Figure 5f). In other examples, cutting could be performed by a punch, a serrated edge or blade drawn across the material or even a laser, as desired.

Finally, as shown in Figure 5g), the strap material M can be reversed back out of the guide channel 110, for example by the feeder unit 160, and the strap stack S is ready for removal. It may be desirable to reverse the strap material M out of the guide channel by a distance so as to protect it from damage while the stack is removed, or simply to return it to its start position as shown in Figure 5a) for application of adhesive to the new leading edge LE. However, if the adhesive is instead applied to the trailing edge of the strap material M, the steps shown in Figures 5a) and 5g) may be omitted entirely, with the adhesive being applied instead at a time between the points shown in Figures b) and c) above.

A second embodiment will now be described with reference to Figures 6 to 8. In the main part, the components of the strapping apparatus 200 are the same as those of the first embodiment, and will therefore not be described again here. For clarity, in Figure 6, the components corresponding to those already described have corresponding reference numerals starting "2xx" (rather than "1xx").

The guide channel 210 in this embodiment is formed of three guide elements 211, 213 and 240 arranged in close relation to one another so as to form a guide surface of substantially the same shape as previously described. Any suitable number of guide elements could be used. The first guide element 211 provides the base portion of the guide channel and the beginnings of the first U-bend, and is generally fixed in relation to the stack receipt zone 201 as will be described in more detail below.

The second guide element 240 is positioned adjacent the first guide element 211 and shaped so as to provide the end of the second U-bend and a portion overlapping the base portion of the channel. The second guide element is pivotably mounted relative to the first guide element 211, as indicated by pivot point 245. As well as guiding the strap material M to form the closed look, the second guide element 240 performs a second function of clamping the leading edge of the strap material during tensioning, and so may also be referred to as the clamp portion of the guide channel. This is explained further below.

The third guide element 213 provides the upper guide portion and completes both U-bends. The third guide element is removable and can be moved away from the first and second guide elements so as to "open" the guide channel. This can be achieved using any convenient means. For example, in Figure 6, the third guide element is shown to be hingedly attached to the first guide element such that the guide channel can be opened by pivoting the third guide channel toward the position shown in dashed lines. Alternatively the third guide element could be lifted away from the channel. By doing so, sheet documents can enter the stack receipt zone (either as a ready formed stack or individually) through the opening left by the third guide element 213. The same function could be achieved, for example, by providing the guide channel of the first embodiment with a removable portion.

Figure 7 shows the first and second guide elements 211 and 240 in perspective view with the third guide element removed. The position of a stack of documents S ready for strapping is depicted in dashed lines. With the guide channel "open" as shown, the stack S can be formed directly within the stack receipt zone such that no transfer means is required. One or more of the guide

elements could be used as the stack support surface for forming and supporting the stack thereon. However, in order to form the loop of strap material it is generally necessary to provide a gap between the stack of documents and the channel elements so that the strap material M can pass through. This is preferably achieved by providing a stack support assembly, such as a lift or clamp mechanism which positions the stack after it has been formed. Alternatively, as shown in Figure 7, the stack support assembly could take the form of two (or more) stack support platforms arranged either side of the guide channel, such that the stack is formed on the platforms at a slightly raised position relative to the guide elements.

Figure 7 also shows in more detail the arrangement of the second guide element 240, which may be supported on a shaft 246 which is rotatable so as to pivot the second guide element between the positions shown in Figure 6.

A stacking operation using the apparatus of the second embodiment will now be described. Figure 8 shows steps in the operation which differ from those already described. However many of the steps are unchanged and these are depicted in Figure 5.

Figure 8a shows a stack S being formed within the stack insertion zone. During this stage, the guide channel 210 is "open" in that the third guide element has been removed. In this example, banknotes B are received from a stacking apparatus above but as previously noted the banknotes may not arrive along a vertical path but could have some other orientation, in which case the guide channel would be re-orientated as desired. The stack S is spaced from the guide elements by means such as those described above.

Once the stack is complete, the guide channel is closed by replacing the third guide element 213, as shown in Figure 8b. The strap material M can now be fed into the guide channel and around the stack to form a closed loop in precisely the same manner as previously described with reference to Figures 5a, b and c.

With the closed loop of strap material formed, the clamp portion 240 of the guide channel is pivoted above point 245 into the position shown in Figure 8b. This is used in place of the brake 140 provided in the first embodiment to

hold the leading edge of the strap material during tensioning of the strap. By pivoting the clamp portion as shown, its end presses a portion of the strap material close to the leading edge LE against the stack of documents. The strap material M can then be reversed out of the guide channel, as previously described, to tension the strap. It should be noted that the use of a portion of the guide channel to provide the retardation means is not limited to the three guide element configuration as described here. For example, the clamp member could be used in combination with a single other guide element performing the functions of the first and third guide elements. Alternatively, if the guide channel is formed of a flexible material, a single unitary element could be used with the clamp portion being flexibly movable relative to the rest.

The overlapping portions of the strap material can then be sealed and finally cut, as described above with reference to Figures 5e, f and g. The strapped stack is removed and passed on for further handling as desired. The clamp portion 240 is returned to its original guiding position and the third guide element 213 is removed ready for the receipt of a new stack of documents.

The above-described methods and apparatus are suitable for use with many different types of strap material M including paper, plastic, metal foil, combinations thereof or other laminate materials. One example of a suitable material is Tecline™. Suitable adhesives include pressure adhesives and contact adhesive. Particular examples include Elmer's Permanent Dot Line™ or the "Dot n Roller"™ by Kokuyo. This latter adhesive has been found particularly well suited to the application since it produces consistently reproducible results, without any threads of glue being created. In this example, the adhesive station comprises a cassette with two reels supporting between them a tape having dots of adhesive thereon. The first reel supports unused tape (with the glue dots still on), and the other collects the used tape. A small roller between the two reels is used to press the tape against a surface to which glue is to be applied (here the strap material), in order to transfer the glue dots from the support tape onto the surface.

Using the above-described techniques, it has been found possible to complete a strapping cycle in less than 1.5 seconds. The time taken to strap a

stack can be reduced even further by forming the loop of strap material before inserting the stack of documents. In addition, the use of adhesive rather than heat sealing ensures that no damage will be caused to polymer based documents. This brings with it the benefit of less power consumption by the machine and less heat generation, making the equipment safer to use. Finally, the ability to use paper strapping material is in itself of significant benefit since this is less expensive than most equivalents.

A stacking apparatus 50 used to form output notes into stacks will now be described in more detail. Figure 9 shows schematically a stacking module 50 which receives banknotes B from transport path 40 and outputs these as stacks S in which the banknotes are arranged face to face. Typically, a transport path 40 will convey banknotes side by side, one after the other along the same transport plane. The stacking apparatus therefore includes a stacking unit 60 which rearranges the incoming banknotes B into the desired stack format. The stacking apparatus 50 and transport unit 40 are in communication with the controller 31.

The stacking unit 60 can operate according to a number of different principles. For example a linear deceleration unit can be used to form stacks, as will be described in more detail below.

However, in a preferred embodiment, as depicted in Figures 10 onwards, the stacking unit 60 comprises one or more stacker wheels 61. Stacker wheels such as these are well known and are described, for example, in WO2005/118443. Each stacker wheel 61 comprises a hub mounted on a shaft 61a, for rotation thereabout, and a number of radially extending tines 63. Each adjacent pair of tines 63 defines a channel 64 therebetween. The tines 63 preferably curve backwards (i.e. opposite to the sense of rotation of the wheel) at their extremities, as shown schematically in Figure 10. It will be appreciated that the wheel 61 depicted in Figure 10 is shown with only a small number of tines 63 for clarity; in practice the tines will be closely spaced.

Banknotes arrive at the stacker wheel 61 at a receipt position X from the transport path 40. An incoming banknote is received into whichever of the channels 64 is at the appropriate position. In Figure 10, banknote B_1

designates a note which has just been received into the stacker wheel and banknote B_0 designates the next banknote to be received. The received banknote B_1 is carried by the tines 63 around at least part of one rotation of the wheel 61, before it exits the tines at a release point Y. The location of release point Y will depend on the configuration of the wheel 61, the stacker pocket housing and other factors including the speed at which the wheel 61 is driven. In the examples shown, the note B_2 is shown exiting the stacker wheel in an approximately horizontal orientation in which the continued rotation of the wheel causes the note to be dropped. The dropped notes, such as B_3, form a stack S_1 below the stacker wheel 61 on a stack support surface 70 (shown in Figure 9). In other arrangements, a stack support plate may be provided in front of the stacker wheel, at an angle to the horizontal (as shown for example in WO2005/118443) with means being provided to direct the banknotes out of the channels 64 and towards the plate 70.

As previously described, it is desirable to be able to retrieve a stack comprising a known quantity of banknotes from a stacker module for strapping, whilst not halting or even slowing the output of the stacker module. Figure 11 shows an embodiment of a stacking apparatus 50 in which this is achieved. Here, the stacking unit (stacking wheels 61 being represented as solid for clarity) is provided with a separation unit 80. This comprises a separator member 81 which is able to be deployed between a selected note and the next. In the following example, a stack of n banknotes is desired so the selected banknote is designated as B_n.

A separator member 81, here in the form of a flexible arm, is mounted via a carriage 82 to a track 83. A timing belt 84 is provided to transfer drive to the separator member 81 from a stepper motor 87 and drive roller 86. At its upper end, the track 83 and timing belt 84 pass round a idler roller 85 which has substantially the same circumference as the hub of the stacker wheel 61.

The separator member 81 has a form substantially akin to one of the tines 63 of the stacker wheel 61, as will be described in more detail below. While a stack of documents S_1 is being formed on stack support plate 70, the separator member 81 is retained at a home position P_1, as shown in Figure 11.

Here, the separator member does not obstruct the passage of documents through the stacking unit 60. The home position could be located at any point around the track 83 which does not obstruct documents, but preferably the home position is immediately adjacent the receipt point X of the stacker wheel 61. When each banknote is received by the stacker wheel, it enters a channel 64 immediately in front of the separator member 81.

