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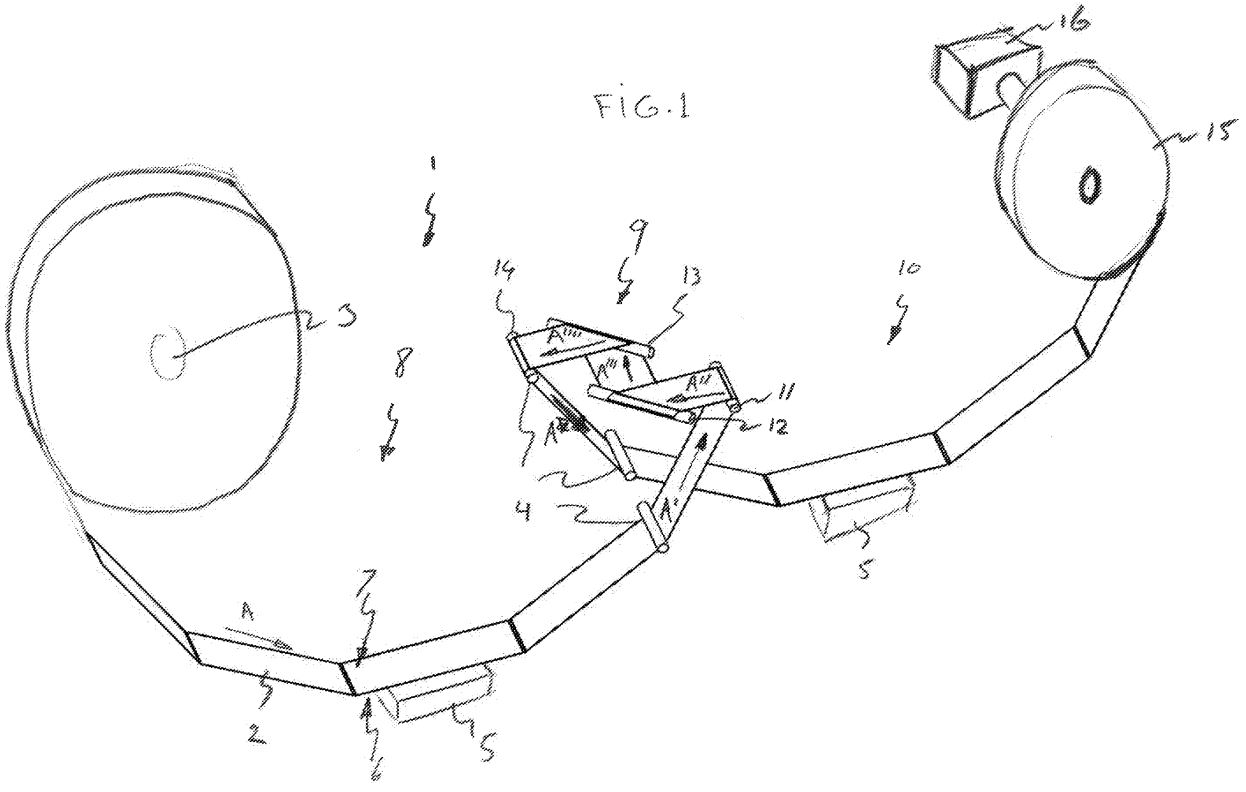
(54) Device for processing a foil substrate

(57) Device (1) for processing a foil substrate (2), e.g., in a roll-to-roll process. The device (1) comprises a holder (3) for a roll of the foil substrate (2) and a transporter unit (16) for unwinding the rolled foil substrate (2) and transporting it in a transport direction along a process path (8,9,10). The device (1) comprises at least one redirecting roller (12) parallel to the surface of the passing foil substrate (2) and which is not under right angles with the transport direction. Optionally, the redirecting rollers (20,21,30,31) comprise independently moveable axial segments and a driving means, such as a tracer pin mechanism, moving the segments to compensate for lateral movement by the foil substrate (2).

FIG. 1



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Description

[0001] The invention relates to a device for processing a foil substrate, comprising a holder for a roll of the foil substrate and a transporter unit for unwinding the rolled foil substrate and transporting it along a process path. Such devices can for example be plasma processing devices or chemical vapour deposition devices in a roll-to-roll process or a roll-to-sheet process, e.g., for production of flexible electronic or optical components, flexible displays or photovoltaic foils.

