Abstract: An arrangement for the separation of an end sheet (21) from a group of parallel sheets overlapping each other comprises a pair of parallel rotatable rollers, which between themselves form a roller nip, the group of sheets moving in the plane thereof toward the roller nip with leading edges substantially parallel to the rollers, and a first one of the rollers being arranged to rotate in a first direction in order to contact and convey the end sheet (2') in the feed direction thereof. The second roller is arranged rotatable in the same rotational direction as the first roller. The envelope surface of the first roller has a higher friction coefficient than the second roller. A displacement arrangement is arranged to mutually bias the rollers into contact against each other, and that the rollers are mutually directed for the displacement toward and away from each other.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
A separating arrangement

The invention relates to a separating arrangement of the kind that is seen in the preamble of the appended independent claim.

In arrangements for feeding out sheet-like documents from a stack or regular sheaf of sheets, for instance documents, in particular documents of value such as, for instance, banknotes, it is well known to press a driver having a given friction coefficient against an end sheet of the stack, and to displace the driver in such a way that the end sheet is moved in the plane thereof away from the stack. It is well known that the driver occasionally not only conveys the end sheet but also one or more adjacent sheets from the stack, and in that connection, it is also well known to let the driver transport the sheet/the group of sheets to a separator, in which the unintentionally conveyed sheets are separated from the end sheet and taken care of, while the end sheet is further transported for another further handling. The outfeed function is repeated all the way until a predetermined number of individual sheets have been detected to leave the separator, of an ordered delivery of sheets.

However, a problem is that the mutual friction between adjacent sheets of the sheaf may vary considerably in different sheaves. Furthermore, the mutual friction between adjacent sheets in the sheaf of sheets may be relatively high, so that an outfeed operation of the kind indicated relatively often entails that a group of additional sheets accompanies the end sheet in the outfeed operation. Even if the separator is capable of separating the unintentionally conveyed sheets, it is a drawback that the sheets separated by the separator are not directly at disposal for feeding to the intended final destination.

If the mutual friction between the sheets in the stack of sheets is annoyingly high, it may furthermore happen that the number of sheets lifted out of the stack by the driver in an
outfeed operation is so great that the separator incapable of separating the additional conveyed sheets. Then further other problems arise, which means that the entire group of sheets has to be diverted, which means that the outfeed operation of the driver does not cause that any sheet can be further transported through the separator and be included in the requested delivery of a certain number of sheets to an end user. Naturally, this means a time delay of the overall delivery operation.

A mutual high friction between sheets in a stack has been noted in many cases. If, for instance, the sheets consist of banknotes that come directly from a banknote printing works or the like in the form of a stack or sheaf, the mutual adhesion of the sheets may be relatively large. Especially when the sheets/banknotes are formed of certain plastic materials, such as polypropylene, high mutual friction in the stack has been noted. However, the problem is not limited to such situations, but also occurs when the friction between the sheets in the stack varies, since the outfeed device should be adjusted so as to present a reliable outfeed of preferably individual sheets, and the separator has to be able to solve the task thereof and should preferably also be able to remove a group of sheets that cannot pass through the separator and that cannot be separated by the separator.

Therefore, an object of the invention is to provide a separating arrangement by means of which the mentioned problems entirely or partly are obviated.

The object is attained by the invention.

The invention is defined in the appended independent claims.

A group of sheets that has been fed out from a stack of sheets up to a separator should have a low speed at the entrance of the separator, in order for the separator to work properly. The outfeed speed of the end sheet from
the sheaf of sheets should be high, for a plurality of reasons, for instance, in order to allow a quick outfeed of individual sheets from the stack, and, as far as possible, in order to produce a quick speed difference between the end sheet and adjacent sheets of the sheaf. The speed of the end sheet and possibly adjacent sheets conveyed thereby has to be reduced before the group of sheets contacts the separator.

Thereby, in a preferred embodiment, the proper separator may comprise two rolls or rollers abutting against each other and being independently rotatable. One of the separator rollers rotates in the same rotational direction as the driver roller. Therefore, the mentioned first separator roller and the driver roller may be driven by a common driving motor and be mutually coupled by a fixed transmission. The second separator roller is preferably arranged rotatable in an opposite direction to the first separator roller. A group of sheets fed towards the entry nip between the separator rollers, in that connection, oriented so that the end sheet comes closest to the first separator roller and the group of the other sheets accordingly comes closest to the second separator roller, and is thereby diverted by the same on the entry side of the nip. By the fact that the group of sheets has a low speed at the entrance of the separator nip, and furthermore the second separator roller has the indicated rotation, the sheets conveyed by the end sheet are diverted on the entry side of the separator nip and can be diverted in order to be taken care of in a manner known per se.

