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(71) Applicant: **Neopost Technologies**
92220 Bagneux (FR)

(72) Inventor: **Jonker, Melle**
9202 DC Drachten (NL)

(74) Representative: **Hatzmann, Martin**
Vereenigde
Johan de Wittlaan 7
2517 JR Den Haag (NL)

(54) **Apparatus and method for folding a sheet**

(57) In an apparatus for folding a sheet (7, 8) of paper, a pair of folding rollers (10, 11) forms a folding nip (12). A sheet (7, 8) is fed in a feeding direction (13) to a first position extending along the folding rollers (10, 11). The sheet (7, 8) is bent adjacent to the folding nip (12) and urged into the folding nip (12). The bent portion of the sheet is folded in the folding nip (12). Then, the folded sheet is transported (7, 8) around one of the folding rollers (10, 11) to a second position extending along the folding nip (12) and the folding rollers (10, 11) at the input side of the folding rollers (10, 11). The sheet is again bent adjacent to the folding nip (12) and a bent portion is again folded in the folding nip (12). The folding roller (10, 11) around which the folded sheet (7, 8) is transported is the downstream one of the folding rollers (10, 11).

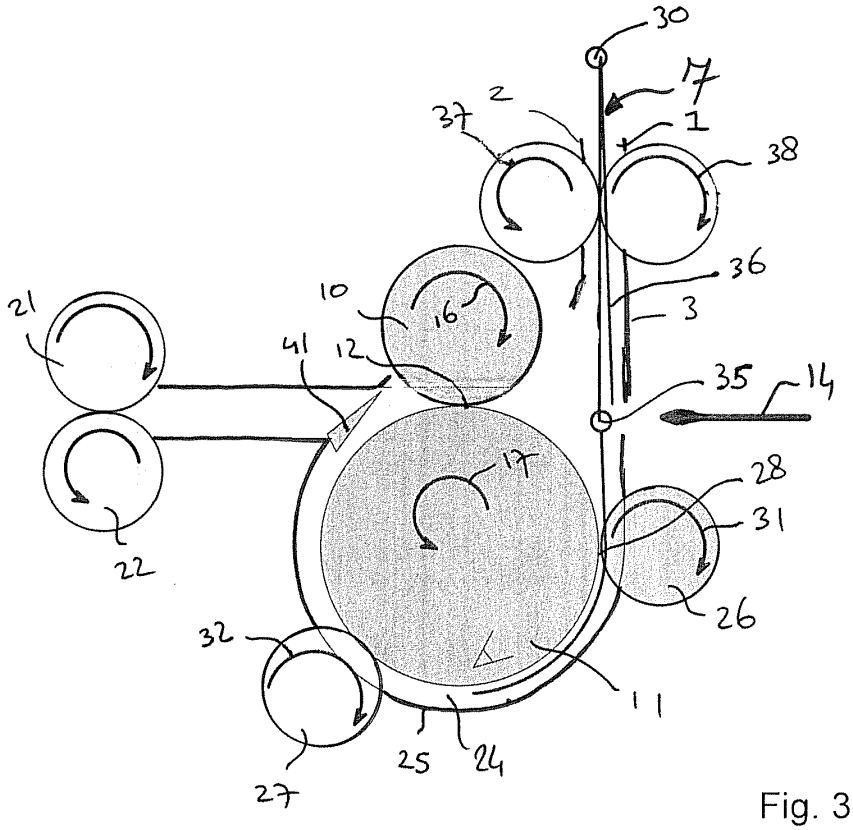

Fig. 3

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Description

FIELD AND BACKGROUND OF THE INVENTION

[0001] The invention relates to an apparatus for folding sheets according to the introductory portion of claim 1 and to a method for folding a sheet according to the introductory portion of claim 4.

[0002] Such a method and such an apparatus are known from the U.S. patent 5 769 774. In this known method and apparatus, sheets in which two folds have to be formed are guided around one of the folding rollers after a first fold has been made therein in the folding nip and subsequently a second fold is formed in the sheet in the same folding nip. Because two folds can be made in the same folding nip, the number of folding rollers, which are relatively costly items, is reduced, which is advantageous for keeping manufacturing costs low and obtaining a compact apparatus, which is of particular importance for apparatuses designed for low production volumes.

SUMMARY OF THE INVENTION

[0003] It is an object of the present invention to provide a solution for providing a further simplified, more compact and more versatile folding apparatus.

[0004] According to the invention, this object is achieved by providing an apparatus according to claim 1. The invention can also be embodied in a method according to claim 4.

[0005] Because the folding roller around which the recirculation transport path extends is located downstream in the feeding direction of the other one of the folding rollers, the recirculation transport path can also receive the leading end of a sheet as it is fed prior to folding. Accordingly, no separate paths for recirculation and receiving a leading sheet portion prior to folding are required. Moreover, a folded or unfolded sheet may be turned over by an additional passage of the sheet through the recirculation transport path.

[0006] Particular elaborations and embodiments of the invention are set forth in the dependent claims.

[0007] Further features, effects and details of the invention appear from the detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Figs. 1-4 are schematic representations in side view of successive stages of operation of an example of an apparatus according to the invention while folding a sheet in a C-fold configuration;

Figs. 5-8 are schematic representations in side view of successive stages of operation of the apparatus shown in Figs. 1-4 while folding a sheet in a Z-fold configuration and subsequently turning the folded sheet;

Fig. 9-11 are schematic representations in side view of successive stages of operation of the apparatus shown in Figs. 1-8 while turning a sheet without folding the sheet.

DETAILED DESCRIPTION

[0009] In the drawings, an example of a folding apparatus according to the invention is shown. The apparatus has a feeding path 1 bounded by guides 2, 3. A pair of transport rollers 4, 5 defining a nip 6 in the feeding path 1 is provided for controlling the feeding of sheets 7 along the feeding path 1. It is observed that in various Figures, sheets 7, 8, 9 are shown in portions intersecting portions of rollers adjacent to a nip. In those instances, the sheets are to be considered as extending through the nip. The intersecting representation has been chosen only to allow respective portions of a sheet in a nip to be represented in a clearly distinguishable manner.

[0010] A pair of folding rollers 10, 11 defines a folding nip 12 between the folding rollers 10, 11. As is known in the art, a folding nip extends over substantially the entire width of a paper path, to allow folds of a length of the largest width of sheets transported along the paper path to be made in the sheets passing through the folding nip. In contrast, a transport nip between transport rollers or between a transport roller and a folding roller may extend over only a small portion of the width of the paper path, since that is sufficient to engage the sheets being transported through the nip or held in the nip.