The arrival of the selected document B_n is notified to the separation unit 80 by controller 31. Since the controller 31 knows the location and type of each note in the document handling apparatus 10, it can inform the separating unit of the instant that the selective document B_n is received. Thus, as soon as the selected document B_n is received by the stacker wheel 61, the motor 87 is activated to drive the separator member 81 forward. The motor 87 is synchronised with the motor driving the stacker wheel 61 and may in some embodiments be replaced by a clutch arrangement adapted to receive drive from the motor which drives the stacker wheels, so that the speed is exactly matched. The separator member 81 then driven in the same direction as the stacker wheel 61, following the selected banknote B_n closely behind. This is shown in Figure 12 which also shows the location of the next banknote B_{n+1}, immediately behind the separator member 81. Of course, the next banknote B_{n+1} may not be directly behind the separator member 81 as this will depend on when the output module receives the next note.

The separator member travels along an arcuate path around the pulley 85 thus following exactly the path of a banknote around the stacker wheel 61. The track 83 is configured so that the separator member 82 departs from the route of the tines 63 at the point where notes begin to exit the stacker wheel, following the path of the notes as they are released from the stacker wheel 61 at release point Y. This is shown in Figure 13.

The separator member continues to be driven to a holding position P_2 which is between the home position P_1 and the stack support surface 70 on which the stack S_1 has been formed. The deployment of the separator member 81 between the selected note B_n and the next note B_{n+1} enables the selected note B_n to continue to the stack support surface 70, thereby completing the first

stack S_1 whilst the next document B_{n+1}, cannot pass the separator member 81. At the holding position P_2, the separator member 81 is either halted or decelerated such that subsequent banknotes are caught thereon. The banknotes can therefore continue to be output by the stacking unit 60, forming a new stack S_2 on the separator member 81, which is kept separate from the first stack S_1. The completed stack S_1 of n banknotes can then be removed from stack support plate 70 in the confidence that no additional notes have been inadvertently been included.

In the preferred case, the stack S_1 is removed and transported to a strapping apparatus as described above with respect to Figures 2 to 5 for strapping. When the first stack S_1 has been removed from the stack support surface 70, the separator member 81 is reactivated (or accelerated) to return to its home position P_1 by completing its circuit of the track 83, travelling around the drive roller 86. In doing so, the separator member 81 lowered the second stack S_2 which is being formed thereon onto the stack support surface 70. The second stack can then continue to be formed on surface 70 until it too reaches n documents. From passing the stack support surface 70 to returning to the home position P_1, the separator member 81 does not intersect the path along which the notes travel through the stacking apparatus and so does not interfere with the processing. The return to the home position can therefore be completed at any desirable time. Once at the home position P_1, the separator member is ready for redeployment when notified of the arrival of the next selected banknote B_n.

Sensors are preferably provided to assist in the accurate control of the separator member 81. To identify when the first stack S_1 has been removed from the stack support surface 70, an optical sensor may be provided, for example in the form of a transmissive sensor 89 comprising an emitter 89a and a receiver 89b, the light path between which is obstructed by the presence of stack S_1. The removal of the stack detected by sensor 89 can therefore be used to trigger the separator member 81 to be returned from the holding position to its home position. Likewise a home position sensor 88 may be provided at the home position P_1 to ascertain when the separator member 81

has returned to its home position. The holding position P_2 may likewise be identified by use of a similar sensor. However, since its location does not require the same degree of accuracy as the home position P_1, in preferred embodiments the arrival of the separator member 81 at the holding position P_2 is determined by timing the motion of the separator member 81 from the home position, and halting the separator member 81 (or decelerating it) when a predetermined time has elapsed (or, analogously, permitting a certain number of steps of the motor 87 to elapse).

As noted above it is desirable for the separator member 81 to follow precisely the path of the document though the stacker unit. This causes the minimum of disruption to the stacking process since no forces in directions other than the transport direction are experienced by the notes. As such, where the stacker unit comprises stacker wheels (as described above) it is desirable for the separator member 81 to take substantially the same shape as one of the tines of the stacker wheel, i.e. a curved elongate member. However, once at the holding position P_2, the separator member is required to provide a surface against which the stack S_2 can form. A curved surface is generally undesirable for stacking and so in a particularly preferred embodiment, the curved elongate separation member 81 is provided with a hinge 81a at approximately its mid-point. The hinge 81a is arranged to allow the separator member to become substantially flat (e.g. parallel to the stack support plate 70) once it exits the arcuate portion of the track 83. The hinge 81a is configured, or stops are provided, to prevent opening beyond a substantially flat position. In other embodiments, two or more hinges 81a could be arranged at different positions along the separation member 81 to achieve a similar effect. Whilst the separator member 81 travels around the arcuate portion, the angular velocity is such that the separator member is urged into its curved configuration as shown by the dotted lines in Figure 15.

The elongate member is preferably also flexibly attached to the carriage 82, for example via a hinge 81b. Hinge 81b permits the separator member an additional degree of flexibility which enables it to form a more compact unit as it turns the corner around the drive roller 86 and returns to the home position P_1,

but does not permit movement relative to the carriage past the substantially horizontal position shown in Figure 15. The carriage 82 to which the separator member 81 is mounted includes attachment means 82a for attaching the carriage to the timing belt 84.

As shown in Figure 16, a typical stacker unit making use of stacking wheels 61 may comprise two such wheels 61 disposed on a common drive shaft, and it is preferable to provide two separating members 81, as shown, to support each side of the banknote B. The two separator members 81 are preferably controlled and driven by the same means so that their movement is exactly synchronous. The stack support plate 70 on which the first stack S_1 is formed may be located between the two separator members 81, so that they pass either side of the plate 70, or could be provided with apertures 71, as shown in Figure 16, to allow the passage of separator members therethrough. Alternatively, the stack support surface could take the form of two spaced surfaces to allow the separator members to pass therebetween and, preferably, the provision of a strapping apparatus as depicted in Figure 7.

The stack support plate may itself be movable between a stacking position, in which the first stack S_1, is formed, and a strapping position, in which the formed stack is positioned within the stack receipt zone of the strapping apparatus.

As mentioned above, one alternative to the use of stacking wheels is to form stacks using a linear deceleration principle. Figure 17 shows schematically the basic components of a second embodiment of a stacking apparatus 300. Documents (in this case, banknotes B) enter the stacking apparatus along a transport path 40 which typically comprises a driven transport belt 305 opposed by idler rollers 310 or a second transport belt. The documents are driven along the path at high speed such that, when they reach the end of the path, they follow a trajectory towards a fixed surface 320. On impact, each note is decelerated, losing all of its forward momentum, and falls onto a stack support surface 70 where a stack S_1 forms.

Figures 18a and 18b show two alternative ways in which a separation unit, akin to that described above, can be incorporated. In Figure 18a, a

separator member 330 is provided in the form of a plate which, in its home position is retracted into the fixed surface 320 within a recess 335. In its holding position (shown in Figure 18a), the separator member extends out of the surface 320 and intercepts the path of the banknotes falling into the stack S_1. In doing so, a second stack S_2 is formed on the separator member 330, whilst the first stack S_1 can be strapped. Once the first stack S_1 has been removed, the separator member can be retracted and the second stack continues on to the stack support surface 70.

Alternatively, a separator member 340 could be provided in the form of a "trap door" in a surface 345 positioned above the stack support surface 70. When the first stack S_1 is complete, the door 340 is closed, either via a pivoting motion (as shown) or sliding. A second stack S_2 can then be formed on the door 340 whilst the first stack is removed for strapping. The door 340 is then opened, allowing the second stack S_2 to drop onto the stack support surface 70.

In both cases, the deployment of the separator member 330 or 340 is controlled by the arrival of the selected note, B_n, at the exit of the transport path 40. There may be a fixed time delay between the exit of the selected note and the instant at which the separator member is deployed, to account for the time taken for the note to reach the stack S_1. Alternatively, a sensor may be provided to detect the passage of the selected note past the deployment position (e.g. just below the recess 335 or surface 345) which confirms that the note has passed before the separator member is deployed.

Again, the embodiment shown in Figures 17 and 18 is preferably used in conjunction with a strapping apparatus as previously described.

CLAIMS

1. A strapping apparatus for strapping a stack of sheet documents, the apparatus comprising:

a strap feeder adapted to feed a length of strap material into the strapping apparatus;

a guide channel arranged to receive the leading edge of the strap material from the strap feeder, to guide the leading edge around a stack receipt zone and to overlap the leading edge with an upstream portion of the strap material, resulting in overlapping portions of strap material in an overlap region of the guide channel, so as to form a closed loop of strap material around the stack receipt zone, the stack receipt zone being configured to accommodate a stack of sheet documents in use;

a sealing unit adapted to join the overlapping portions of the strap material to one another at a joining point; and

a cutting unit for cutting the strap material upstream of the joining point.

2. A strapping apparatus according to claim 1 wherein the sealing unit is adapted to apply pressure to the overlapping portions of the strap material.

3. A strapping apparatus according to claim 2 wherein the sealing unit comprises a pressure member movable between a storage position in which the passage of the strap material is not impeded, and a sealing position in which the pressure member is extended towards the stack receipt zone at which, in use, the overlapping portions of the strap material are pressed against a stack of documents in the stack receipt zone.

4. A strapping apparatus according to any of the preceding claims further comprising an adhesive station adapted to apply adhesive to the strap material.

5. A strapping apparatus according to claim 4 wherein the adhesive station is disposed upstream of the overlap region of the guide channel.

6. A strapping apparatus according to claim 4 or claim 5 wherein the adhesive station is disposed between the guide channel and the strap feeder.

7. A strapping apparatus according to any of claims 4 to 6 wherein the adhesive station is configured to apply adhesive adjacent the leading edge of the strap material on its surface forming the outer surface of the loop.

8. A strapping apparatus according to any of claims 4 to 7 wherein the adhesive station is configured to apply adhesive adjacent a trailing edge position of the strap material on its surface forming the inner surface of the loop.

9. A strapping apparatus according to any of the preceding claims further comprising a tensioning unit arranged to adjust the tension of the loop of strap material prior to sealing by the sealing unit.

10. A strapping apparatus according to claim 9 wherein the tensioning unit comprises means for reversing the trailing edge of the strap material out of the guide channel.

11. A strapping apparatus according to claim 10 wherein the tensioning unit further comprises retardation means arranged to oppose reversal of the leading edge of the strap material, preferably a brake arranged to hold the leading edge of the strap material at a fixed position.

