



- (51) International Patent Classification:
B65H 45/14 (2006.01)
- (21) International Application Number:
PCT/EP2011/070256
- (22) International Filing Date:
16 November 2011 (16.11.2011)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
10193108.7 30 November 2010 (30.11.2010) EP
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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

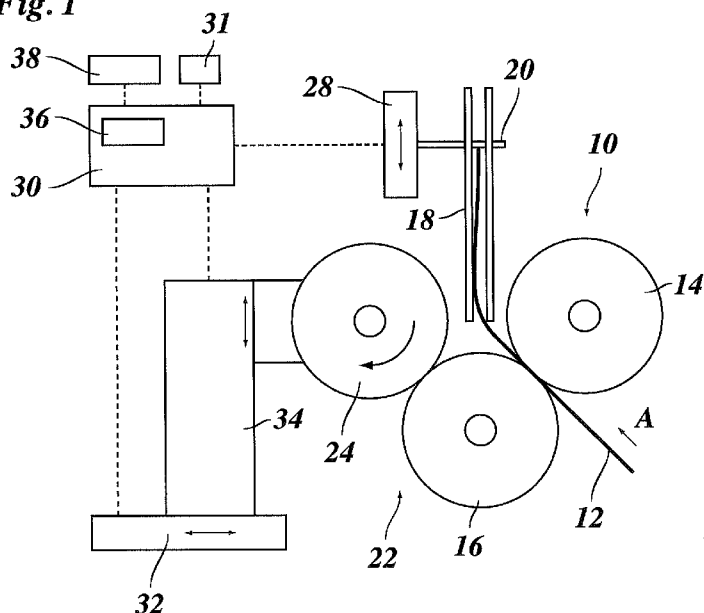
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: SHEET FOLDING APPARATUS, SHEET FOLDING METHOD, AND PRINTING SYSTEM INCLUDING THE SHEET FOLDING APPARATUS

Fig. 1



(57) Abstract: A sheet folding apparatus comprising a sheet transport system (10), adjustable folding members (20, 22) arranged to bend and fold a sheet (12) fed by the transport system (10), and a control system (30) arranged to adjust the folding members (20, 22) to set positions in accordance with information on sheet properties, characterised in that the control system stores a table (36) that specifies different set positions of the folding members (20, 22) for different bending properties of the sheets (12) and is adapted to read information on the bending properties of the sheets (12) to be folded and to adjust the folding members to set positions as specified by the bending properties.

Sheet folding apparatus, sheet folding method, and printing system Including the sheet folding apparatus

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The invention relates to a sheet folding apparatus comprising a sheet transport system, adjustable folding members arranged to bend and fold a sheet fed by the transport system, and a control system arranged to adjust the folding members to set positions in accordance with information on sheet properties.

10

The invention further relates to a sheet folding method and to a printing system including the sheet folding apparatus.

US 4 518 380 describes a sheet folding apparatus wherein a first folding member is
15 formed by a stop member arranged in a feed path of the sheets. When a leading edge of a sheet is stopped by the stop member while the trailing part of the sheet is still fed by the transport system, the sheet will be bent and will form a loop. A second folding member is formed by a pair of rollers forming a nip that will capture and fold the loop formed in the sheet. The position of the stop member will determine the folding length of
20 the sheet and can be adjusted manually in accordance with the desired folding length.

US 5 242 364 discloses a sheet folding apparatus comprising a plurality of folding stations, each including a stop member and a roller pair. The transport system includes deflection members for controlling the path of the sheets through the folding stations, so
25 that different folding patterns may be programmed. The control system includes actuators for actively adjusting the positions of the stop members in accordance with the desired folding lengths. Further, the control system includes actuators for adjusting the widths of the gaps formed at the nip of each roller pair. The width of the gap is automatically adjusted in accordance with the thickness of the sheets and the number of
30 layers of the folded sheet that have to pass through the respective nip.

It is an object of the invention to provide a sheet folding apparatus and method that permit to control the folding pattern of the sheets more precisely.

35 This object is achieved by a sheet folding apparatus of the type indicated in the opening

paragraph, wherein the control system stores a table that specifies different set positions of the folding members for different bending properties of the sheets and is adapted to read information on the bending properties of the sheets to be folded and to adjust the folding members to set positions as specified by the bending properties.