[0011] The feeding path 1 extends in a feeding direction 13 (see Figs. 1, 5 and 9) along an input side of the folding rollers 10, 11 for transporting a leading end portion of a sheet 7, 8, 9 in the feeding direction 13 to a position extending along the folding nip 12 and the folding rollers 10, 11 at the input side of the folding rollers 10, 11 (see Figs. 1 and 5).

[0012] Adjacent to the folding nip 12 on the input side of the folding nip 12 a pressing member in the form of a folding knife 14 is provided for pressing against a portion of a sheet 7, 8, 9, causing said portion to bend and to be urged into the folding nip 12.

[0013] A drive system for driving rotation of the folding rollers 10, 11 in senses of rotation 16, 17 in which sections of the folding rollers 10, 11 defining the folding nip 12 move away from the input side of the folding nip 12 to an output side of the folding nip 12 is depicted schematically in Fig. 1 only. The drive system includes a motor unit 15 coupled to the folding roller 11 via a coupling 18. The motor unit 15 is also coupled to a transport roller 4 via a coupling 19 and to a transport roller 21 of a pair of output transport rollers 21, 22, via a coupling 20. A control unit 23 is connected to the motor unit 15 and to the couplings 18-20 for controlling the motor unit 15 and the couplings 18-20.

[0014] A recirculation transport path 24 extends from the output side of the folding rollers around one of the

folding rollers 11 and is bounded by the folding roller 11 on one side and a guide 25 and transport rollers 26, 27 on the opposite side. The folding roller 11 around which the recirculation transport path 24 extends is located downstream in the feeding direction 13 of the other one 10 of the folding rollers 10, 11.

[0015] The recirculation transport path 24 is connected to the feeding path 1 for transporting a folded sheet 7, 8 from the folding nip 12 to a position extending along the folding nip 12 and the folding rollers 10, 11 at the input side of the folding rollers 10, 11.

[0016] The transport roller 26 has a circumferential portion opposite a circumferential portion of the downstream one of the folding rollers 11. The transport roller 26 and the downstream one of the folding rollers 11 defining a sheet holding nip 28 for holding a sheet 7, 8 in a position extending along the folding rollers 10, 11 on the input side of the folding nip 12. Traction transferred to a sheet in the sheet holding nip 28 may also be used for displacing a sheet through the sheet holding nip 28, for instance to feed a portion of a sheet back into the feeding path 1.

[0017] How the apparatus according to the present example is operated for folding a sheet 7 into a C-fold or letter fold configuration is described with reference to Figs. 1-4.

[0018] First, a leading end portion 29 of a sheet 7 is fed in the feeding direction to a first position extending along the folding rollers 10, 11 in the feeding direction 13 at the input side of the folding nip 12. This position is shown in Fig. 1, the leading portion of the sheet 7 being constituted by approximately the leading three quarter part of the sheet 7 including the position 30 on the sheet where a fold is to be made. While the sheet 7 is transported to the position shown in Fig. 1, the transport rollers 26, 27 and the folding rollers 10, 11 rotate in senses of rotation opposite to the senses of rotation indicated by arrows 16, 17, 31, 32 and the folding knife 14 is still in the retracted position as shown in Fig. 2.

[0019] Next, the folding knife 14 is displaced to a slightly projecting bending position shown in Fig. 1 and the senses of rotation of the folding rollers 10, 11 are reversed so that the folding rollers 10, 11 and the transport rollers 26, 27 rotate in the senses of rotation 16, 17, 31, 32 shown in Fig. 1. At the same time, the transport rollers 4, 5 defining a transport nip 6 in the feeding path 1 are driven in feeding senses of rotation 33, 34, preferably at the same circumferential speed, so that the sheet 7 buckles in the area around the position 30 where the fold is to be made. The slightly projecting position of the folding knife 14 ensures that the sheet 7 bends towards the folding nip 12 as it is buckles and not away from the folding nip 12.

[0020] As the sheets 7 buckles further, the bent portion of the sheet 7 is urged into the folding nip 12 where a fold is made. For a more positive control of the sheet 7 entering the folding nip 12, the folding knife 14 may be displaced to a third position projecting further towards the folding nip than the position shown in Fig. 1. The folding knife 14 is each time retracted briefly after the sheet 7 has been urged into the folding nip.

[0021] By rotating the folding rollers 10, 11 further such that sections of the folding rollers 10, 11 defining the folding nip 12 move away from the input side of the folding rollers 10, 11 to the output side of the folding rollers 10, 11, the first bent portion of the sheet 7 is flattened and a first fold 30 (see Fig. 2) is formed in the first bent portion of the sheet 7.

[0022] As is shown in Fig. 2, the folded sheet 7 is subsequently guided into the recirculation transport path 24 by the switch 41 in the recirculation position. The folded sheet 7 is then transported around the downstream one 11 of the folding rollers 10, 11 to a second position extending along the folding nip 12 and the folding rollers 10, 11 at the input side of the folding nip 12 (see Fig. 3). During this recirculation of the sheet 7, the transport rollers 4, 5 defining the transport nip 6 in the feeding path 1 are circulated in a sense 37, 38 (see Fig. 3) for displacing a sheet against the feeding direction until about one third of the full (unfolded) length of the sheet 7 has passed the folding knife 14 (how far upstream the sheet 7 is transported precisely depends on the selected setting of the position of the first and second fold).

[0023] Next, the senses of rotation of the transport rollers 4, 5 defining the transport nip 6 in the feeding path 1 are reversed back to the senses of rotation 33, 34 for transport in feeding direction 13 so that the sheet 7 is again bent in essentially the same manner as has been described with regard to the formation of the first fold 30, but now in an area around the position 35 of a second fold to be made in the sheet. This second bent portion of the sheet 7 is subsequently urged into the folding nip 12. The folding knife is preferably displaced to a position projecting to closely adjacent to the folding nip 12, so that the end of a panel of the sheet 7 that has been folded towards the second bent portion around the second folding position 35 is reliably urged into the folding nip.

[0024] The folding rollers 10, 11 are then again rotated further in the senses of rotation 16, 17 such that also the second bent portion of the sheet is flattened and a second fold 35 is formed in the second bent portion of the sheet 7.

[0025] In the meantime, the position of the switch 41 has been changed into the discharging position shown in Fig. 4, so that, as the folded sheet 7 is transported out of the folding nip 12, the sheet 7 is discharged away from the output side of the folding rollers 10, 11. According to the present example, the sheet 7 is then transported further by driving rotation of the discharge rollers 21, 22 in the discharge sense of rotation 39, 40.