[0002] WO 98/13882 discloses a method of manufacturing a photovoltaic foil. The process uses a temporary substrate on which flexible thin-film solar cells are deposited. The use of the temporary substrate allows relatively high processing temperatures while using (semi-) continuous roll-to-roll (or reel-to-reel) production processes. The active layers of such solar cells comprise a transparent conductive oxide layer (TCO), an active absorbent layer (e.g., thin-film silicon), and a back contact layer (e.g. a reflective metal layer). After depositing the transparent conductive oxide layer on a temporary metal substrate foil using chemical vapor deposition (CVD) at about 500 °C, the active absorber layer, which can for instance be a thin film silicon layer, is deposited, e.g., using plasma enhanced CVD. The reflective back contact can then be deposited by means of physical vapor deposition and a pattern can be prepared for monolithic interconnection. The film can then be laminated to a permanent carrier foil. Wet etching techniques can be used to remove the temporary substrate foil.

[0003] To obtain high quality deposit layers of even thickness, the foil can be stretched when it follows its path during the depositing process steps, e.g., with the aid of rollers positioned at regular distances of each other on the same side of the foil substrate. The rollers push on one of the foil surface, so that each roller deflects the process path over a certain angle. Since all rollers push on the same side, the cumulative effect is that the foil substrate follows a polygonal or curved process path, with the processing stations being directed to the convex outer surface of the foil substrate. If a large number of rollers are used, it is desirable to redirect the process path to prevent that the process path curls up too much. Redirecting could be done with the aid of a turning roller on the opposite side of the foil substrate. However, such a turning roller would act upon the surface with the freshly deposited layer, which could be damaged as a result.

[0004] It is an object of the invention to provide a device for layer deposition on a foil substrate in a roll-to-roll or roll-to-sheet process which can turn or redirect the unrolled substrate without contacting freshly deposited layers on the substrate.

[0005] The object of the invention is achieved with a device for processing a foil substrate, comprising a holder for a roll of the foil substrate and a transporter unit for unwinding the rolled foil substrate and transporting it in a transport direction along a process path, wherein the device comprises at least one redirecting roller with an axis of rotation which is parallel to the surface of the passing foil substrate and which is not under right angles with the transport direction. When the foil passes the redirecting roller, the foil is redirected under an angle which is dependent on the angle between the roller and the transport direction of the foil before passing the redirection roller, and which is also dependent on the angle between the roll-on direction and the tangential roll-off direction of the foil passing the roller. For instance, a single roller under an angle of 45 degrees with the transport direction can redirect the foil under an angle of 90 degrees if the foil is turned over 180 degrees over the circumference of the roller.

[0006] Optionally, a number of stretching members, such as rollers, is configured to push upon one side of the foil substrate, the stretching members extending along the full width of the foil substrate in a direction perpendicular to the transportation direction. This way, the stretching members create a polygonal process path, wherein one or more processing stations can be positioned at the convex side of the process path. The processing stations can for example be chemical vapour deposition stations.

[0007] The device can for example comprise two subsequent redirecting rollers each turning the process path over a right angle. These two redirecting rollers can for example be parallel. As a result, after the foil substrate passes the two redirecting rollers the transportation direction will be the same but offset over a certain distance in comparison to the transportation direction of the foil before passing the redirecting rollers. Alternatively, the two redirecting rollers can for example be under right angles with each other.

[0008] The device according to the present invention can also have more than two, e.g., three or four redirecting rollers, for gradually redirecting the processed foil substrate into the desired direction.

[0009] When a foil is turned by a roller under an angle with the transport direction, the foil will tend to move laterally. To correct this, the redirecting rollers can comprise independently moveable axial segments, which compensate for the lateral movement of the foil. The segments can be moved actively by a programmed driver or they can be moved passively, e.g., by a tracer following a guiding surface when the roller is turned, wherein either the tracer of the guiding surface is connected to the axial segment. The tracer can for example be a tracer pin or tracer wheel. Also the foil material itself may exert a force acting against the lateral movement. Depending on the type of foil material used and on further process conditions, this force exerted by the foil may be sufficient to compensate for the lateral movement.

[0010] A suitable type of roller turner that could be useful in a device according to the present invention is a roller turner as disclosed in NL 9402031, disclosing the use of such a roller to correct lateral movement of a conveyor belt.