In order for the separator to have a proper separation function, it is required that the surface of the first roller has a higher friction coefficient than the surface of the second roller, and furthermore, it is naturally required that the abutment pressure between the separator rollers can be maintained within narrow limits in spite of wear.

Known constructions to maintain an adjustable contact force between the rollers in that connection, in spite of wear, com-
mands a high price. In accordance with a further development of the invention, a special displacement arrangement is utilized for this purpose for pressing one of the separator rollers by an easily controllable force, which is substantially independent of the wear of the separator rollers and the diameter change following thereby. According to the invention, this arrangement may be formed of a solenoid comprising a magnet winding and a core displaceable thereby. A person skilled in the art knows that such a solenoid produces a driving force that varies considerably with the applied current from a given driving voltage, along the displacement path. However, by guaranteeing that only a small portion of the possible distance of motion of the solenoid is made use of for the mutual parallel displacement of the separator rollers, the state is attained that upon constant voltage, the force exerted by the solenoid becomes substantially linearly dependent on the applied current. Accordingly, one of the movable separator rollers may be driven against the second separator roller by a force that is easily controllable and insensitive to changes in the active length of the solenoid (the wear of the separator rollers).

In the following, the invention will be described by way of examples, reference being made to the appended drawing.

Fig. 1 schematically shows a side view of an outfeed arrangement and a separator for sheets from a sheaf of sheets.

Fig. 2 schematically shows an arrangement in order to control the abutment force of the outfeed arrangement against the sheaf of sheets.

Fig. 3 schematically shows an arrangement for the control of the abutment force between two rollers of the separator.
Fig. 4 schematically shows the variation of the force exerted by a solenoid over the entire stroke-length range thereof, at a constant driving voltage and driving current.

Fig. 5 shows the relation between the force and feed current of the solenoid within a small part range of the stroke length of the solenoid.

In Fig. 1, a substratum 3 is shown, on which a stack of sheets 1 rests. The stack of sheets 1 comprises sheets stacked on each other such as, for instance, banknotes, which normally have an identical format and usually have the extension plane thereof perpendicular to the substratum surface 3, which is parallel to the adjacent side surface of the stack. The stack 1 is displaced in the longitudinal direction 4 thereof so that the end sheet 2' thereof is pressed against an outfeed roller 12, which is parallel to the substratum and to the sheets 2, and contacts the stack 1 at a height above the substratum 3 that preferably is in the upper half thereof, i.e., at a distance in the range of 0.4-0.9 h above the substratum 3.

The stack 1 is pressed against the roller 12 by a force N₂, which in combination with the friction coefficient of the circumference surface of the roller 12 produces a selected displacement force of the end sheet 2 upon the rotation of the roller 12.

The stack of sheets 1 may be displaced in relation to the roller 2 together with the substratum 3. Alternatively, the stack 1 may be displaced along the substratum 3. The substratum 3 is provided at least in the area below the end sheet 2'. In Fig. 1, furthermore a separator 48 is seen, which is arranged to receive and lead through the end sheet 2 when the same is fed upward in the plane thereof. If the end sheet 2' is accompanied by one or more adjacent sheets 2 from the stack, the separator serves to separate and divert the accompanying sheets
and divert them by a diversion arrangement 49 (not shown in
detail), so that only a single sheet, the end sheet 2', passes
the separating arrangement and is further led to a conveyor 60.
A sensor 61 may be arranged beyond the separator 48 and detect
passed banknotes, for instance in order to detect a banknote 2'
possibly accompanying the end banknote 2', so that in such a
case the passing group of banknotes 2, 2' can be diverted by a
diversion arrangement 61 in a known way per se.

The separator 48 is shown to comprise two cylindrical rollers
11, 31 being mutually parallel and pressed against each other.
A motor 10 is shown to rotationally drive the separator roller
11 via a belt transmission 21, and the outfeed roller 12 via
another transmission 22. The second separator roller 31 is
rotationally driven from a motor 31 via a transmission 41, and
the roller 31 is rotatable independently of the rotation of the roller 11.