12. A strapping apparatus according to claim 11 wherein the retardation means comprises a clamp portion of the guide channel which is movable relative to the remainder of the guide channel from a guiding position, in which the clamp portion is arranged to guide the leading edge of the strap material into a closed loop, in conjunction with the remainder of the guide channel, and a clamping position, in which at least part of the clamp portion is extended toward the stack

receipt zone so as to, in use, press a portion of the strap material against the stack of documents.

13. A strapping apparatus according to claim 12, wherein the clamp portion of the guide channel is pivotable between the guiding position and the clamping position, an end of the clamp portion extending toward the stack receipt zone when the clamp portion is in the clamping position.

14. A strapping apparatus according to any of the preceding claims further comprising means for reversing the trailing edge of the strap material out of the guide channel.

15. A strapping apparatus according to any of the preceding claims wherein the strap feeder is further adapted for reversal of the strap material out of the strapping apparatus.

16. A strapping apparatus according to any of the preceding claims further comprising at least one sensing unit for sensing the position of the leading edge of the strap material.

17. A strapping apparatus according to any of the preceding claims further comprising a stack support assembly arranged outside the guide channel and configured to support the stack of sheet documents within the stack receipt zone at a position spaced from the guide channel.

18. A strapping apparatus according to any of the preceding claims wherein the guide channel is configured so as to receive the strap material on the innermost surface of the guide channel in the region of the strap material, such that in use the closed loop of strap material is formed around the stack receipt zone only.

19. A strapping apparatus according to any of the preceding claims wherein the guide channel comprises one or more guide elements encircling the stack receipt zone, arranged to receive the leading edge of the stack material on their interior surface.

20. A strapping apparatus according to claim 19 wherein the one or more guide elements form a substantially closed loop, at least part of the one or more guide elements overlapping, and the overlapping portions of the guide elements being spaced from one another so as to receive the leading edge of the strap material therebetween.

21. A strapping apparatus according to claim 19 or claim 20 wherein the guide channel comprises first, second and third guide elements, the second and third guide elements being movable relative to each other and to the first guide element.

22. A strapping apparatus according to claim 21 wherein the first guide element forms a base portion of the guide channel and is in fixed relation to the stack receipt zone.

23. A strapping apparatus according to claim 21 or claim 22 when dependent on at least claim 12 wherein the second guide element constitutes the clamp portion of the guide channel and is spaced from and arranged to at least partially overlap a portion of the first guide element.

24. A strapping apparatus according to any of claims 21 to 23 wherein the third guide element forms an upper portion of the guide channel and is movable between a guiding position in which the third guide element adjoins the first and second guide elements to guide the leading edge of the strap material to form a closed loop, and an open position in which the third guide element is removed from the first and second guide elements so as to permit entry of sheet documents into the stack receipt zone.

25. A method of strapping a stack of sheet documents positioned at a stack receipt zone, the method comprising:

a) feeding the leading edge of a length of strap material into a guide channel arranged to guide the leading edge around the stack receipt zone and to overlap the leading edge with an upstream portion of the strap material, resulting in overlapping portions of strap material in an overlap region of the guide channel, so as to form a closed loop of strap material around the stack receipt zone;

b) sealing the overlapping portions of strap material to one another at a sealing point; and

c) cutting the strap material upstream of the sealing point.

26. A method according to claim 25, wherein in step (a), the strap material is received by the innermost surface of the guide channel in the region of receipt of the stack material so as to form the closed loop around only the stack receipt zone.

27. A method according to claim 25 or claim 26, further comprising placing a stack of sheet documents into the stack receipt zone either before, during or after step a), and prior to step b).

28. A method according to claim 27, wherein the stack of sheet documents is supported at a position within the stack receipt zone spaced from the guide channel by a stack support assembly outside the guide channel.

29. A method according to any of claims 25 to 28, wherein step b) comprises applying pressure to the overlapping portions of strap material.

30. A method according to claim 29 wherein pressure is applied to the overlapping portions of strap material by pressing them against the stack of sheet documents.

31. A method according to any of claims 25 to 30 wherein at least portions of the strap material are self-adhesive.

32. A method according to any of claims 25 to 30 further comprising a step of applying adhesive to the strap material.

33. A method according to claim 32 wherein adhesive is applied to the strap material at a location upstream of the overlap region of the guide channel.

34. A method according to claim 32 or 33 wherein adhesive is applied to the strap material at a location upstream of the entrance to the guide channel.

35. A method according to any of claims 32 to 34 wherein adhesive is applied adjacent the leading edge of the strap material on its surface forming the outer surface of the loop.

36. A method according to any of claims 32 to 34 wherein adhesive is applied adjacent a trailing edge position of the strap material on its surface forming the inner surface of the loop.

37. A method according to any of claims 32 to 36 wherein the adhesive is a pressure adhesive or a contact adhesive.

38. A method according to any of claims 25 to 37 further comprising a step of tensioning the loop of strap material prior to step b).

39. A method according to claim 38 wherein the tensioning step comprises reversing the trailing edge of the strap material out of the guide channel.

40. A method according to claim 39 wherein the tensioning step further comprises retarding motion of the leading edge of the strap material while the trailing edge is reversed.

41. A method according to claim 40 wherein motion of the leading edge of the strap material is retarded by moving a clamp portion of the guide channel relative to the remainder of the guide channel from a guiding position in which the clamp portion is arranged to guide the leading edge of the strap material into a closed loop, in conjunction with the remainder of the guide channel, into a clamping position, in which at least part of the clamp portion extends toward the stack receipt zone so as to press a portion of the strap material against the stack of documents.

42. A method according to any of claims 25 to 41 further comprising, after step c), reversing the new leading edge formed by cutting the strap material out of the guide channel.

43. A method according to any of claims 25 to 42, wherein the guide channel comprises a plurality of guide elements movable relative to one another, further comprising, prior to performing step a), the steps of:

i) removing at least one of the guide elements from the guide channel, so as to provide an opening;

ii) receiving sheet documents at the stack receipt zone through the opening so as to form a stack; and

iii) returning the at least one of the guide elements to the guide channel, so as to substantially close the opening.

44. A stacking apparatus for forming stacks of sheet documents, comprising:

a stacker unit adapted to receive sheet documents from a transport path and to output the sheet documents face to face;

a stack support surface for receiving the sheet documents from the stacker unit so as to form a first stack, and supporting the first stack thereon;

a separation unit adapted to deploy a separator member between a selected sheet document received by the stacker unit and the next, the separator member being movable between a home position, in which the separator member does not impede passage of the sheet documents, and a holding position between the stacker unit and the stack support surface, at which the separator member receives stacked sheet documents from the stacker unit so as to form a second stack thereon, the second stack being spaced from the first stack such that the first stack can be removed from the stack support surface while the second stack is being formed; and

a controller adapted to control the deployment of the separator member.

45. A stacking apparatus according to claim 44, wherein the separation unit is further adapted to retract the separator member once the first stack has been removed from the stack support surface such that the second stack is placed on the stack support surface.

46. A stacking apparatus according to claim 44 or claim 45, wherein the separator member is arranged to move from the home position to the holding position along a deployment path which follows the path of a sheet document through the stacking unit.

47. A stacking apparatus according to any of claims 44 to 46, wherein the separator member is arranged to move from the holding position to the home position along a retraction path which follows the path of a sheet document between the holding position and the stack support plate, and does not intercept the path of sheet documents through the apparatus between the stack support plate and the home position.

48. A stacking apparatus according to any of claims 44 to 47, wherein the separator member is arranged to follow a path which is a continuous loop.

49. A stacking apparatus according to any of claims 44 to 48, wherein the stacking unit comprises at least one stacker wheel, the or each stacker wheel having a plurality of tines extending from a central hub, each pair of the plurality of tines defining a channel therebetween for receiving a sheet document from the transport path at a receipt position, and stacker drive means for rotating the or each stacker wheel such that, at a release position, the sheet documents exit the channel(s) facing one other to thereby form a stack, the receipt position being angularly displaced from the release position.

50. A stacking apparatus according to claim 49, wherein the separator member is arranged to follow a path which includes an arcuate portion concentric with the at least one stacker wheel such that the separator member follows the path of a sheet document carried by a channel of the at least one stacker wheel between the receipt and release positions.

51. A stacking apparatus according to claim 49 or 50, wherein, in the home position, the separator member is disposed in line with or behind the trailing tine of a channel of the stacker wheel(s) at the receipt position, such that a sheet document arriving at the stacker wheel is not prevented from entering the channel.

52. A stacking apparatus according to any of claims 44 to 51, wherein the separator member is moved between its home and holding positions by a timing belt driven by a motor, preferably a stepper motor.

53. A stacking apparatus according to any of claims 44 to 52, wherein the separator member is supported by a carriage mounted on a track along which the separator member is movable between its home and holding positions.

54. A stacking apparatus according to any of claims 44 to 53 wherein the separation unit further comprises a home sensor configured to detect when the separation member is at its home position.

55. A stacking apparatus according to any of claims 44 to 54 wherein the separation unit is configured to stop the separator member at the holding position when a predetermined duration has elapsed since the separator member left the home position.

56. A stacking apparatus according to any of claims 44 to 55 wherein the separation unit further comprises a stack sensor configured to detect when the first stack has been removed from the stack support plate.

57. A stacking apparatus according to any of claims 49 to 56, wherein the separator member comprises an elongate member having an arcuate shape, preferably of substantially the same form as a tine of the stacker wheel(s).

58. A stacking apparatus according to any of claims 44 to 57 wherein the separator member is hinged so as to provide a substantially flat surface for forming the second stack thereon, a hinge preferably being provided at approximately the midpoint of the separator member.

59. A document handling apparatus comprising a stacking apparatus according to any of claims 44 to 58, and a strapping apparatus according to any of claims 1 to 24.

60. A document handling apparatus according to claim 59 wherein the stack support plate of the stacking apparatus is arranged to support the first stack within the stack receipt zone of the strapping apparatus.

61. A document handling apparatus according to claim 59 or claim 60, further comprising a transport unit for transporting the first stack from the stack support plate of the stacking apparatus to the stack receipt zone of the strapping apparatus.

62. A method of stacking sheet documents, comprising:

receiving documents from a transport path into a stacker unit;

outputting the received documents face to face from the stacker unit;

receiving the outputted documents on a stack support surface so as to form a first stack;

when a selected sheet document is received into the stacker unit, deploying a separator member between the selected sheet document and the next, by moving the separator member from a home position in which the passage of sheet documents is not impeded, to a holding position disposed between the stacker unit and the stack support surface;

receiving the outputted documents on the separator member so as to form a second stack spaced from the first stack; and

removing the first stack from the stack support surface.