[0026] As can be seen from the successive stages of operation, the recirculation transport path 24 serves both for recirculating a sheet 7 to the input side of the folding nip 12 (Fig. 2) and for receiving a portion of a sheet prior to folding (Figs. 1 and 3). A separate path for receiving a portion of a sheet prior to folding is therefore omitted.

[0027] As can be seen in Figs. 1 and 3, the sheet in

the first and second position is held in a sheet holding nip 28 between the downstream one of the folding rollers 11 and a transport roller 26. This provides the advantage, that the sheet 7 can be held in different positions for causing the fold to be made in different positions. Therefore, changing the setting of the position of the fold does not require a stop to be displaced. Moreover, when the sheet is bent for urging it into the folding nip, the sheet can be driven from two sides of the area where the fold is to be made simultaneously. This is advantageous for the accuracy with which the position of the fold can be controlled.

[0028] With reference to Figs. 5-8, an example of a method according to the invention for folding a sheet in a Z-fold configuration is described.

[0029] As was described with reference to Fig. 1, the sheet 8 is transported by the transport rollers 4, 5 defining a nip 6 in the feeding path 1, but less far than in the example shown in Fig. 1. The letter "A" in Figs. 5-8 indicates the position and orientation of an address on the sheet 8 which is to end up face down with a bottom and leading in discharge direction, so that the address will appear in the proper orientation in an envelope in which the folded sheet 8 will be inserted.

[0030] After about one third of the sheet 8 has been transported in the feeding direction 13 past the folding knife 14, the senses of rotation of the folding rollers 10, 11 are reversed to the senses of rotation shown in Fig. 5 and the folding knife 14 pushes the sheet to the folding nip 12 so that the sheet 8 is folded in a folding position 50. Again, the folding knife 14 is each time retracted briefly after the sheet has been urged into the folding nip.

[0031] The switch 41 is in recirculation position and guides the folded sheet 8 around the folding roller 11 through the recirculation transport path 24. In the meantime, the senses of rotation of the transport rollers 4, 5 defining a nip 6 in the feeding path 1 are reversed to the senses of rotation 37, 38 shown in Fig. 6 for transporting the sheet 8 in upstream direction. After about the one third of the full (unfolded) length of the sheet has been transported along the folding knife 14, the senses of rotation of the transport rollers 4, 5 defining a nip 6 in the feeding path 1 are reversed again to the senses of rotation 33, 34 shown in Figs. 5, 7 and 8, while the folding knife 14 pushes the buckle formed in sheet 8 around the position 55 for a second fold into the folding nip 12.

[0032] If the sheet 8, which is now folded in a Z-fold configuration, were to be discharged directly, the address A would be facing upwardly and, accordingly, would not appear behind a downward facing window of an envelope into which the folded sheet would be inserted. To achieve that the address A is facing down, the Z-folded sheet is again guided into the recirculation transport path by the switch 41 as is shown in Fig. 7 and the senses of rotation of the transport rollers 4, 5 defining a nip 6 in the feeding path 1 are again reversed to the senses of rotation 37, 38 shown in Fig. 6. This causes the folded sheet 8 to be transported upstream into the feeding path 1.

[0033] The senses of rotation of the transport rollers 4, 5 defining a nip 6 in the feeding path 1 are reversed again to the senses of rotation 33, 34 shown in Figs. 5, 7 and 8, when the trailing fold 50 in sheet 8 has been transported past the folding knife 14 or at least to a position close enough to the folding knife 14 for the trailing fold 50 to be diverted into the folding nip as a leading fold 50 when the folding knife 14 is displaced to a position projecting to close to the folding nip 12. Thus, in this instance, the folding knife 14 operates as a guide. The z-folded sheet 8 is now transported through the folding nip with the address "A" face down and with the bottom side of the address "A" leading, so that the address can appear behind the window in a panel of an envelope facing down after the sheet 8 has been inserted into that envelope.

[0034] Thus, by transporting the sheet 8 again through the recirculation transport path 24 around the downstream one 11 of the folding rollers 10, 11 after the second fold 55 has been formed and the passing the sheet 8 through the folding nip 12 without folding, the sheet 8 is inverted to bring the address side of the sheet to the opposite side.

[0035] The position of the sheet 8 each time when folding of the sheet is initiated is controlled in a simple manner by a sheet presence detector 52 along the feeding path 1. When a sheet is fed in the feeding direction 13, the reversal of the folding rollers 10, 11 is initiated in response to a predetermined amount of rotation of the transport rollers 4, 5 after detection of the leading edge of the sheet being fed. When a recirculated sheet is transported upstream, i.e. in a direction opposite to the feeding direction, the reversal of the transport rollers 4, 5 is initiated in response to a predetermined amount of rotation of the transport rollers 4, 5 after detection of the leading edge of the sheet being displaced upstream.

[0036] As is illustrated by Figs. 9-11, the turning function can also be applied without folding a sheet. This is achieved by holding a folding knife 14 in the fully projecting position as a new sheet 9 is fed in the feeding direction by the transport rollers 4, 5 defining a nip 6 in the feeding path. This causes the leading end of the sheet 9 to be guided into the folding nip 12 and the sheet 9 to be transported through the folding nip 12 without folding. Thus, the folding knife 14 operates as a guide as during turning of a folded sheet shown in Fig. 8. The folding knife 14 is each time retracted briefly after the sheet has been urged into the folding nip 12.

[0037] As is shown in Fig. 9, the switch 41 causes the sheet 9 to be guided into the recirculation transport path 24. In the meantime, after the trailing edge 56 of the sheet is free from the transport nip 6 in the feeding path 1, the senses of rotation of the transport rollers 4, 5 defining the transport nip 6 in the feeding path 1 are reversed to the upstream direction 37, 38 shown in Fig. 10. The returned sheet 9 is transported upstream until the trailing edge 56 passed the folding knife 14 or at least has approached the folding knife 14 close enough to be urged

into the folding nip. Then the senses of rotation of the transport rollers 4, 5 defining the transport nip 6 in the feeding path 1 are reversed again to the feeding sense 33, 34 shown in Fig. 11., and the folding knife 14 is displaced to the fully projecting position extending to close to the folding nip 12 to guide the sheet 9 into the folding nip 12. In the meantime, the switch 41 has been repositioned to the discharge position shown in Fig. 11 and guides towards output transport rollers 21, 22.