When feeding out the end sheet 2' from the stack 1, the roller
12 is first rotated in a first rotational direction 12A so that
the end sheet 2' is driven toward the substratum 3 and in that
connection experiences an elastic bulged shape between the sub-
stratum 3 and the contact point between the roller 12 and the
stack 1. In that connection, the conveying distance of the
sheet 2' is small in order to guarantee that the bulging of the
sheet 2' is elastic and that the bulged sheet 2' still is in
engagement with the roller 12. Next, the rotation of the roller
12 is reversed so that the roller rotates in the rotational
direction 12B, whereby the end sheet 2' is displaced upward,
away from the substratum 3 toward an entrance nip between the
separator rollers 11, 31. If the end sheet 2' is accompanied by
one or more adjacent sheets in the movement thereof toward the
separator, said accompanying sheets 2 can be separated from the
end sheet 2', provided that the group of sheets enters the
separator 48 at a low speed. By rotating the roller 31 in a
direction such that the circumference surface thereof runs
reverse the circumference surface of the roller 11, a separa-
tion effect is attained for the accompanying sheets/banknotes 2. The envelope surface of the roller 11 has a friction coefficient $\mu_1$ that is higher than the friction coefficient $\mu_2$ of the roller 31, and the opposite rotational directions of the rollers 11 and 31 entail that the circumference surface of the roller 31 can affect the upper edges of the accompanying sheets 2 along a relatively long distance, so that an efficient separation process is attained compared with the roller 31 standing idle. The periphery speed of the roller 31 is usually lower than the periphery speed of the roller 11. An outfeed operation of a banknote 2' is carried out within a period of time of a few milliseconds.

An efficient separation of sheets in a group of sheets that enters the separator 48 implies that the sheets enter the separator at a low speed, but the roller 12 has to feed out the sheet 2' at a high speed from the stack 1 in order for a sheet-outfeed operation to be executable within a necessarily short period of time. Since the driving motor 10 of the roller 10 is arranged to quickly accelerate the roller 12 and then brake the roller 12, this function may in an advantageous manner be utilized by the fact that the acceleration and the retardation of the roller 12, and thereby of the sheet 2' and possible accompanying sheets 2', are repeated one or more times during the transportation of the sheet 2' toward the separator 48. During each such subsequent acceleration of the end sheet 2', the possibility of a separation of the end sheet 2' from the nearby sheet 2 is improved.

The driving of the end sheet 2' by the roller 12 in a controlled manner implies, among other things, that the abutment force of the roller 12 against the end sheet 2' is maintained within narrow limits.

For that sake, it is suggested that the roller 12' is arranged displaceable in the direction of motion 4 of the stack 1. A mounting 70 for the shaft shank of the roller 12 is carried
from a support 80 via a spring 71 having a known spring characteristic. A sensor 72 detects the distance between the support 80 and the mounting 70. This distance $s$ represents the support force against one end of the shaft shank. With the corresponding arrangements at both shaft ends, the normal force $N_2$ of the roller 12 against the end sheet 2 can be maintained by means of a pusher 75, which applies a force for which the sensors 72 detect a preselected distance $s$.

Since the rollers 11, 31 in the separator 48 will slide against each other or against sheets 2 situated between the same, they are subjected to wear, which means that the rollers 11, 31 have to be movable toward each other and be pressed by an external force transducer in order to have a predetermined mutual abutment force $N_0$ (Fig. 3).

In accordance with a further development of the invention, for that sake it is suggested that one of the separator rollers is arranged displaceable in parallel toward the other roller 11 in a common axis plane, the shaft journals of the roller 31 being received in corresponding displaceable mountings 33, which are displaced by a respective linear solenoid 90.

Fig. 4 illustrates that such commercially available solenoids 90 have a linear stroke length between a minimum value $L_{hi}$ and a maximum value $L_{max}$. When a constant voltage $U$ and a constant current $I$ is applied to such a solenoid, the solenoid develops a varying force over the stroke-length range thereof. This makes that a plain solenoid has been considered less suitable for force control.

We have found that for such a solenoid, a small stroke-length range $\delta i$ may be selected, in which the force can be considered linear. In that connection, Fig. 5 illustrates that, at a constant driving voltage $U$, it is easy to control the generation of force of the solenoid 90 by a feed current $I$ being proportional thereto. In this way, there are good prospects to main-
tain a total abutment pressure between the separator rollers and also to compensate for wear of the rollers 11, 31.