5

In the context of the present invention, "information on the bending properties of a sheet" means information that permits to anticipate how the sheet will bend under the influence of the folding members and the transport system. Thus, although the dimensions of a sheet and the sheet thickness may have an influence on the bending properties, this information, as such, cannot be considered as information on the bending properties, because supplemental information, e.g. on the material or stiffness of the sheet is necessary for anticipating the bending behaviour. For example, information on the bending properties of a sheet may be formed by the folding length and the stiffness or bending strength (flexural module) of the sheet (independent of the sheet width). Another example would be information on the sheet thickness combined with information on the material of the sheet, including information on thickness and material of a coating, as the case may be.

The invention is based on the observation that, for given settings of the folding members, the bending properties of the sheets have an influence on the exact shape of the loop that the sheet will form in the folding apparatus and, consequently, on the exact location of the fold. By taking this effect into account and adjusting the set positions of the folding members in accordance with the bending properties of the sheets to be folded, the influence of different bending strengths of sheets of different types can be cancelled, so that a more uniform folding pattern is obtained for different types of media.

A folding method according to the invention, and a printing system including a sheet folding apparatus as described above are specified in further independent claims.

More specific optional features of the invention are indicated in the dependent claims.

The information on the bending properties of the sheets may be included in a so-called media catalogue that is supplied to the folding apparatus in the form of an electronic file in conjunction with a batch of sheets to be folded. In case of a printing system comprising a printer and an in-line sheet folding apparatus, the media catalogue may

specify the types of media that are available in media stacks of the printer, and the information on the bending properties of the sheets may be derived from the media catalogue in conjunction with instructions that are included in the print job specifications and indicate the media stack from which the sheets are to be taken.

5

In another embodiment, the bending properties of the sheets may be measured in the sheet folding apparatus or somewhere upstream in the printing system. For example, when it is known that the material of the sheets will be paper, it may be sufficient to measure the thickness of the paper in order to derive sufficiently reliable information on the bending properties. On the other hand, it will also be possible to measure the bending strength directly, so that no additional information on the material of the sheets is needed.

Optionally, the user may be given the possibility to adjust the settings of the folding members manually for a given type of media, based on his experience or try and error. For example, instructions for modifying the settings may be entered via a suitable input system such as a keyboard or a touch screen. As an alternative, the user may manipulate adjusting mechanisms for directly changing the position of the folding members. In this case, the control system may include sensors for detecting the set positions. In any case, the set positions that have been manually corrected by the user will be stored in the table in the control system, so that the apparatus will "learn" the appropriate settings and may make these settings automatically when the same media are used next time.

The optimal settings for given bending properties of the sheets may depend upon the folding pattern that has been selected. Thus, the control system may store a separate table for each folding pattern. As an alternative, a default setting may be stored for each folding pattern, and the table may just include corrections that depend upon the bending properties of the sheets but not on the selected folding pattern.

30

Preferred embodiments of the invention will now be described in conjunction with the drawings, wherein:

Fig. 1 is a schematic view of a folding apparatus according to the invention;

Fig. 2 shows essential parts of the folding apparatus in another stage of the

35 folding process;

Fig. 3 is a flow diagram illustrating a learning mode of the folding apparatus shown in Fig. 1;

Fig. 4 is a flow diagram of a folding method according to the invention;

Fig. 5 is a schematic view of a part of a printing system including a device for
5 measuring bending properties of a sheet; and

Fig. 6 is a flow diagram of a folding method according to a modified embodiment of the invention.

As is shown in Fig. 1, a sheet folding apparatus comprises a sheet transport system 10
10 for feeding a sheet 12, e.g. paper or any other print medium, in the direction indicated by an arrow A. In the simplified example that has been shown here, the sheet transport mechanism 10 is formed by two rollers 14, 16 forming a nip through which the sheet 12 is passed. Behind the nip of the rollers 14, 16, the leading edge of the sheet 12 enters into a vertical sheet guide 18.