[0038] As is indicated by the position of the latter "A" representing an address on the sheet 9, the sheet 9 has been turned about an axis parallel to the leading and trailing edges.

[0039] It will be clear to the skilled person that, within the framework of the present invention set forth in the claims, many other variants than the examples described above are possible. For instance, buckling of a sheet may also be induced by causing a leading end of the sheet arriving from the feeding path to abut against an abutment in the recirculation transport path, which then constitutes the pressing member, while a trailing part of the sheet is still driven in the feeding path. Also in such an embodiment, the advantage is achieved that the recirculation transport path can also be used for receiving a leading part of a sheet prior to bending the sheet into the folding nip.

[0040] Furthermore, instead of discharging the folded sheets via a discharge path, it could also be provided that the folded sheets are discharged in upstream direction via the feeding path. A switch for guiding sheets either into the discharge path or into the recirculation path can then be omitted. If a folded sheet is to be discharged via the feeding path, the folded sheet has to be passed through the recirculation transport path after folding has been completed. If the sheet is then to be turned over, the sheet has to be passed through the folding nip without folding and then again through the recirculation transport path. It is also possible to provide that a sheet is first turned over, for instance as described with reference to Figs. 9-11 and then folded instead of being directly discharged via the output transport path or the feeding path.

[0041] Finally, it is noted that in the description an example is described in which a single sheet is folded and/or turned over. It is however also possible to fold and/or turn over a stacked set of sheets.

Claims

1. An apparatus for folding a sheet (7, 8) of paper comprising:

a feeding path (1);
a pair of folding rollers (10, 11) defining a folding nip (12) between the folding rollers (10, 11), the feeding path (1) extending in a feeding direction (13) along an input side of the folding rollers (10, 11) for transporting a leading end portion of a sheet (7, 8) in the feeding direction (13) to a position extending along the folding nip (12) and the folding rollers (10, 11) at the input side of the folding rollers (10, 11);
a pressing member (14) adjacent to the folding nip (12) on the input side of the folding nip (12), for pressing against a portion (30, 50) of a sheet (7, 8), causing said portion (30, 50) to bend and to be urged into the folding nip (12); and
a drive (15, 18-20, 23) for driving rotation of the folding rollers (10, 11) in senses of rotation(16, 17) in which sections of the folding rollers (10, 11) defining the folding nip (12) move away from the input side of the folding rollers (10, 11) to an output side of the folding rollers (10, 11);
a recirculation transport path (24) extending from the output side of the folding rollers (10, 11) around one of the folding rollers (10, 11) and connected to the feeding path (1) for transporting a folded sheet (7, 8) from the folding nip (12) to a position extending along the folding nip (12) and the folding rollers (10, 11) at the input side of the folding rollers (10, 11);
characterized in that the folding roller (11) around which the recirculation transport path (24) extends is located downstream in the feeding direction (13) of the other one (10) of the folding rollers (10, 11).

2. An apparatus according to claim 1, further comprising a transport roller (26) having a circumferential portion opposite a circumferential portion of the downstream one (11) of the folding rollers (10, 11), the transport roller (26) and the downstream one of the folding rollers (10, 11) defining a sheet (7, 8) holding nip (28) for holding the sheet (7, 8) in a position extending along the folding rollers (10, 11) on the input side of the folding nip (12).

3. An apparatus according to claim 1 or 2, wherein drive (15, 18-20, 23) is arranged for driving the folding rollers (10, 11) such that a sheet (8) is passed through the folding nip (12) without folding and through the recirculation transport path (24) into a turned over orientation.

4. A method for folding a sheet (7, 8) of paper comprising:

providing a pair of folding rollers (10, 11) defining a folding nip (12) between the folding rollers (10, 11);
feeding a leading end portion of a sheet (7, 8) in a feeding direction (13) to a first position extending along the folding rollers (10, 11) in the feeding direction (13) at an input side of the folding nip (12);
bending the sheet (7, 8) adjacent to the folding

nip (12);
urging a first bent portion of the sheet (7, 8) into the folding nip (12);
rotating the folding rollers (10, 11) such that sections of the folding rollers (10, 11) defining the folding nip (12) move away from the input side of the folding rollers (10, 11) to an output side of the folding rollers (10, 11), thereby flattening the first bent portion and causing a first fold (30, 50) to be formed in the first bent portion of the sheet (7, 8);
transporting the folded sheet (7, 8) around one of the folding rollers (10, 11) to a second position extending along the folding nip (12) and the folding rollers (10, 11) at the input side of the folding rollers (10, 11);
bending the sheet (7, 8) adjacent to the folding nip (12);
urging the second bent portion of the sheet (7, 8) into the folding nip (12);
rotating the folding rollers (10, 11) such that sections of the folding rollers (10, 11) defining the folding nip (12) move away from the input side of the folding rollers (10, 11) to the output side of the folding rollers (10, 11), thereby flattening the second bent portion and causing a second fold (35, 55) to be formed in the second bent portion of the sheet (7, 8); and
transporting the folded sheet (7, 8) away from the output side of the folding rollers (10, 11),
characterized in that the one of the folding rollers (10, 11) around which the folded sheet (7, 8) is transported is the one of the folding rollers (10, 11) located downstream in the feeding direction (13) of the other one of the folding rollers (10, 11).

5. A method according to claim 4, wherein the sheet (7, 8) in the first and second position is held in a sheet (7, 8) holding nip (28) between the downstream one (11) of the folding rollers (10, 11) and a transport roller (26).

6. A method according to claim 4 or 5, wherein the sheet (8) is turned over by transporting the sheet (8) through the folding nip (12) without folding and through the recirculation transport path (24).