[0011] The invention will now be described in more detail, by way of example only, with reference to the accompanying drawing, wherein:

Figure 1: shows schematically in perspective a layout of a foil processing device according to the present invention;
Figure 2: shows an arrangement of two turner rollers in a device according to the present invention;
Figure 3: shows an alternative arrangement of a set of turner rollers of a device according to the invention;
Figure 4: shows in detail a tracer mechanism for axially moving an axial segment of a redirection roller of the device of Figure 2 or 3.

[0012] Figure 1 shows a device 1 according to the present invention for manufacturing a photovoltaic foil by depositing the various layers on a foil substrate 2 in a roll-to-roll process. The device 1 comprises a holder 3 for a roll of foil substrate 2 and rollers 4 for transporting the foil substrate 2 along a process path with chemical vapor deposition (CVD) stations 5. The foil substrate 2 runs in a direction indicated in the drawing by reference sign A, A', A", A"', A"", and A^V respectively. The CVD stations 5 deposit a layer onto a deposition side 6 of the foil substrate 2 opposite the side 7 contacted by the rollers 4.

[0013] The process path includes a first curved section 8, a redirecting section 9 and a second curved section 10. In order to obtain a uniformly tensioned foil the turner rollers 4 push on the passing foil substrate 2 at regular distances. Since each roller 4 deflects the path of the foil substrate 2 over a small angle, the process path curves. After passing a number of rollers 4 in the first curved process path section 8 the foil substrate 2 runs in an almost vertical direction A' to a final roller 11 turning the foil substrate 2 over more than 90 degrees to a horizontal direction A". Subsequently, the foil substrate 2 runs to a first redirecting roller 12. The axis of rotation of the redirecting roller 12 and of the final roller 11 are within the same plane making an angle of 45 degrees with each other.

[0014] The foil substrate 2 runs over 180 degrees over the circumference of the redirecting roller 12. Due to the fact that the redirecting roller 12 is positioned under an angle of 45 degrees with the roll-on direction A" of the foil substrate 2, the foil substrate 12 is redirected to a horizontal roll-off direction A"' under right angles with the horizontal roll-on direction A" of the foil substrate 2. Subsequently the foil substrate 2 passes a second redirecting roller 13, which is parallel to and in the same plane as the first redirecting roller 12. Again, the foil substrate 2 passes the circumference of the second redirecting roller 13 over 180 degrees and is again redirected over 90 degrees to a horizontal direction A"" parallel to the direction A" of the foil between the final roller 11 and the first redirecting roller 12. Subsequently, the foil substrate 2 passes a first roller 14 of the second curved process path section 10. This way, the upwards direction A' of the substrate foil 2 is turned to a downwards direction A^V without using a turner roller contacting the freshly processed lower surface 6 of the foil substrate 2.

[0015] At the end of the second curved process path section 10, the foil substrate is rewound to a roll 15. The roll 15 is operatively connected to a transporter unit 16. By winding the roll 15, the roll 3 is unwound and the foil substrate is transported in the transport direction along the process path 8, 9, 10.

[0016] Figure 2 shows a set of two parallel redirection rollers 20, 21. A foil 22 is transported in a direction indicated with arrow B. The first roller 20 is under an angle of about 45 degrees with the transport direction B. The foil 22 passes the roller 20 over 180 degrees relative to the longitudinal axis of the roller 20 over the circumference of the roller 20. As a result, the foil substrate 22 is redirected over an angle of 90 degrees in plan view to a roll-off direction B'. After passing the first redirecting roller 20, the foil 22 passes the second redirection roller 21 which is substantially parallel to the first redirection roller 20. Again, the foil 22 passes the second redirection roller 21 over 180 degrees relative to the longitudinal axis of the second roller 21 of its circumference, resulting in a redirection of again 90 degrees in plan view, and a new curved process path, parallel to the first process path can be followed with a transport direction B", which is in plan view the same as the transport direction B of the first flow path.

[0017] An alternative arrangement can be seen in Figure 3 where two redirection rollers 30, 31 are arranged under right angles with each other. With such an arrangement, the resulting transport direction C" is opposite to the first transport direction C.

[0018] The redirection rollers 20, 21, 30, 31 comprise axial surface segments 32 which can be moved independently in the axial direction relative to the rest of the redirection roller 20, 21, 30, 31. When the foil 22 passes the redirection roller 20, 21, 30, 31 it tends to move laterally into the direction indicated by arrow D. To compensate for this, the axial segments of the roller 20, 21, 30, 31 are moved in the opposite direction E.