15 A first folding member 20 takes the form of a stop member that blocks the sheet guide 18 in a certain height.

A second folding member 22 comprises a roller 24 that forms a nip with the roller 16.
20 Thus, the roller 16 forms part of both, the transport mechanism 10 and the second folding member 22.

When the sheet 12 is transported upwardly in the sheet guide 18 and its leading edge abuts at the stop member 20, the upward movement of the leading edge of the sheet is
25 stopped while the rollers 14, 16 continue to feed the trailing part of the sheet. As a result, the sheet will bend and form a loop 26, as shown in Fig. 2. When this loop 26 reaches a certain size, it will be captured in the nip of the rollers 16 and 24 and drawn-in further, so that the sheet is folded and discharged in the direction indicated by an arrow B in Fig. 2.

30 The exact position where the fold is formed in the sheet 12 will be determined by the height of the stop member 20 and the location of the nip of the rollers 24 and 16 and also by the bending properties of the sheet.

35 As is shown in Fig. 1, an electro-mechanical actuator 28 is provided for adjusting the

height of the stop member 20. The actuator 28 is controlled by a control unit 30.

Two further electro-mechanical actuators 32 and 34 are also controlled by the control unit 30 and are provided for adjusting the roller 24 two-dimensionally in the plane
5 normal to its axis of rotation.

In the example shown, the axis of the roller 16 is stationary. Nevertheless, as is shown in Fig. 2, it is possible to control the width d of the nip formed between the rollers 16 and 24 by suitably adjusting the roller 24 with the actuators 32 and 34. In this way, the width
10 d of the nip may for example be adapted to the thickness of the sheet 12. Further, the angular position of the nip relative to the axis of the roller 16 may be modified by controlling the actuators 32 and 34 so as to move the axis of the roller 24 on a circle around the axis of the roller 16.

15 In a modified embodiment, the axis of the roller 16 might also be adjustable, with the constraint that the rollers 14 and 16 have to form the transport nip for the sheet 12.

By way of example, it shall be assumed here that the sheet folding apparatus shown in Fig. 1 forms part of a printing system which further includes a printer on which an image is
20 printed on each of the sheets 12 which will then leave the printer one by one and will directly be fed into the folding apparatus. The control unit 30 of the folding apparatus

communicates with a control unit (not shown) of the printer via a communication interface 31. As is generally known, the printer may have several paper trays on which
25 print media of different types may be loaded. The control system of the printer stores information on the type of media contained in each tray. When an electronic print job is sent to the printer, the job specifications will include an instruction designating the paper tray from which the print media shall be taken as well as instructions on the folding pattern in which the printed sheets shall be folded in the folding apparatus. These
30 instructions as well as the information on the print media, including the type of the sheets 12, will be transmitted to the control unit 30 of the folding apparatus.

While Fig. 1 shows only a simplified folding apparatus with only one folding station, it will be understood that, in practice, the folding apparatus may have a plurality of folding
35 stations, so that more complex folding patterns may be realised, as is generally known in

the art. Depending on the desired folding pattern, the control unit 30 will control the actuator 28 so as to set the height of the stop member 20 to a value that corresponds to the desired folding length of the sheet 12. Optionally, the actuators 32, 34 may be controlled to set the width d of the folding nip.

5

Nevertheless, the resulting folding pattern of the sheets 12 may slightly deviate from what was intended, if the bending properties, e.g. the stiffness and bending strength of the sheets 12 are not taken into account.

- 10 Fortunately, the required information on the bending properties is available here because the media type of the sheets 12 is transmitted from the control unit of the printer to the control unit 30 of the folding apparatus. It will be observed that the "media type" includes not just the dimensions of the sheets, but also the thickness of the sheets and the material of the sheets or, more generally all supplementary information that is
15 needed for determining the bending properties of the sheets.

The control unit 30 includes a memory which stores a table 36 in which optimal settings for the height of the stop member 20 and, optionally, also appropriate settings for the second stop member 22, are stored for each of a plurality of pre-defined bending
20 properties. The bending properties may be specified by physical parameters of the sheets or may be specified implicitly by a unique identifier for each media type. Thus, when information on the bending properties of the sheets 12 that are actually output by the printer is received from the control unit of the printer, the control unit 30 can automatically optimize the settings of the folding members such that the sheets 12 will
25 bend exactly in the desired shape and the fold will be formed exactly in the correct position.