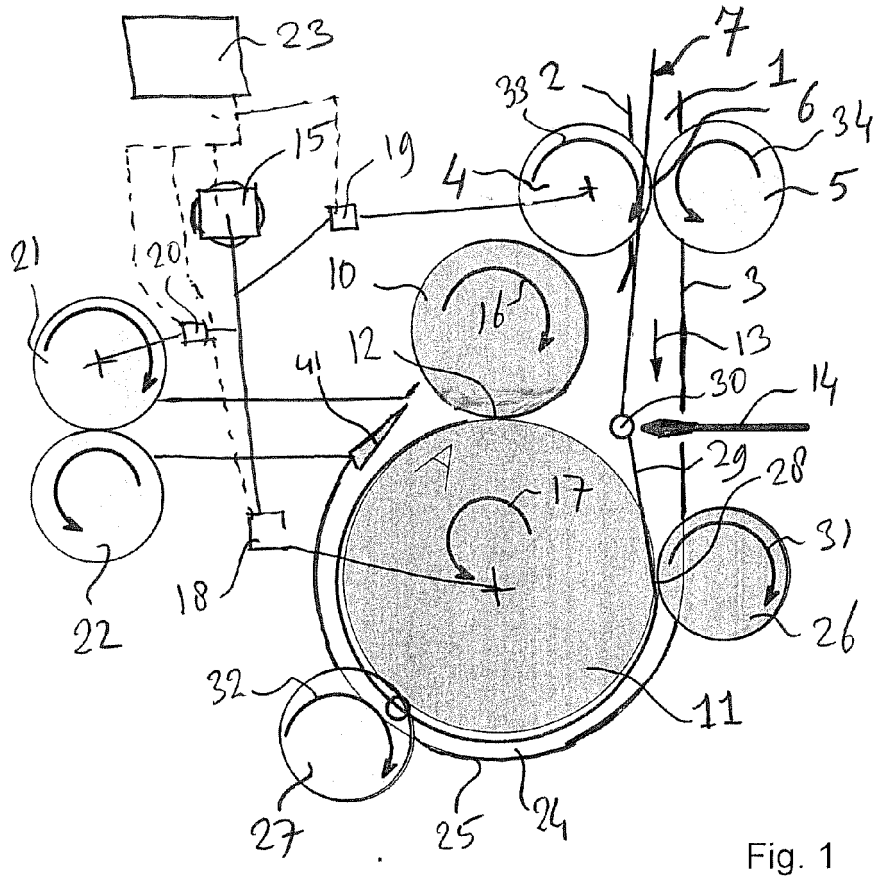
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Fig. 1

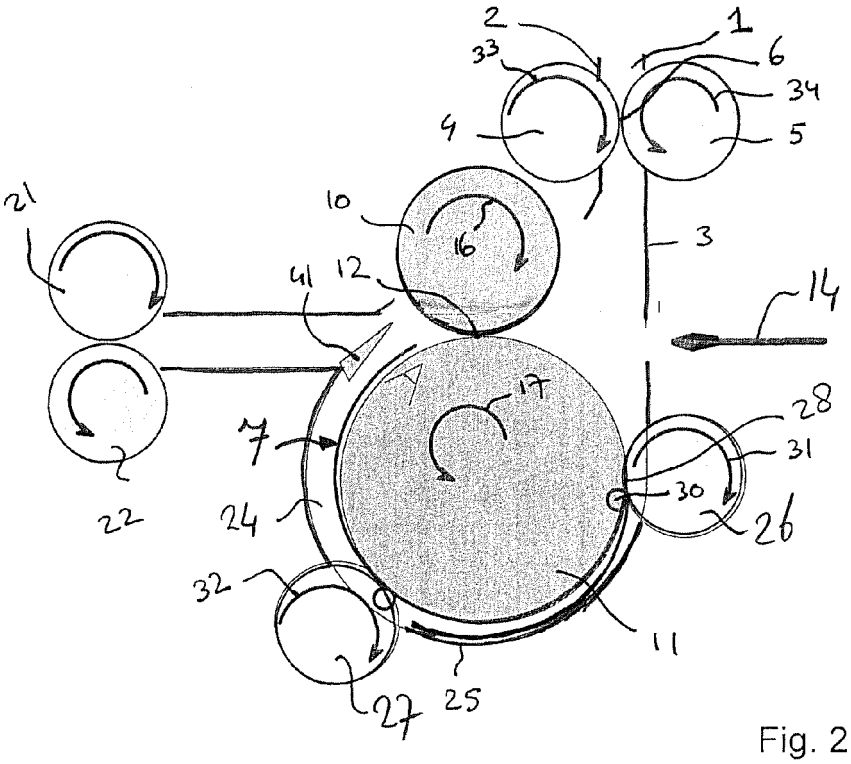
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Fig. 2

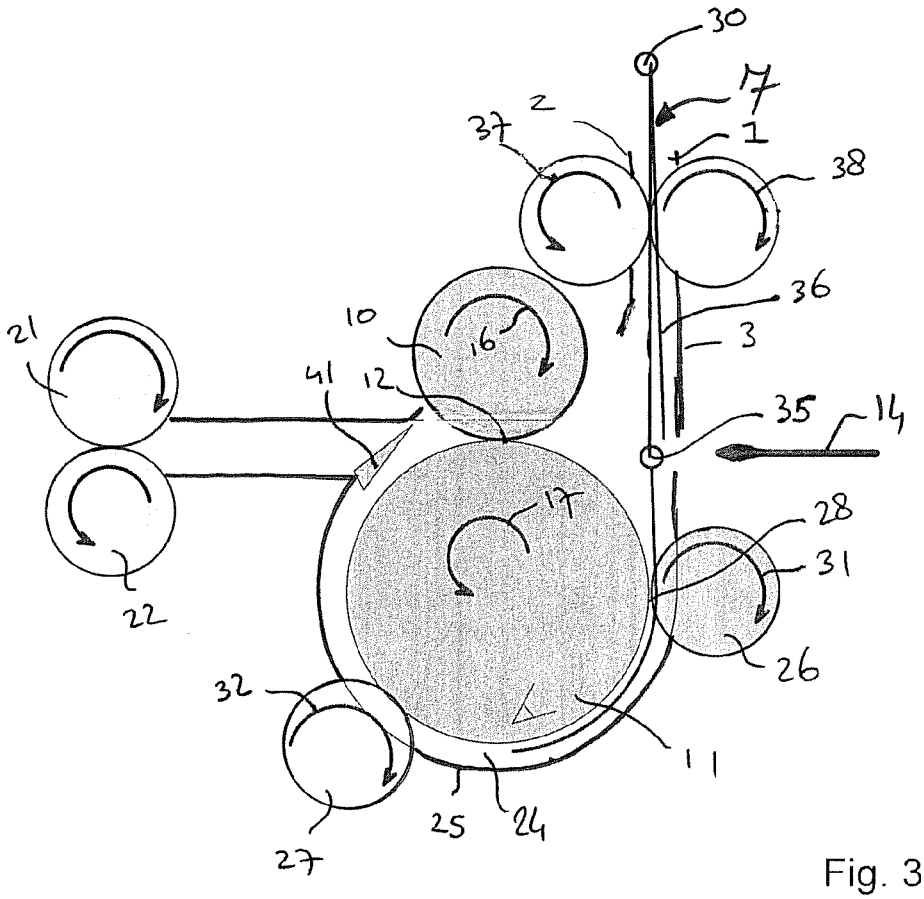
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Fig. 3