[0019] Figure 4 shows a roller 34 corresponding to the rollers 20, 21, 30, 31 and provided with a tracer mechanism 35. The tracer mechanism 35 comprises a guiding surface 36 extending radially from the circumference of the roller 34. The guiding surface 36 comprises a first rounded turning point 37 and a second rounded turning point 38 which is at a distance from the first turning point 37 viewed in the longitudinal direction of the roller 34. Between the two rounded turning points 37, 38 the guiding surface 36 runs smoothly and uninterrupted.

[0020] The roller 34 is provided with four axially moveable segments 40, only one of which is shown in the drawing of Figure 4 for reasons of clarity. The axially moveable segment 40 comprises an outer shell 41

shaped as a quarter of a cylinder and having a concave inner surface with a slider head 42 in the middle of the concave surface extending in a direction parallel to the longitudinal axis of the roller 34. The slider head 42 is arranged on a guiding rail 43 on the cylindrical surface of a cylindrical core 44 of the roller 34. The guiding rail 43 extends into a direction parallel to the longitudinal axis of the roller 34. The slider head 42 is slideable over the guiding rail 43.

[0021] A stationary bus 45 fits over one end of the cylindrical core 44 of the roller 34. The bus 45 does not rotate with the cylindrical core 44. To minimize friction between the bus 45 and the core 44, sufficient play between the two parts should be provided. The stationary bus 45 is made of a single part with the guiding surface 36.

[0022] The axially moveable segment 40 has a tapered end 46 directed to the guiding surface 36. The tapered end 46 carries a shoe 47 with a tracer wheel 48 contacting the guiding surface 36. When the roller 34 with the axial segments 40 rotates, the tracer wheel 48 moves along the stationary guiding surface 36. When the tracer wheel 48 moves to the first rounded turning point 37, the guiding surface 36 pushes the axial segment 40 away towards the other end of the roller 34. When a foil substrate 2 runs over the roller 34 in a direction which is not under right angles with the roller 34, the foil substrate 2 will tend to move towards the guiding surface 36. The guiding surface 36 is arranged in such a way that the second rounded turning point 38 is in line with the first roll-on contact line of the foil substrate with the roller 34. When the roller 34 is rotated, the axial segment 40 is pushed away against the lateral movement of the foil substrate 2 until the tracer wheel 48 reaches the first rounded turning point 37. This point 37 is in line with the last roll-off contact line between the foil substrate 2 and the roller 34, where the foil substrate departs from the roller 34. Subsequently, the axial segment is allowed to slide back towards the second rounded turning point 38 of the guiding surface 36, e.g., under the action of a spring or the like.

Claims

1. Device (1) for processing a foil substrate (2), comprising a transporter unit (16) for unwinding a roll (3) of the foil substrate and transporting it in a transport direction along a process path (8, 9, 10), wherein the device comprises at least one redirecting roller (12, 13) with an axis of rotation which is parallel to the surface of the passing foil substrate (2) and which is not under right angles with the transport direction.

2. Device according to claim 1 wherein a number of stretching members (4) is configured to push upon one side (7) of the foil substrate (2), the stretching members extending along the full width of the foil substrate in a direction perpendicular to the transportation direction, creating a polygonal process path (8, 10), wherein one or more processing stations (5) are positioned at the convex side (6) of the process path.

3. Device according to claim 1 or 2 wherein the device comprises two subsequent redirecting rollers (12, 13; 20, 21; 30, 31) each turning the process path over a right angle.

4. Device according to claim 3 wherein the two redirecting rollers (12, 13; 20, 21) are parallel.

5. Device according to claim 3 wherein the two redirecting rollers (30, 31) are under right angles with each other.

6. Device according to any one of the preceding claims wherein at least one of the redirecting rollers comprises independently moveable axial segments (32, 40).

7. Device according to claim 6 wherein at least one of the axially moveable segments (40) is operatively connected to a driving means (35) moving the segment to compensate for lateral movement by the foil substrate.

8. Device according to claim 6 or 7 wherein at least one of the axially moveable segments (4) is moved in the axial direction by a tracer (48) following a guiding surface (36) when the roller is turned.

9. Device according to any one of the preceding claims comprising a control for adjusting the angle of the redirecting roller.