In case that the user should find out that, nevertheless, the results of the folding operation are not optimal, the user may instruct the control unit 30, e. g. via a keyboard
30 38, to correct the actual settings (by controlling the actuators 28, 32 and 34) and to store the corrected settings for the present bending properties in the table 36. Thus, when the same media type will be used next time, the control unit 30 will adjust the folding members 20, 22 to the correct settings from the outset.

35 The initial contents of the table 36 may be determined in advance by experiment. As an

alternative, the folding apparatus may be operated in a learning mode so as to establish or improve the table 36, as is illustrated by the flow diagram in Fig. 3.

In step S1, a so-called media catalogue is read from the control system of the printer.

- 5 This media catalogue includes information on the media sheets that are used in the current print job, including not only information on the size of the sheets but also information on the bending properties.

- 10 In step S2, a folding program is selected, dependent upon instructions in the print job specification or on the size of the sheets.

In step S3, the control unit 30 adjusts the folding members 20 and 22 to default settings, i. e. standard settings that are suitable for the selected folding program but not specifically adapted to the bending properties of the sheets.

15

Step S4 is a test run in which the sheets are folded in accordance with the selected folding program.

- 20 The user will then inspect the results of the folding process, and if the results are not found acceptable, he will manually instruct the control unit 30 to adjust the settings in Step S5.

After another test run (step S6), the results will be inspected again in 5 step S7, and the steps S5 - S7 will be repeated in a loop until satisfactory settings have been found.

25

In step S8, the control unit 30 will read the bending properties of the sheets from the media catalogue. Finally, in step S9, the current settings will be stored for the read bending properties in the table 36.

- 30 Fig. 4 illustrates a production mode which may be employed once the table 36 has been set up. Again, the media catalogue is read in step S10, and the folding program is selected in step S11. Then, in step S12, the bending properties of the sheets are read from the media catalogue, and the corresponding settings are read from the table 36 in step S13. Now, in step S14, the control unit 30 may automatically adjust the settings to
35 the values read from the table 36 before the operation of the folding apparatus (and in

fact the entire print line) is started in step S15.

While it has been assumed in the examples described above that the bending properties of the sheets are read from a media catalogue, it will also be possible to measure the bending properties directly in the print line. By way of example, Fig. 5 schematically shows a discharge side of a printer 40 which discharges printed sheets 12 one by one via discharge rollers 42. The sheets 12 are taken over by a sheet path 44 which connects the printer 40 to the sheet transport system 10 of the folding apparatus shown in Fig. 1. The feed path 44 comprises a plurality of pairs of rollers 46 feeding the sheets 12 in a horizontal plane, i.e. without causing the sheets 12 to bend.

A detector 48, e.g. in the form of a light barrier, is arranged to detect the passage of the sheets 12 on the upstream side of the feed path 44. A force sensor 50 is arranged between the detector 48 and the upstream end of the feed path 44 and has a head 52 that may be extended downwardly so as to press onto the trailing part of the sheet 12 and deflect the same. When a new sheet 12 is supplied, the head 52 is retracted upwardly so as not to interfere with the leading edge of the sheet. Then, when the detector 48 detects the trailing edge of the sheet, the head 52 is extended so as to deflect the sheet as shown in Fig. 5. The force sensor 50 measures the reaction force that the sheet 12 exerts upon the head 52. While the sheet advances, this reaction force will gradually decrease, until it is eliminated completely when the trailing edge of the sheet passes the head 52. The last reading of the reaction force, before it is eliminated, is a reliable measure for the bending strength, i.e. the bending properties of the sheet 12.

As is shown in Fig. 6, according to a modification of the method illustrated in Fig. 4, the information of the force sensor 50 may be used for adjusting the set positions of the folding members 20, 22. The steps that have been illustrated in Fig. 6 are the same as in Fig. 4, with the only difference that step S12 has been replaced by a step S12' wherein the bending properties of the sheets are measured with a suitable sensor, e.g. the force sensor 50 shown in Fig. 5.