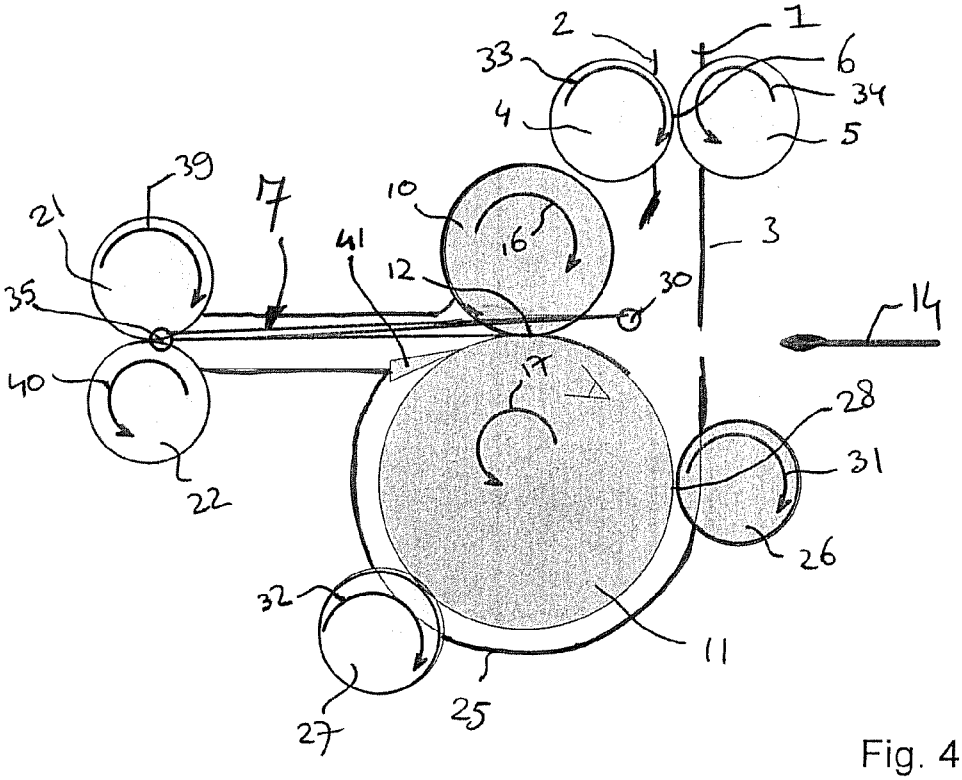
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Fig. 4

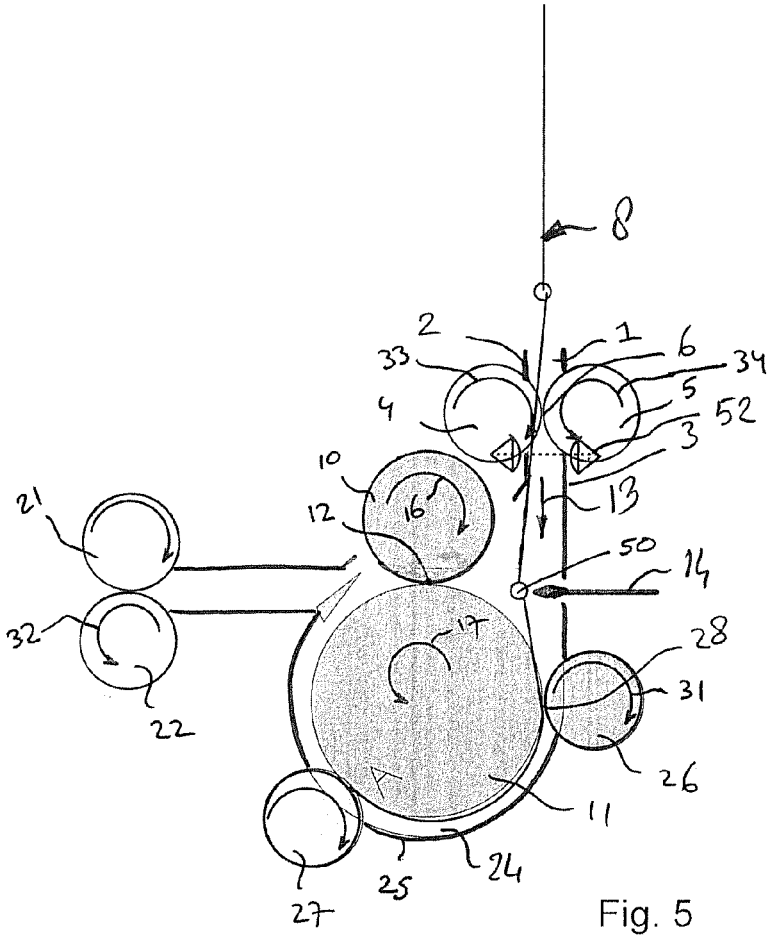
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Fig. 5

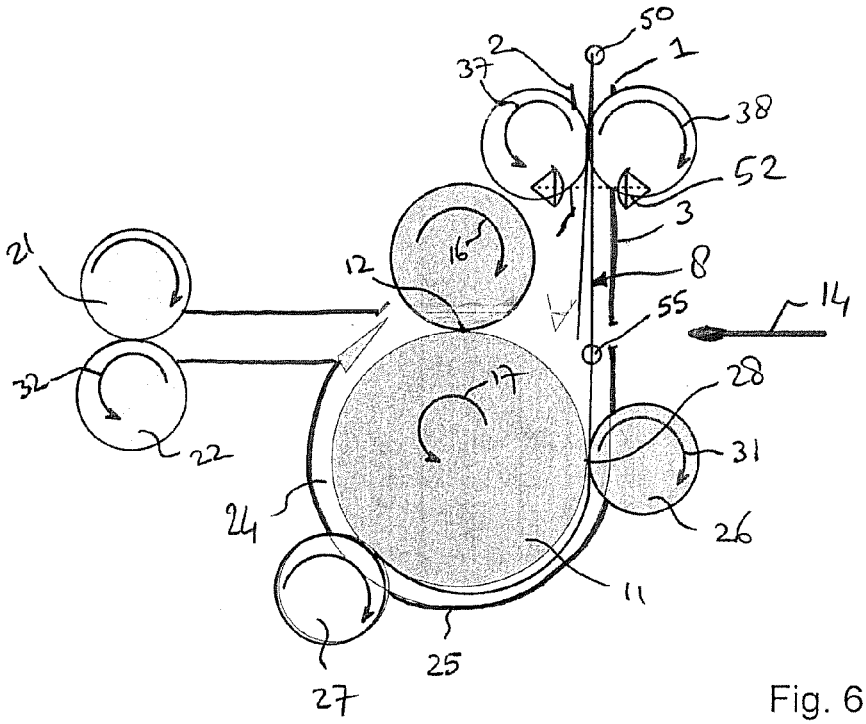
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Fig. 6