A particular advantage of using rollers 11, 31 that are pressed against each other is that, in the situation that a group of sheets 2', 2 cannot be separated by the separator but remains on the entrance nip of the separator, this condition can be detected by, for instance, the sensor 49, which then provides for the withdrawal of the solenoids 90, so that the sheaf can pass through the separator, the sensor 61 situated downstream of the separator detecting that a plurality of sheets simultaneously pass the separator and, in that connection, instructing the diversion arrangement 62 to divert said group of sheets. The alternative would otherwise be that the assembly would need to be stopped, waiting for an operator to obviate the problem (to remove the sheaf abutting against the entry side of the separator 48).

The use of the solenoids 90 implies naturally that the wear of the rollers 11, 31 is relatively small, i.e., that the axial distance between the rollers 11, 31 is a short length much smaller than the maximal stroke length of the solenoids.

From the structure according to Fig. 1, it can be understood that the roller 12 may be directly driven from the motor 10 via the transmissions 21, 22 and that the roller 11 also may be directly driven by the motor 10, i.e., that no freewheels or the like are required. The same thing applies to the roller 31 and the direct driving thereof from the motor 30 via the transmission 41.

By rotating the roller 31 in an opposite direction to the roller 11, a prolonged sliding motion is attained between the envelope surface of the roller 31 and the end edges of the sheets in the group of sheets brought to the roller nip of the separator by the feed roller 12.
Claims

1. Arrangement for the separation of an end sheet (2') from a group of parallel sheets, which overlap each other, the separating arrangement comprising a pair of parallel rotatable rollers, which between themselves form a roller nip, the group of sheets moving in the plane thereof toward the roller nip with heading edges substantially parallel to the rollers, and a first one of the rollers being arranged to rotate in a first direction in order to contact and convey the end sheet (2') in the feed direction thereof, characterized in that the second roller is arranged rotatable in the same rotational direction as the first roller, that the envelope surface of the first roller has a higher friction coefficient than the second roller, that a displacement arrangement is arranged to mutually bias the rollers into contact against each other, and that the rollers are mutually directed for the displacement toward and away from each other.

2. Separating arrangement according to claim 1, characterized in that the rollers are mutually biased by a displacement arrangement that is drivable to apply a selected mutual bias force between the rollers, substantially independently of an axial distance alteration between the rollers produced by wear, that means are provided for suspension of or reversal of the action direction of the displacement arrangement, in order to allow the rollers to separate for letting through a group of sheets that cannot be separated and thereby otherwise cannot pass through the roller nip, that a sensor is situated upstream of the pair of rollers and is arranged to detect the presence of a group of sheets comprising at least one sheet, and that evaluation members are provided in order to bring the bias arrangement to allow the sheaf of sheets to pass after a predetermined period of time of a sheet-presence signal from the sensor.
3. Separating arrangement according to any one of claims 1-2, characterized in that the bias arrangement comprises a linear solenoid, a small fraction of its maximal stroke length of which is made use of in order to compensate for wear of the mutual abutment surfaces of the rollers, whereby the applied bias force is essentially constant within said portion of the interval and the alteration of the axial distance of the rollers that is allowable in view of the wear.

4. Separating arrangement according to claim 3, characterized by means for varying the driving power of the solenoid for controlling the bias force of the solenoid, the means comprising an arrangement to vary the current feed of the solenoid at a constant voltage, whereby the bias force is substantially proportional to the feed current.

5. Separating arrangement according to any one of claims 1-4, characterized in that a second sensor is arranged downstream of the pair of rollers and that the second sensor is arranged to distinguish between an individually passing sheet and a group of sheets, and that the second sensor is arranged to direct a diversion arrangement to divert a group of sheets having passed the roller nip to a store, and that the diversion arrangement is arranged to allow an individual sheet to pass to a transportation for forwarding.
**INTERNATIONAL SEARCH REPORT**

**International application No.**
PCT/SE2006/001371

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC: B65H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**EPO-INTERNAL, WPI DATA, PAJ**

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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**D** Further documents are listed in the continuation of Box C. **X** See patent family annex.

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**Date of the actual completion of the international search**

5 March 2007

**Date of mailing of the international search report**

7-03-2007

**Name and mailing address of the ISA/Swedish Patent Office**

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**International patent classification (IPC)**

B65H 3/46 (2006.01)
B65H 3/06 (2006.01)
B65H 7/12 (2006.01)

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Use the application number as username.
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Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.
### INTERNATIONAL SEARCH REPORT

**Information on patent family members**

#### 26/01/2007

**International application No.**

**PCT/SE2006/001371**

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