CLAIMS

1. A sheet folding apparatus comprising a sheet transport system (10), adjustable folding members (20, 22) arranged to bend and fold a sheet (12) fed by the transport system (10), and a control system (30) arranged to adjust the folding members (20, 22) to set positions in accordance with information on sheet properties, **characterised** in that the control system stores a table (36) that specifies different set positions of the folding members (20, 22) for different bending properties of the sheets (12) and is adapted to read information on the bending properties of the sheets (12) to be folded and to adjust the folding members to set positions as specified by the bending properties.
5
2. The sheet folding apparatus according to claim 1, wherein at least one of the folding members is a stop member (20) for a leading edge of the sheet (12).
10
3. The sheet folding apparatus according to claim 1 or 2, wherein at least one folding member (22) comprises a pair of rollers (16, 24) forming a nip for catching and folding a loop (26) of the sheet (12).
15
4. The sheet folding apparatus according to any of the preceding claims, wherein a the control system (30) comprises an input device (38) permitting a user to enter or correct set positions for the folding members (20, 22) and for instructing the control system to store the entered or corrected set positions in the table (36) in conjunction with the current bending properties of the sheet (12).
20
5. The sheet folding apparatus according to any of the preceding claims, wherein the control system (30) comprises a communication interface (31) for receiving information on the bending properties of the sheets (12).
25
6. The sheet folding apparatus according to any of the preceding claims, comprising at least one sensor (50) for measuring information on the bending properties of the sheets (12).
30
7. A printing system comprising a printer (40) and a sheet folding apparatus according to any of the preceding claims.
35

8. The printing system according to claim 7, wherein the printer (40) is adapted to receive and store information on bending properties of the sheets (12) that are used as print media and to communicate this information to the control system (30) of the sheet
5 folding apparatus.

9. The printing system according to claim 7 or 8, comprising at least one sensor 50 for measuring information on bending properties of the sheets (12).

10 10. A sheet folding method using a sheet folding apparatus that comprises a sheet transport system (10), adjustable folding members (20, 22) arranged to bend and fold a sheet (12) fed by the transport system (10), and a control system (30) arranged to adjust

the folding members (20, 22) to set positions in accordance with information on sheet
15 properties, the method comprising the steps of:

- storing, in the control system (30), a table (36) that specifies different set positions of the folding members (20, 22) for different bending properties of the sheets,
- inputting bending information on the sheets to be folded into the control system (30), whereupon the control system adjusts the folding members (20, 22) to set
20 positions as specified in the table (36) for the input bending properties.

11. The method according to claim (10), wherein information on the bending properties of the sheets (12) is read from a media catalogue.

25 12. The method according to claim 10 or 11, wherein information on the bending properties of the sheets (12) is measured with at least one sensor (50).

13. The method according to any of the claims 10 to 12, comprising a step of manually correcting the set positions for the type of media (12) that are currently
30 processed, and storing the corrected set positions in the table (36).