63. A method according to claim 62, further comprising halting the separator member at the holding position until the first stack is removed from the stack support surface.

64. A method according to claim 62 or claim 63, further comprising retracting the separator member once the first stack is removed such that the second stack is placed on the stack support surface.

65. A method according to any of claims 62 to 64 wherein the separator member is moved from the home position to the holding position along a deployment path which follows the path of a sheet document through the stacking unit.

66. A method according to any of claims 62 to 65, wherein the separator member is moved from the holding position to the home position along a retraction path which follows the path of a sheet document between the holding position and the stack support plate, and does not intercept the path of sheet

documents through the apparatus between the stack support plate and the home position.

67. A method according to any of claims 62 to 66, wherein the movement of the separator member from the home position to the holding position and back to the home position follows a path which is a continuous loop.

68. A method according to any of claims 62 to 67, wherein the stacking unit comprises at least one stacker wheel, the or each stacker wheel having a plurality of tines extending from a central hub, each pair of the plurality of tines defining a channel therebetween for receiving a sheet document from the transport path at a receipt position, and the or each stacker wheel is driven to rotate such that, at a release position, the sheet documents exit the channel(s) facing one other to thereby form a stack, the receipt position being angularly displaced from the release position.

69. A method according to claim 68, wherein the separator member follows a path which includes an arcuate portion concentric with the at least one stacker wheel so as to follow the path of a sheet document carried by a channel of the at least one stacker wheel between the receipt and release positions.

70. A method according to any of claims 62 to 69 further comprising detecting when the separation member is at its home position.

71. A method according to claim 70 wherein the separator member is decelerated or halted at the holding position when a predetermined duration has elapsed since the separator member left the home position.

72. A method according to any of claims 62 to 71 further comprising detecting when the first stack has been removed from the stack support plate.

73. A method according to any of claims 62 to 72 wherein the first stack is removed from the stack support surface while the second stack is being formed.

74. A method according to any of claims 62 to 73 further comprising strapping the first stack in accordance with the method of any of claims 25 to 43.

Fig.1.

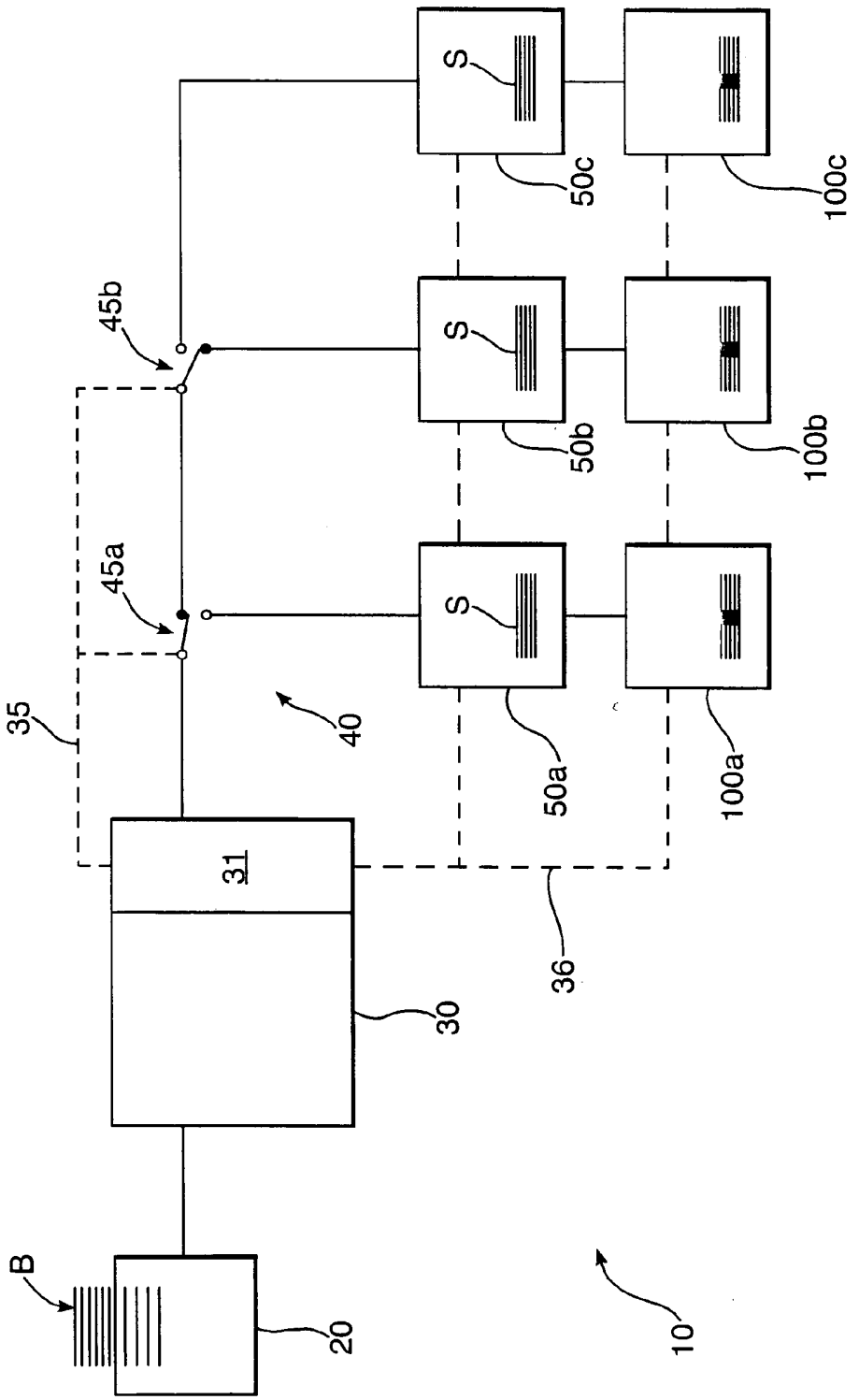

Fig.2.

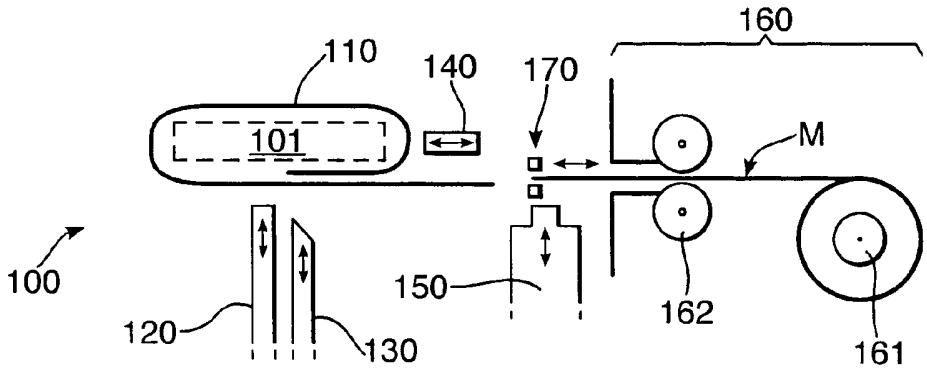
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Fig.3.

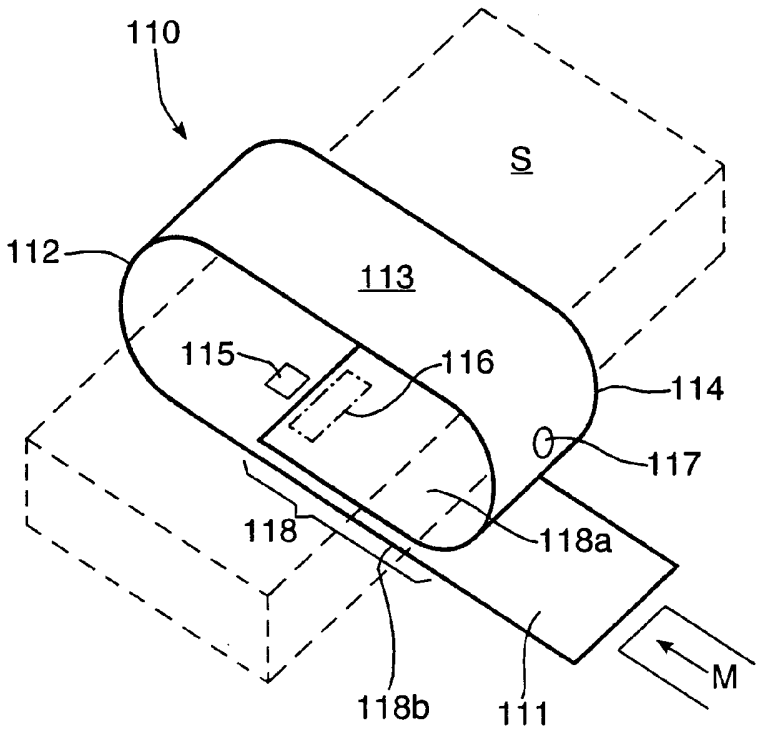
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Fig.4.

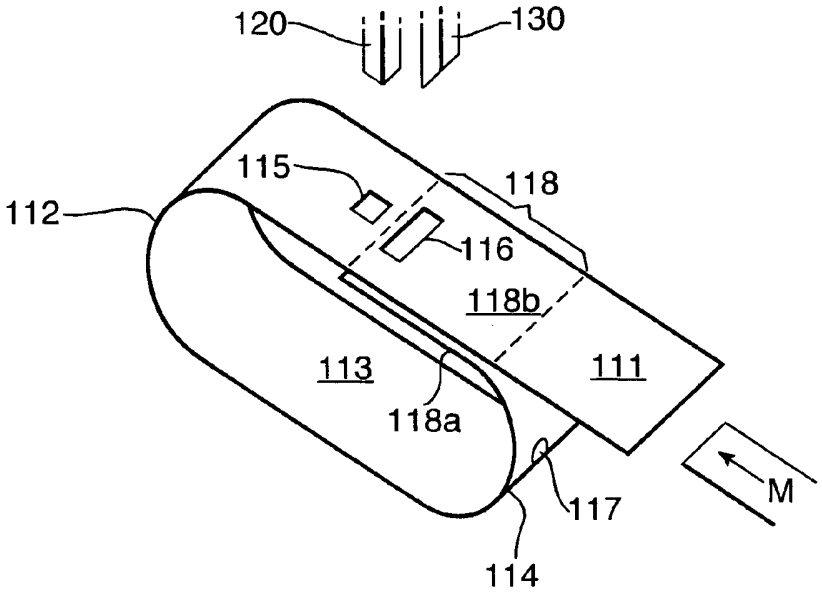


Fig.5a.