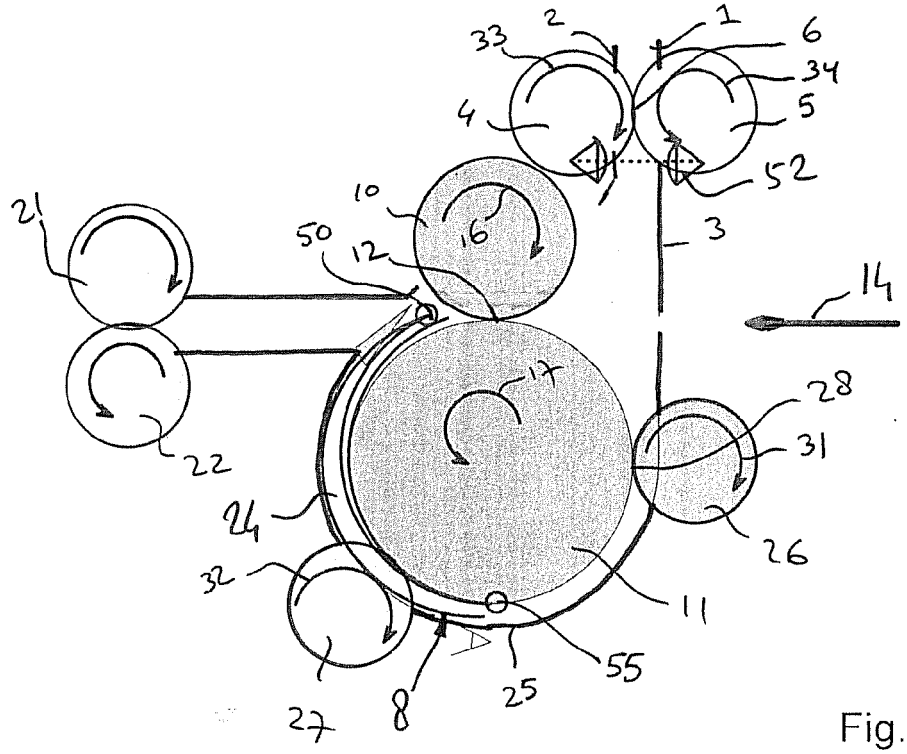
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Fig. 7

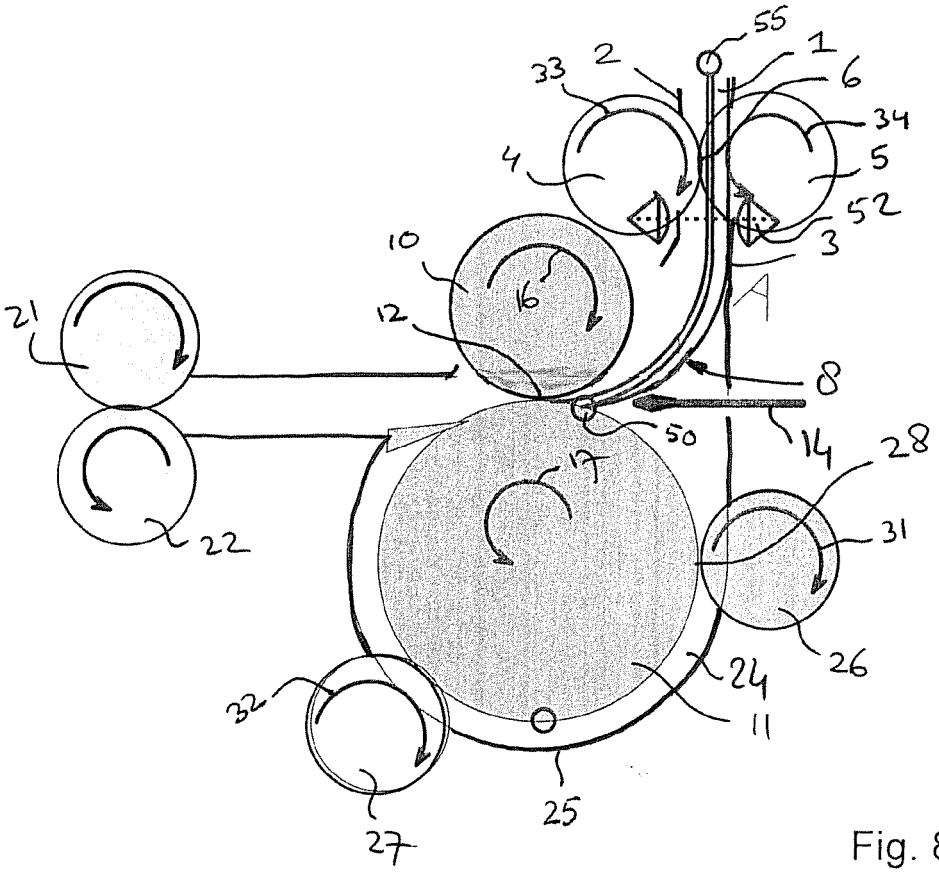
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Fig. 8