10. Device according to claim 9 wherein the control is programmed to adjust the angle to correct lateral movement by the foil substrate.

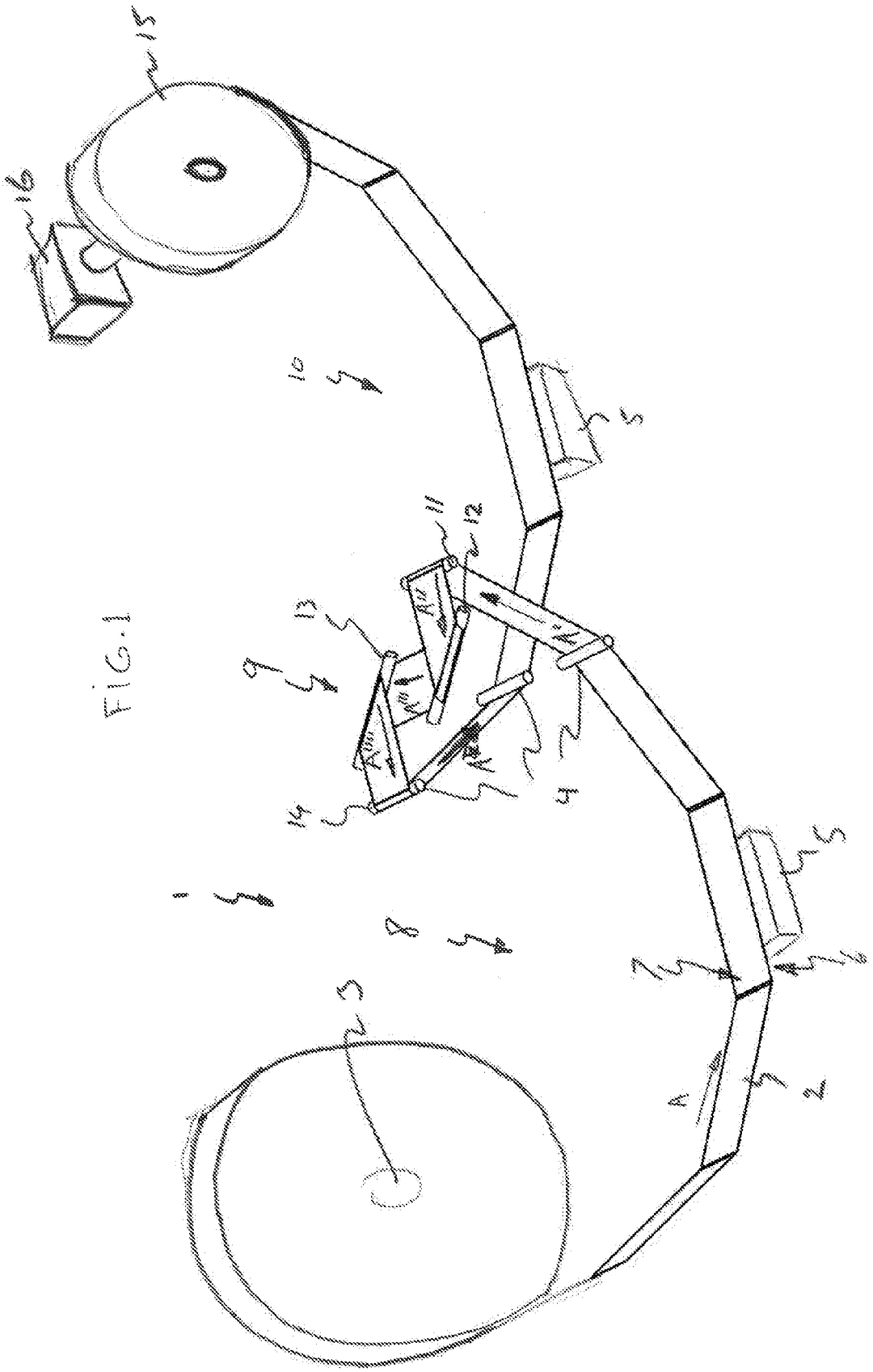

FIG.1

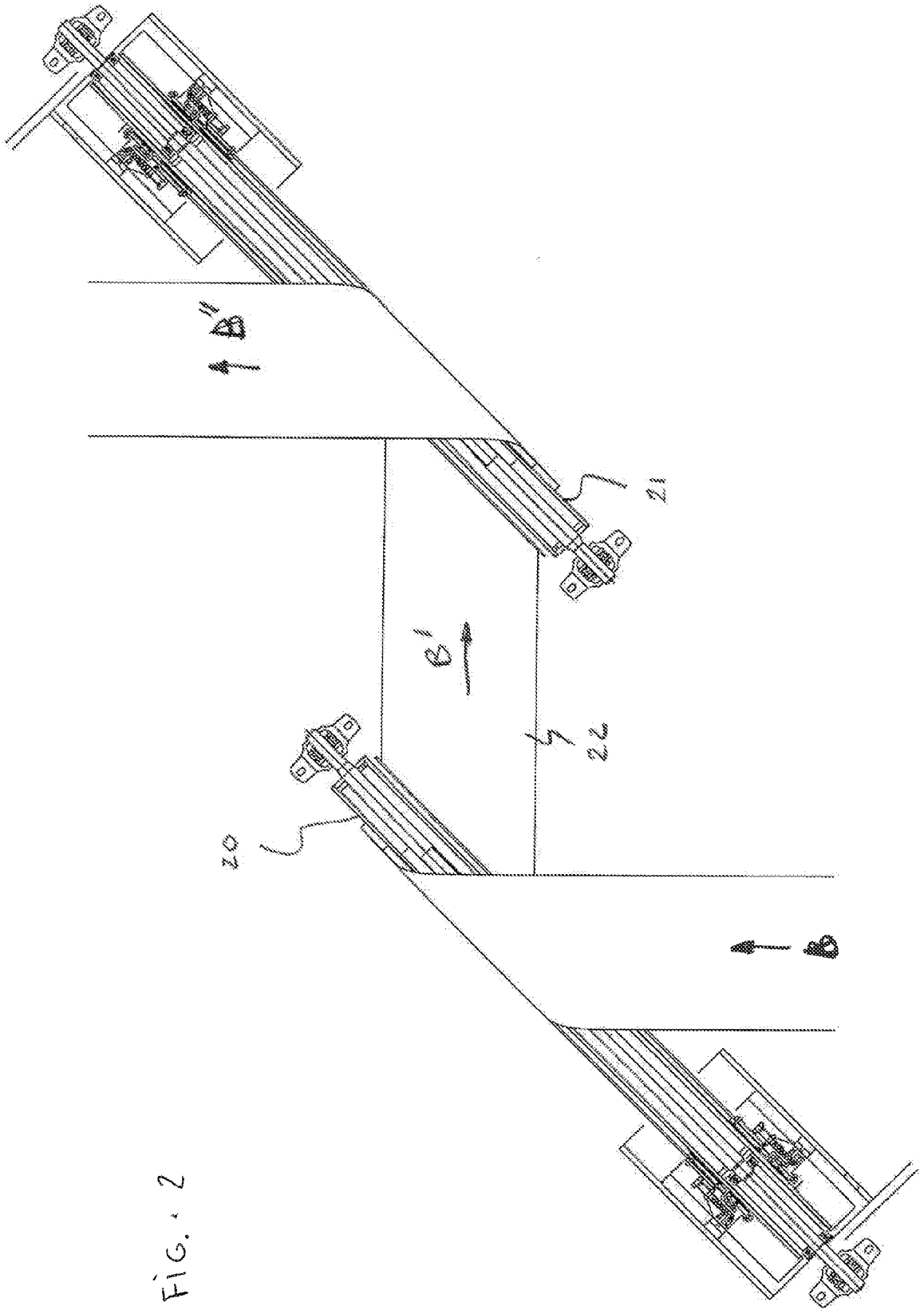

FIG. 2

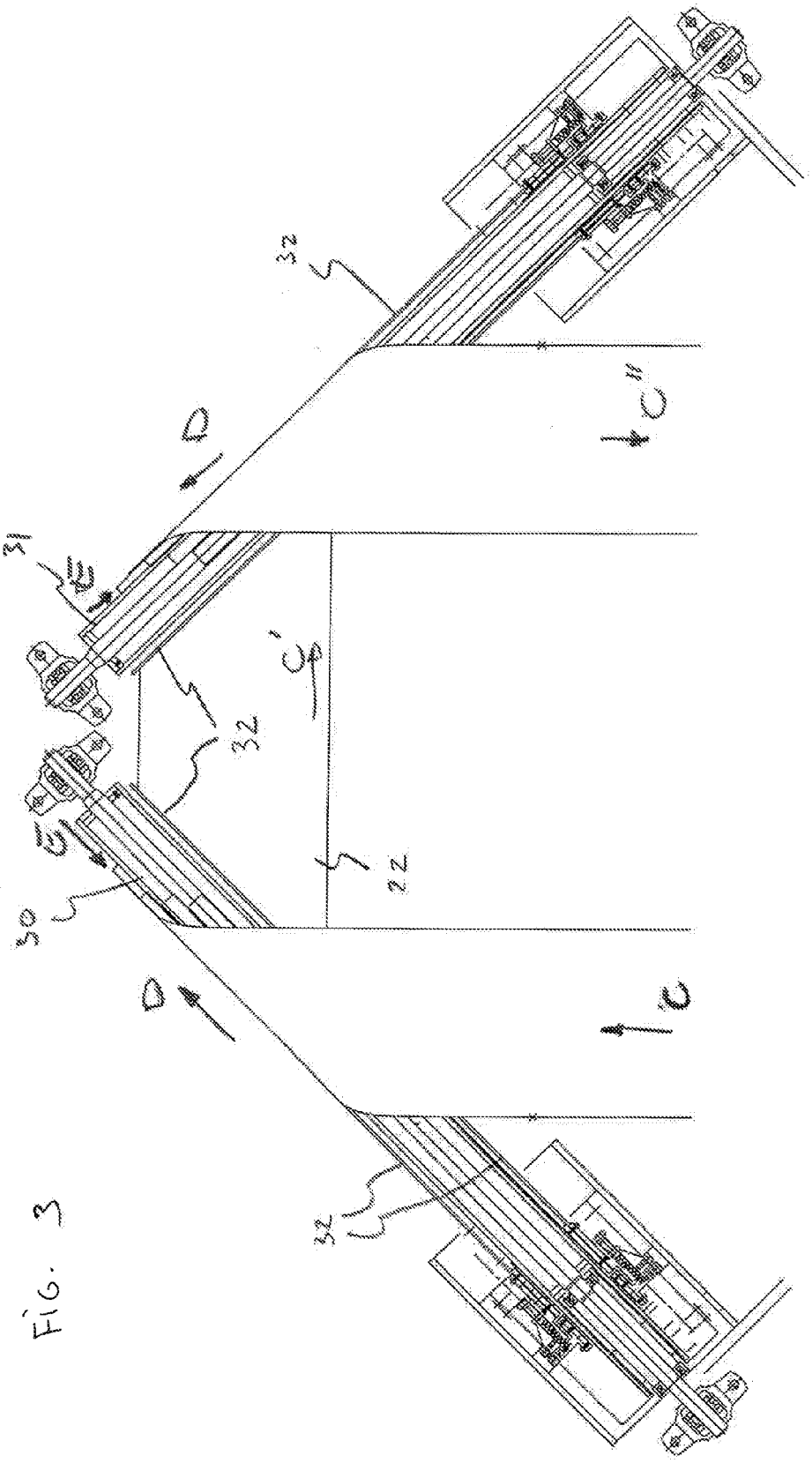

FIG. 3

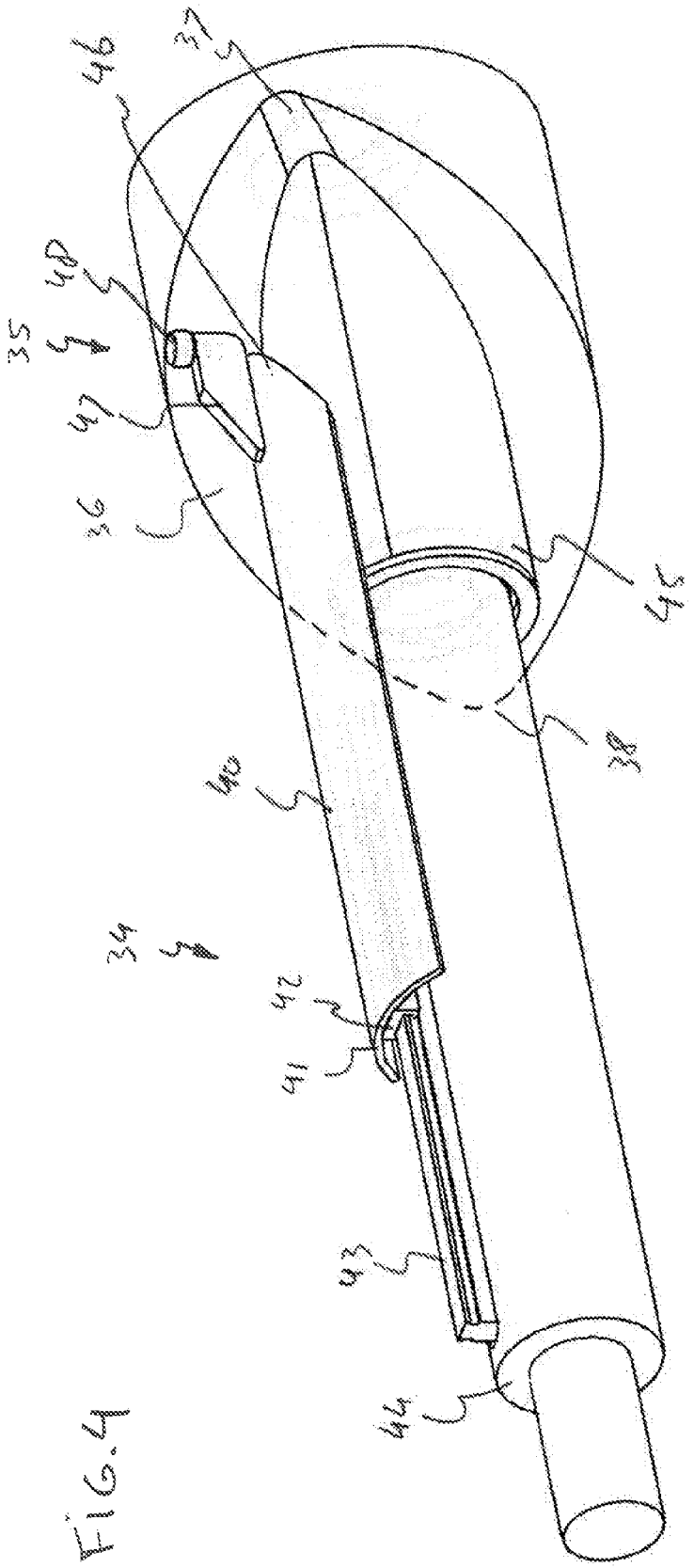

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 09 16 6492

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2008/029640 A1 (CHIU WAN-WEN [TW] ET AL) 7 February 2008 (2008-02-07) * paragraphs [0002], [0024] - [0028] * * figures 1A,1B * -----	1-5 6-10	INV. B65H23/32 B65H23/025