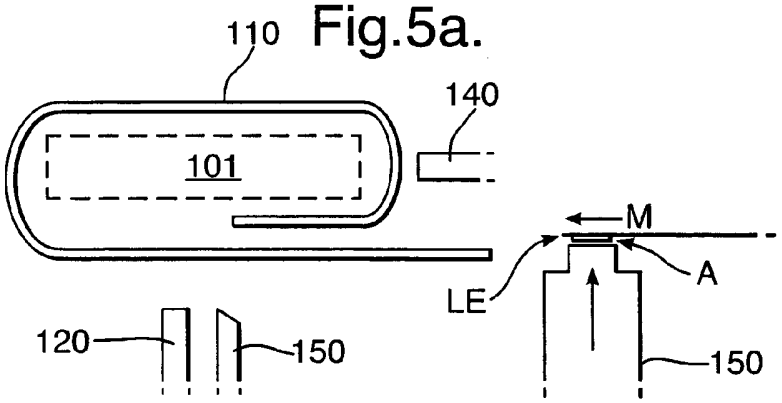


Fig.5b.

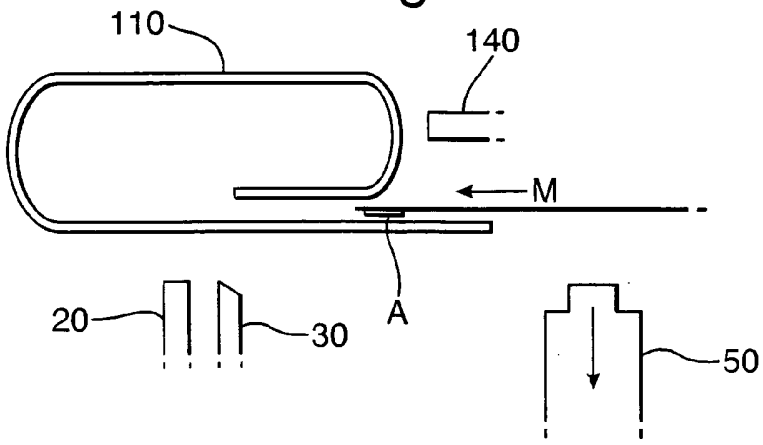


Fig.5c.

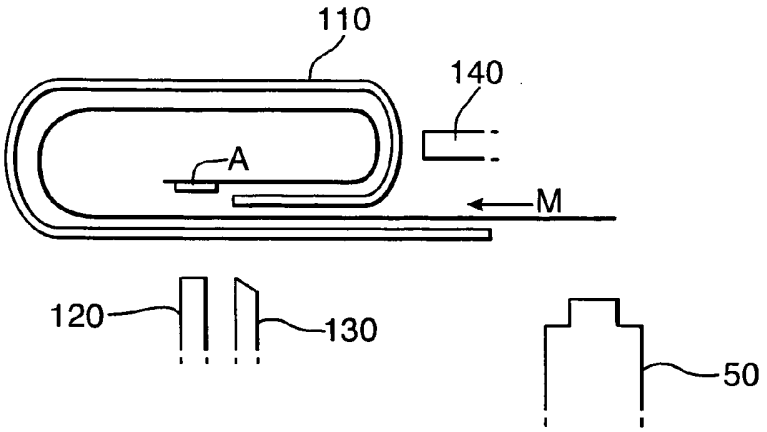


Fig.5d.

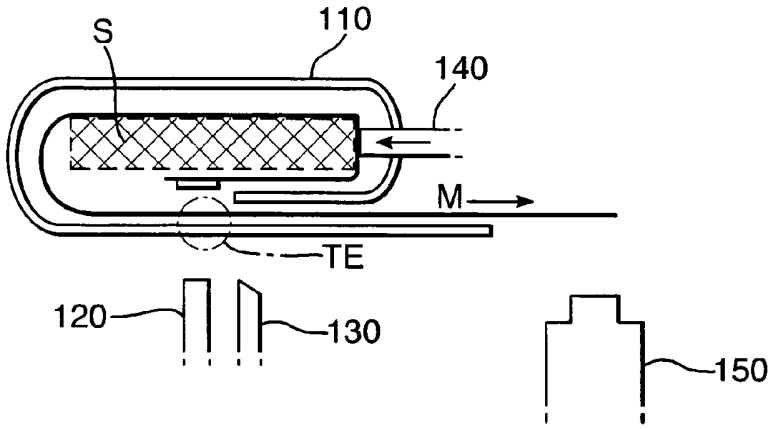


Fig.5e.

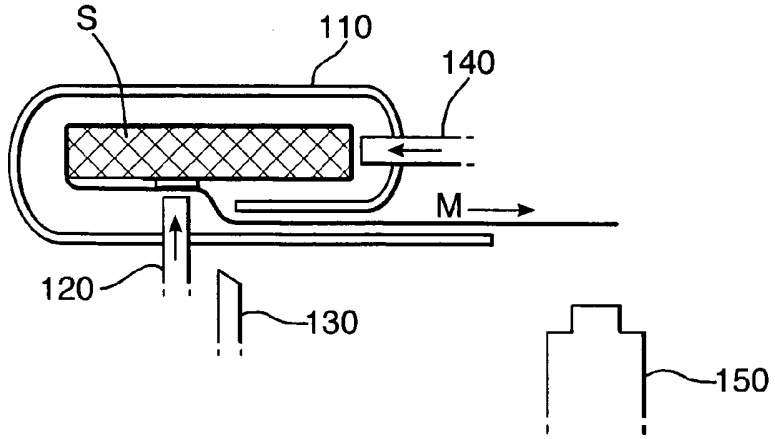


Fig.5f.

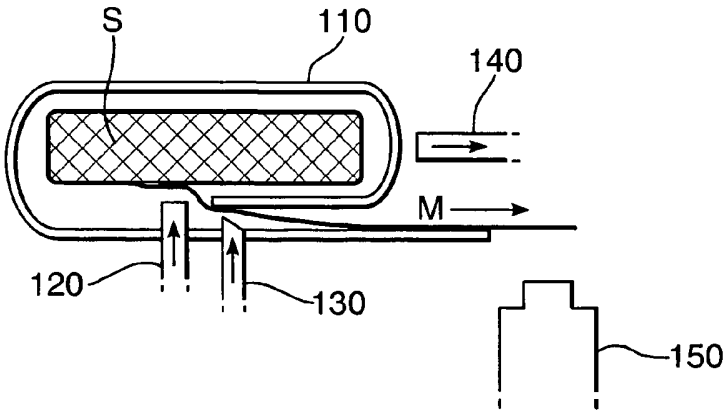


Fig.5g.

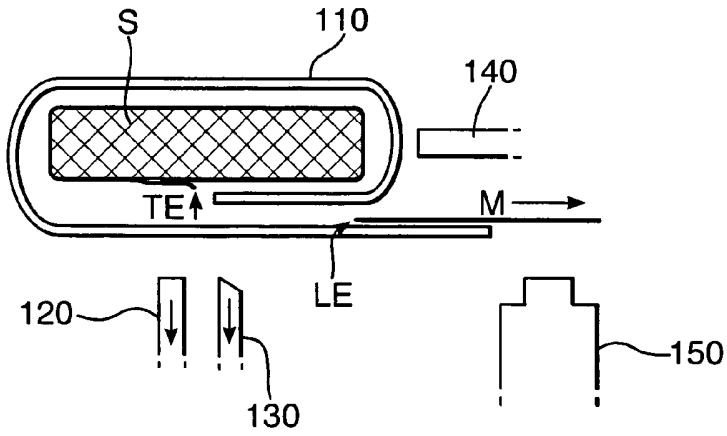
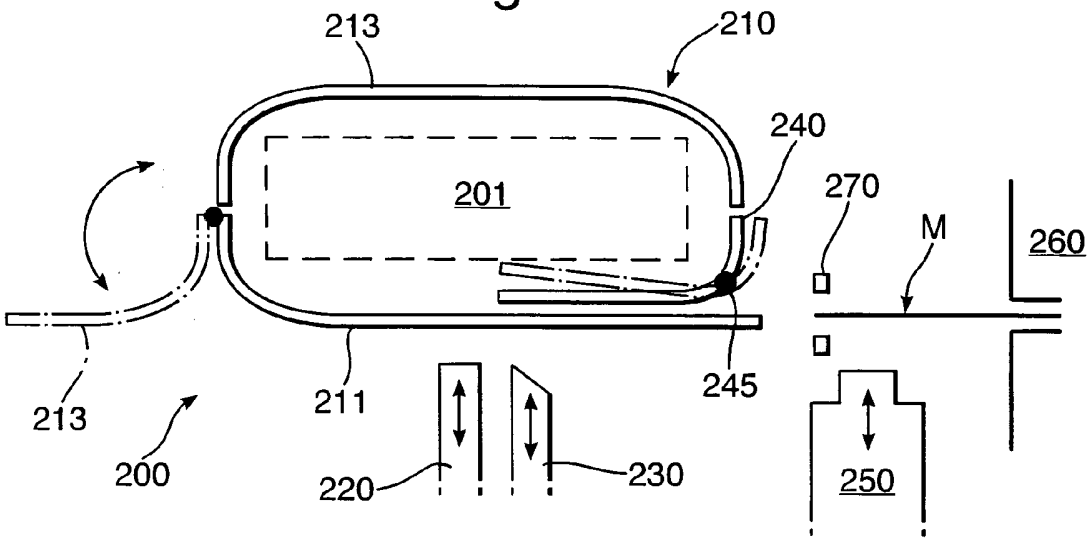


Fig.6.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250

Fig.7.