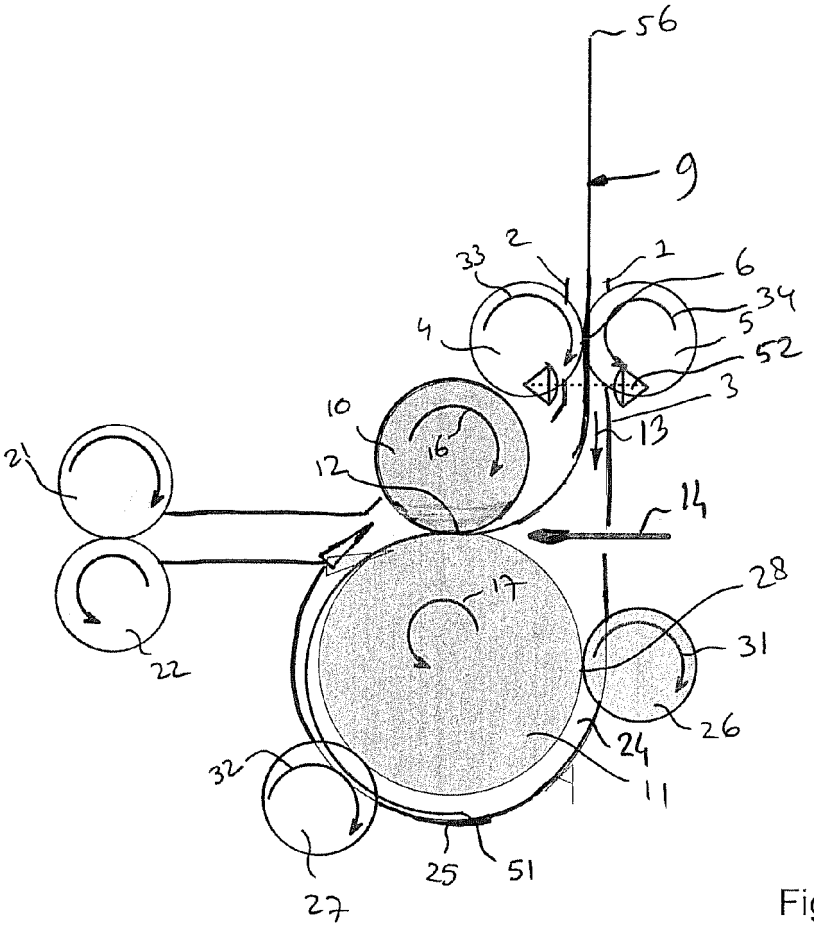
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Fig. 9

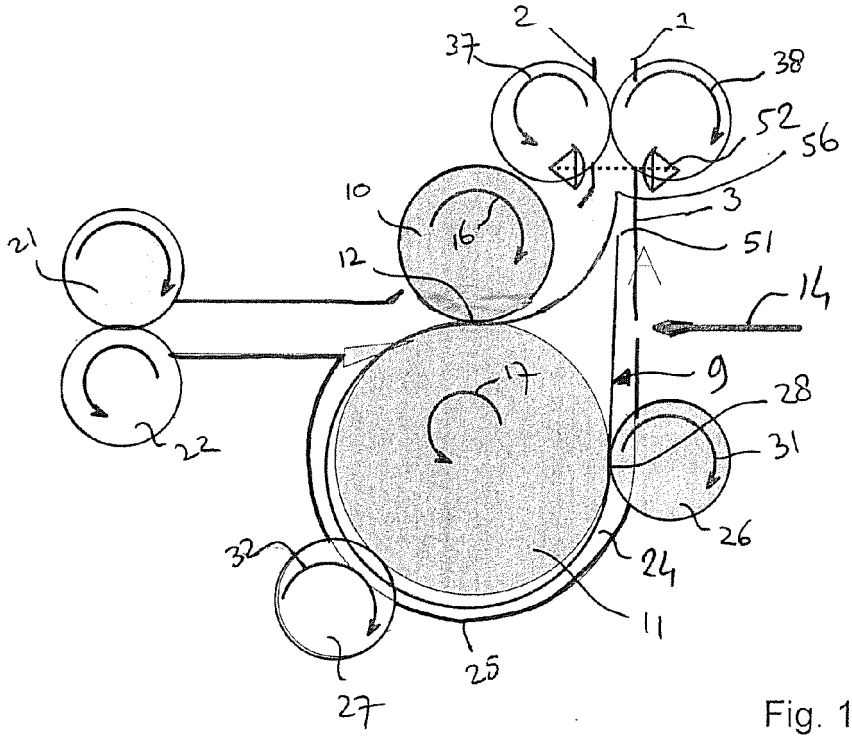
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Fig. 10

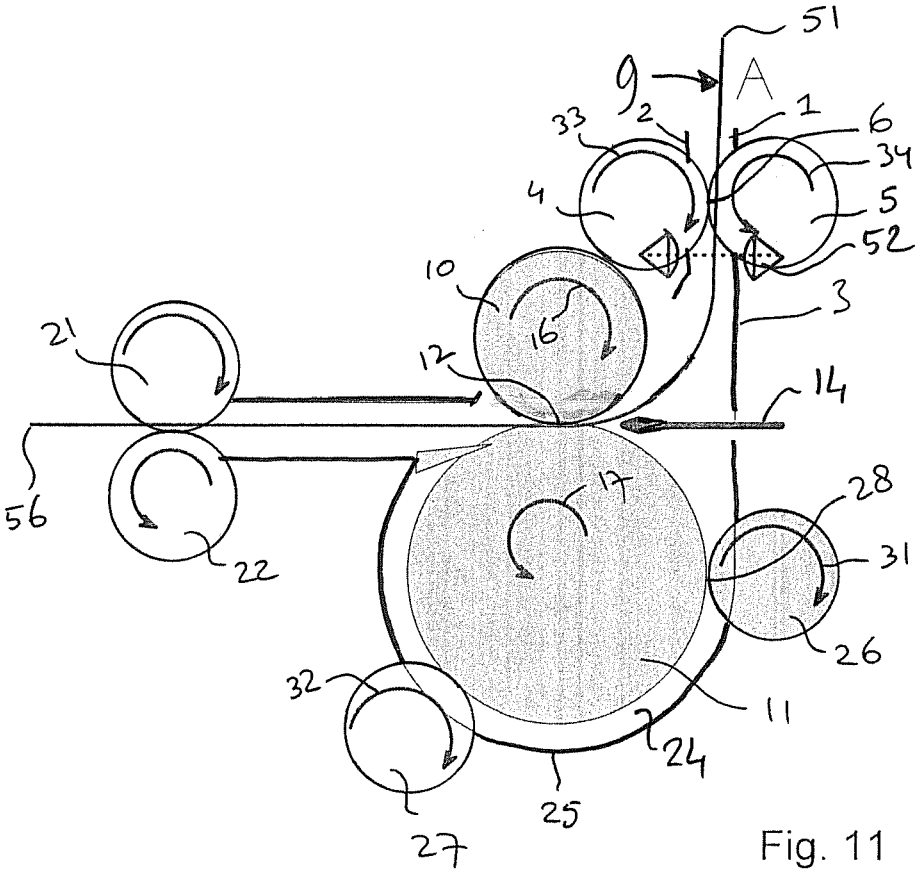

Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 09 15 4003

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B65H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	30 July 2009	Raven, Peter

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