X A	US 2002/108709 A1 (FUKADA KOICHI [JP]) 15 August 2002 (2002-08-15) * paragraphs [0003], [0040] - [0044], [0060] * * figures 1,5-7 * -----	1,9 2-5	
Y	CH 690 548 A5 (BOBST SA [CH]) 13 October 2000 (2000-10-13) * column 1, lines 1-9,27-32,59-62 * * column 3, line 40 - column 4, line 11 * * column 4, line 37 - column 5, line 10 * * figures 1,2 * -----	6-8	
Y	US 3 095 131 A (DOUGLAS ROBERTSON JOHN ET AL) 25 June 1963 (1963-06-25) * column 1, lines 10-15,34-45 * * column 2, lines 11-71 * * column 3, line 25 - line 40 * * figures 2,4,5 * -----	9,10	TECHNICAL FIELDS SEARCHED (IPC) B65H
A	DE 43 22 114 A1 (BARMAG BARMER MASCHF [DE]) 13 January 1994 (1994-01-13) * column 3, line 17 - column 57 * * figure 2 * -----	6-8	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	10 September 2010	Cescutti, Gabriel

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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O : non-written disclosure
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EPO FORM 1503 03.82 (P04C01)

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Application Number
EP 09 16 6492

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 09 16 6492

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-5

   Device for processing a foil subtrate redirecting an unrolled subtrate without contacting freshly deposited layers on the subtrate

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2. claims: 6-10

   Device for processing a foil substrate redirecting an unrolled subtrate by controlling the lateral postioning of the substrate

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 16 6492

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10-09-2010

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- WO 9813882 A **[0002]**
- NL 9402031 **[0010]**