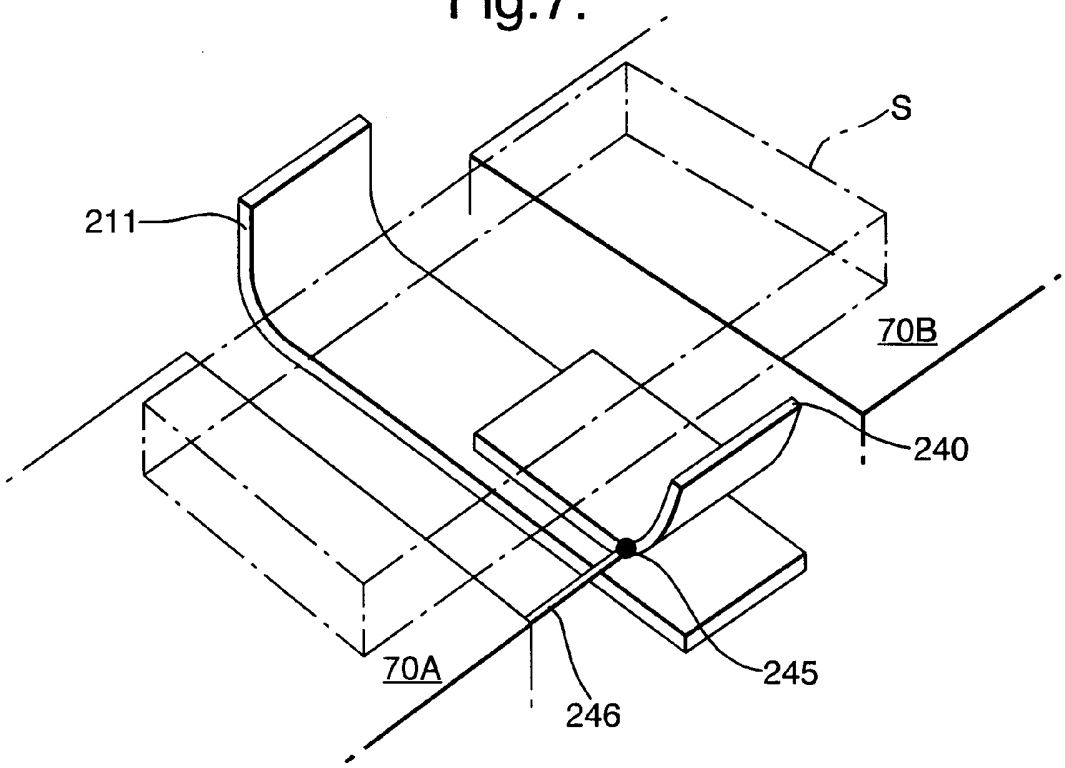
S
211
70B
240
70A
245
246

Fig.8a.

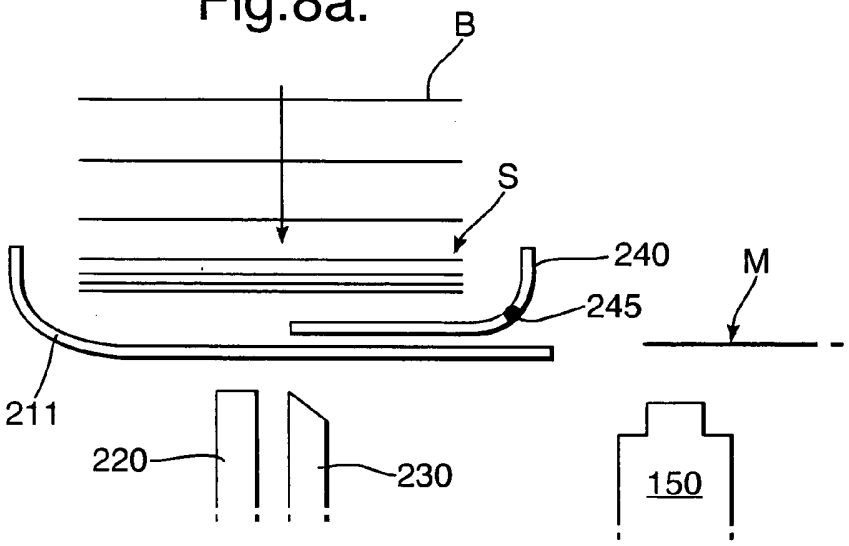

Fig.8b.

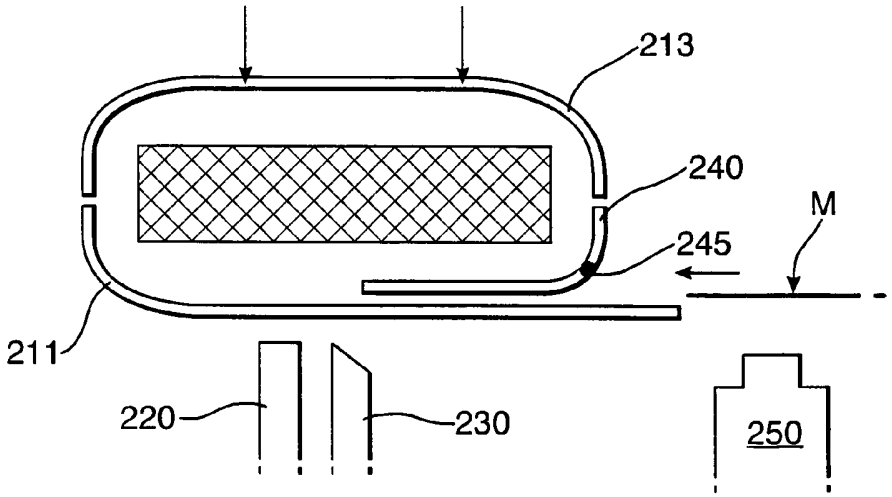

Fig.8c.

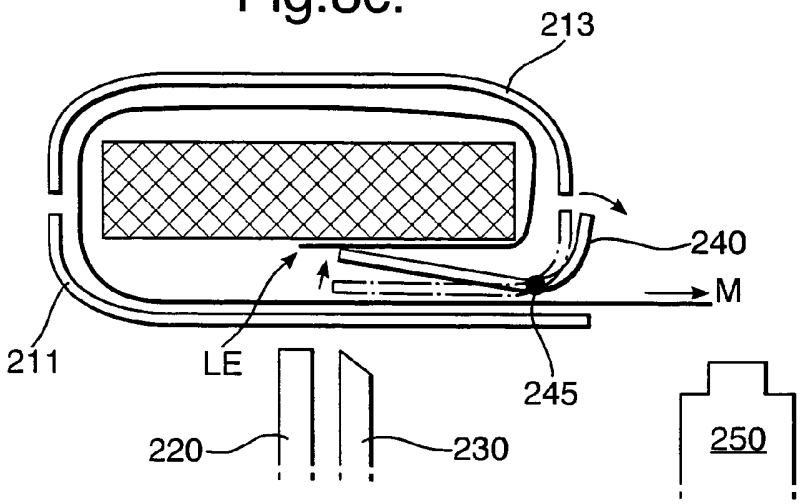

Fig.8d.

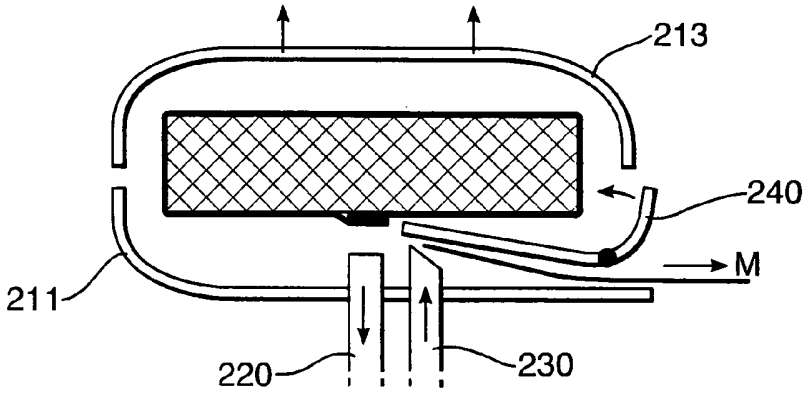

Fig.9.

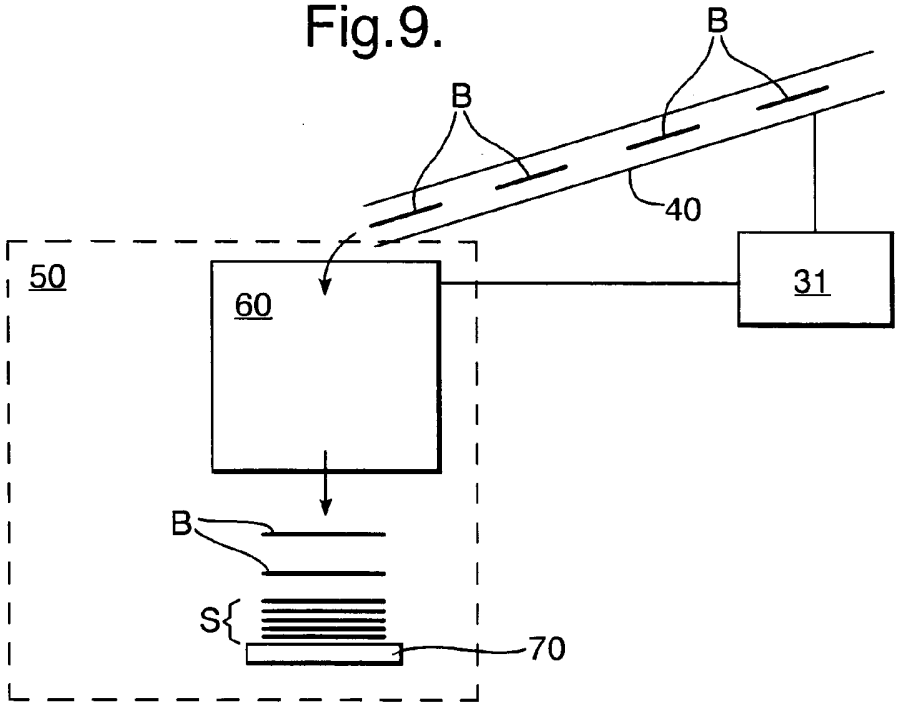

Fig.10.

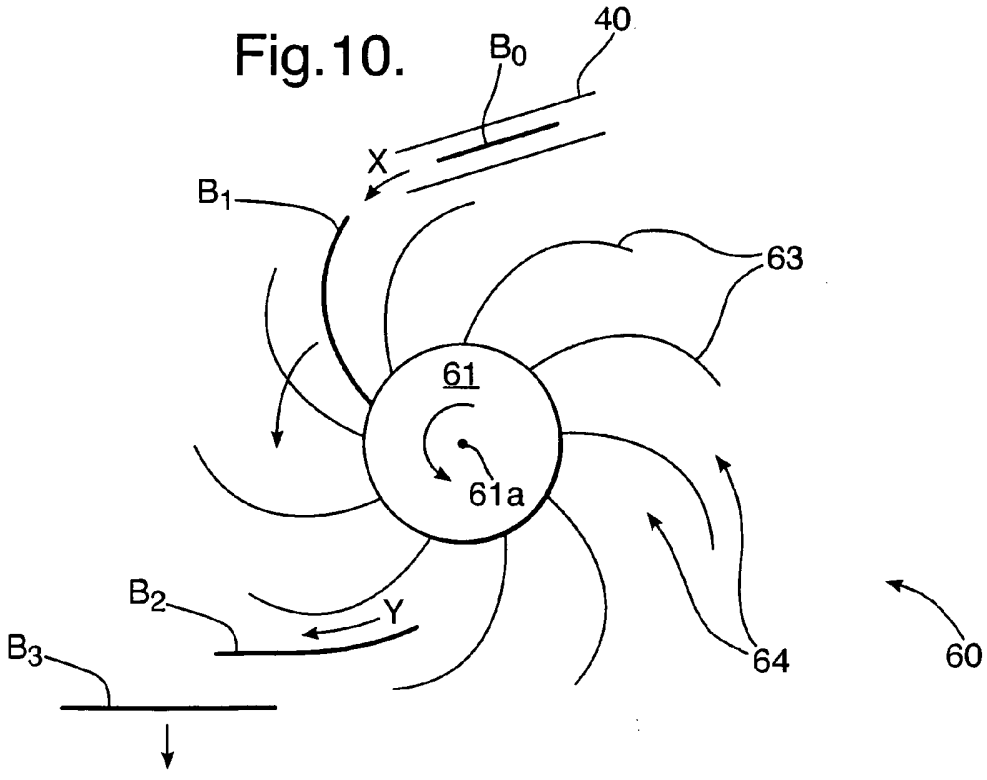

Fig.11.

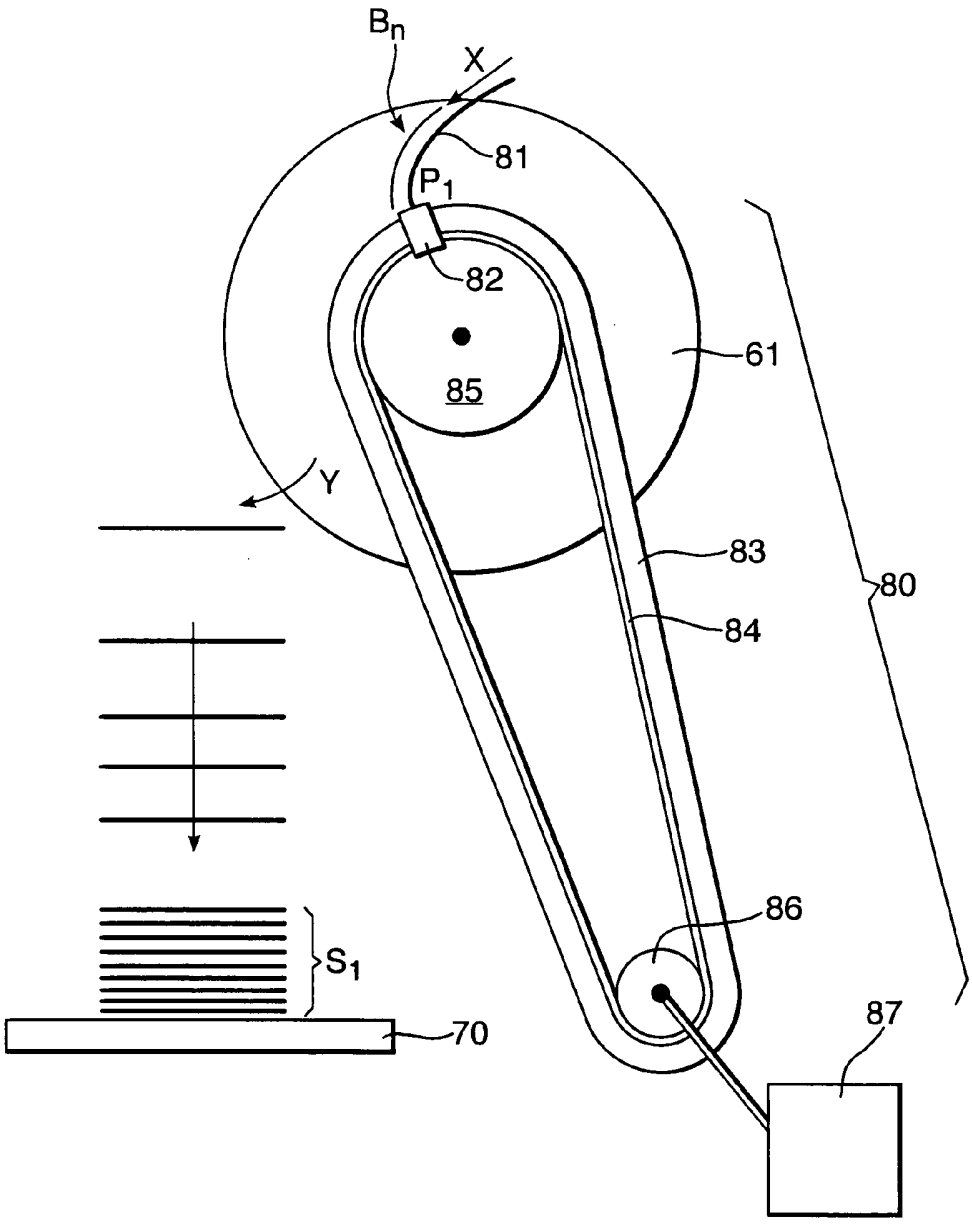

Fig.12.

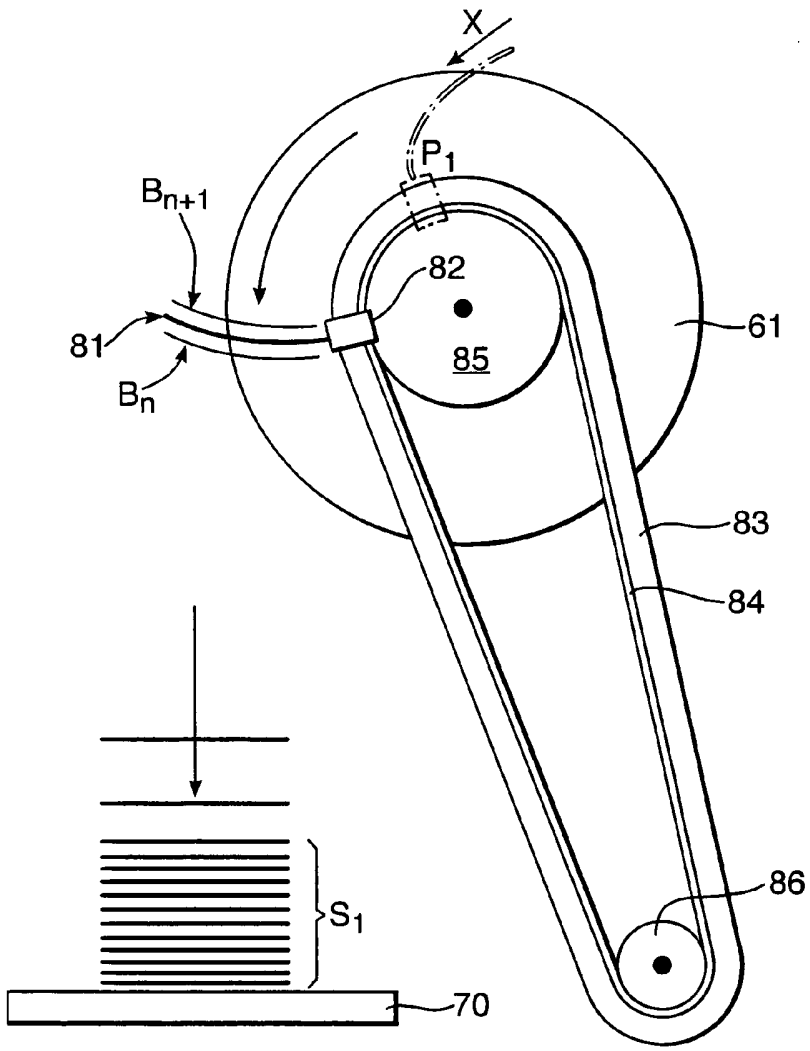

Fig.13.

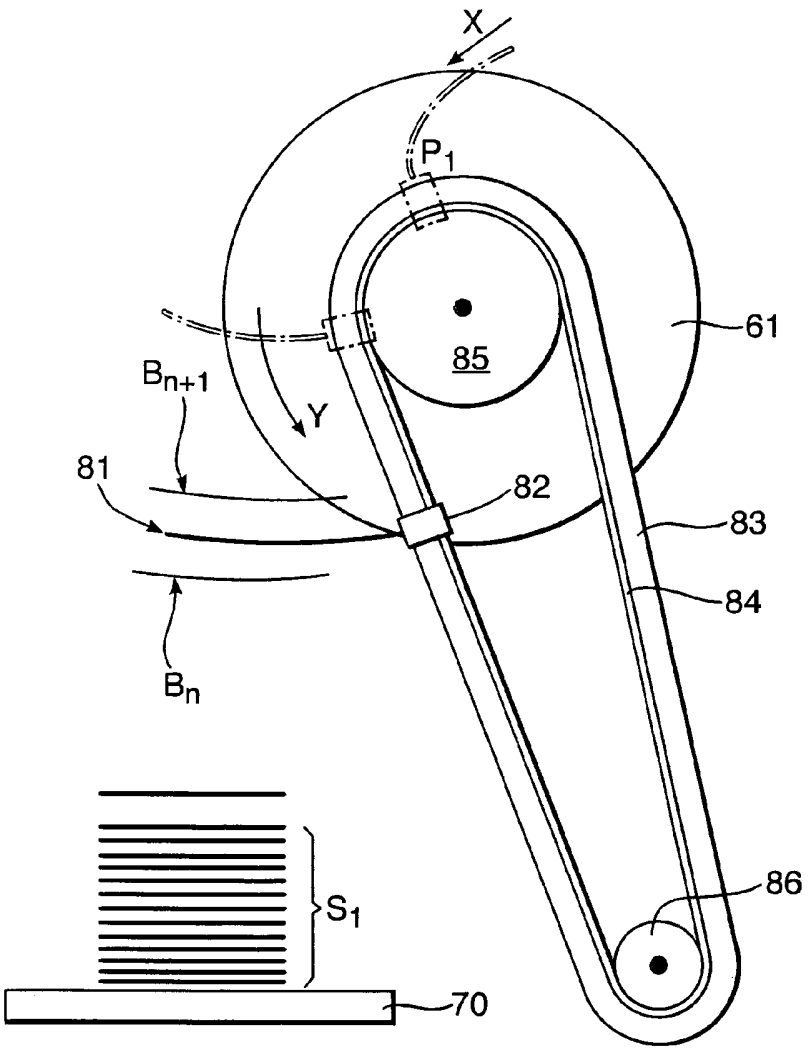

Fig.14.

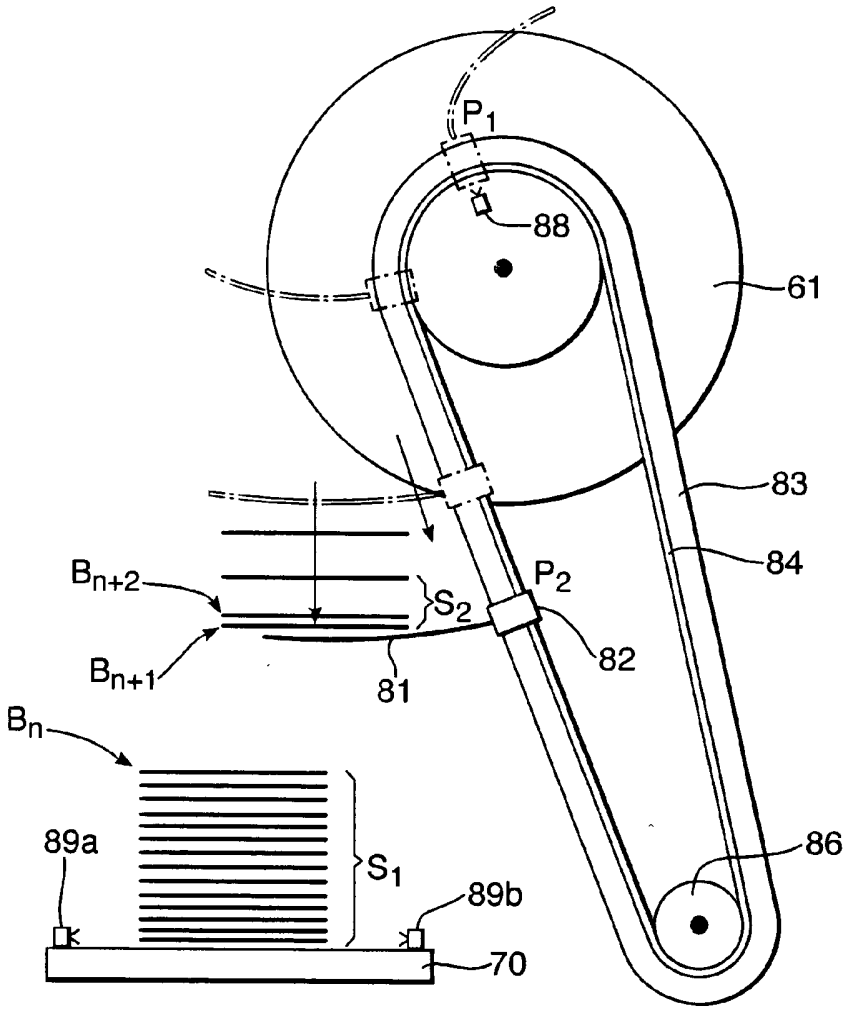

Fig.15.

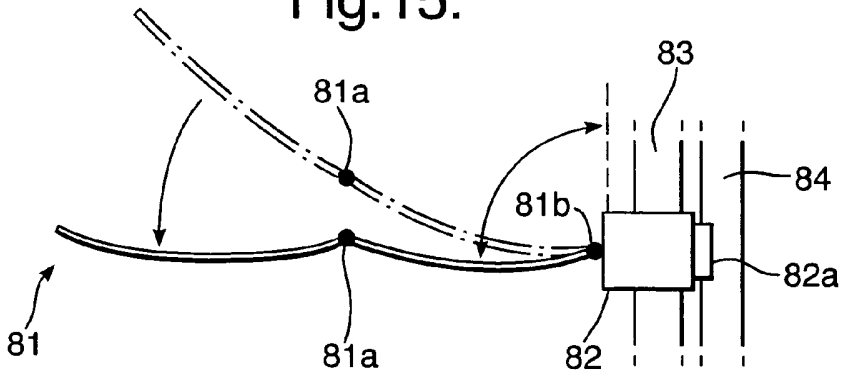

Fig.16.

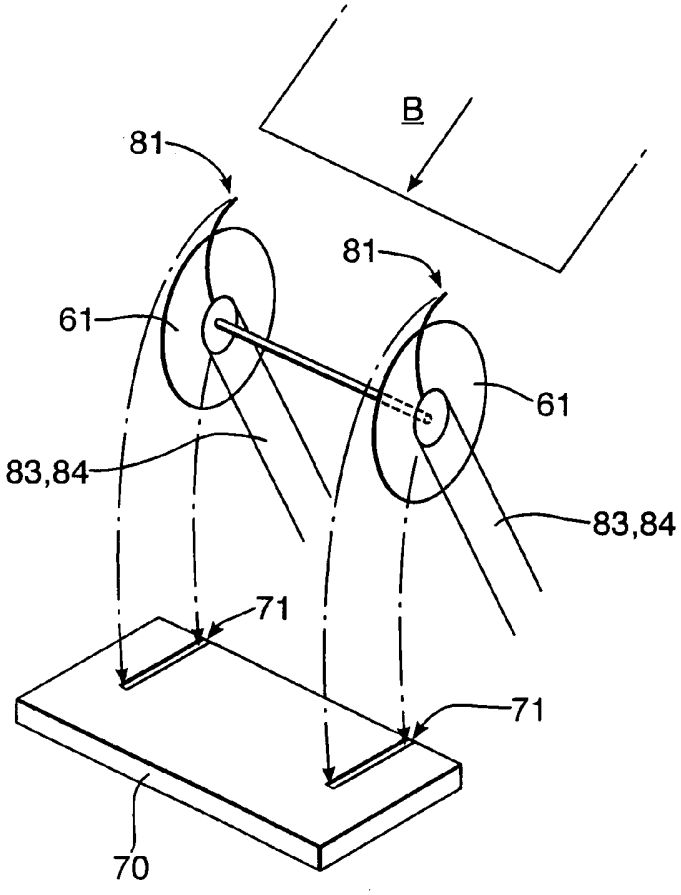

Fig.17.

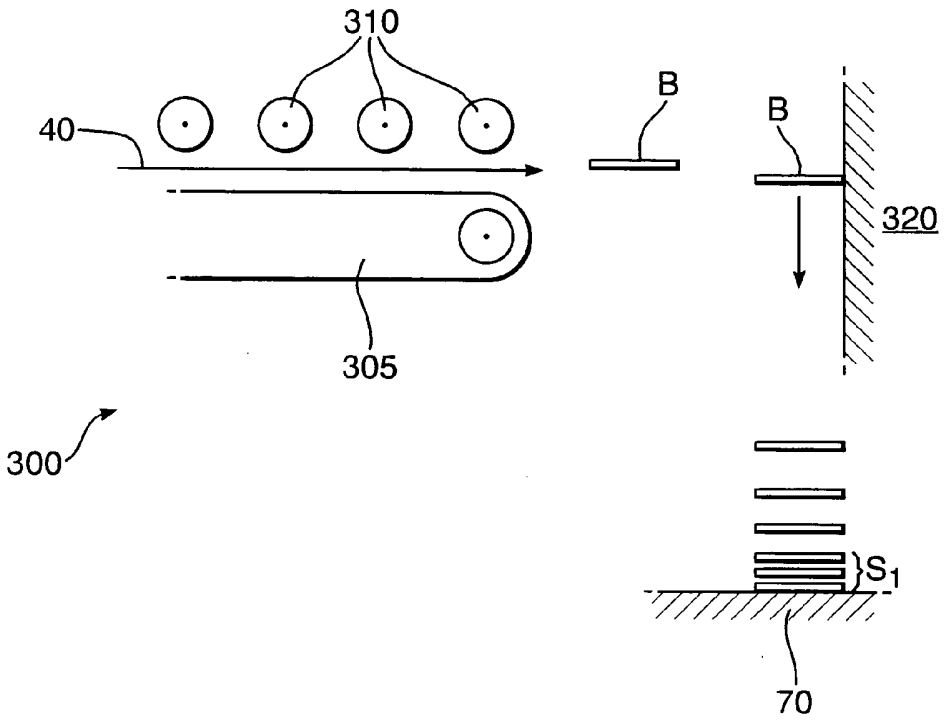

Fig.18a.

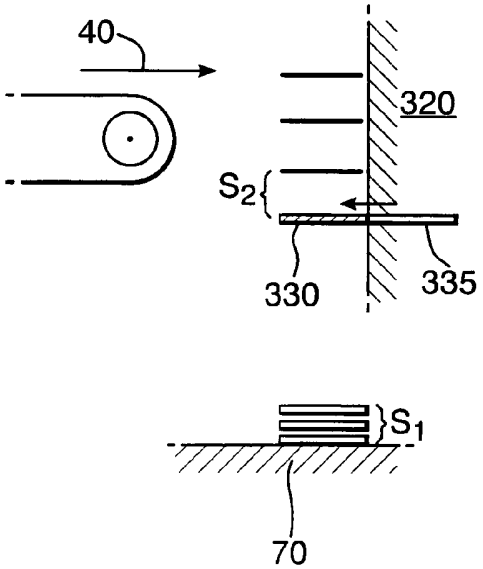

Fig.18b.