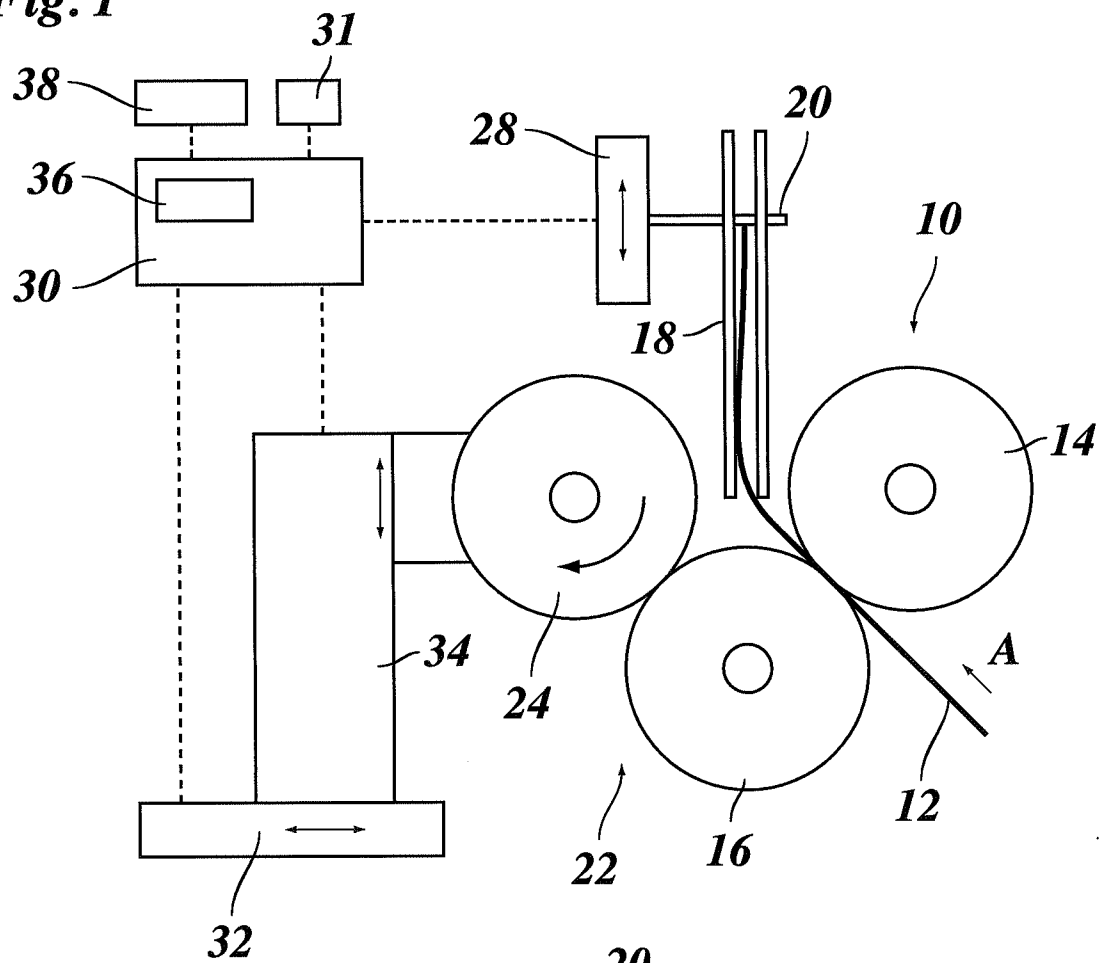
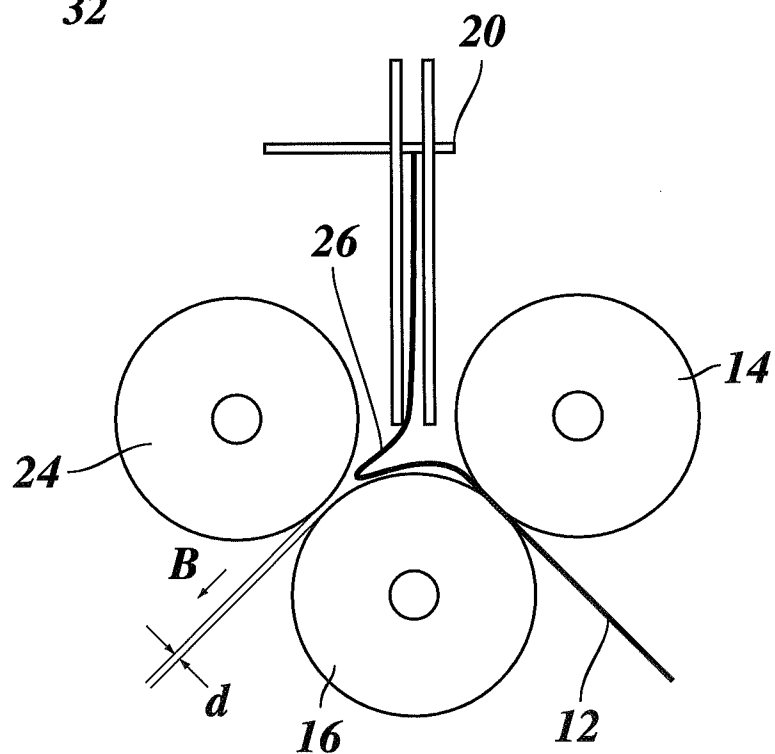
Fig. 1**Fig. 2**

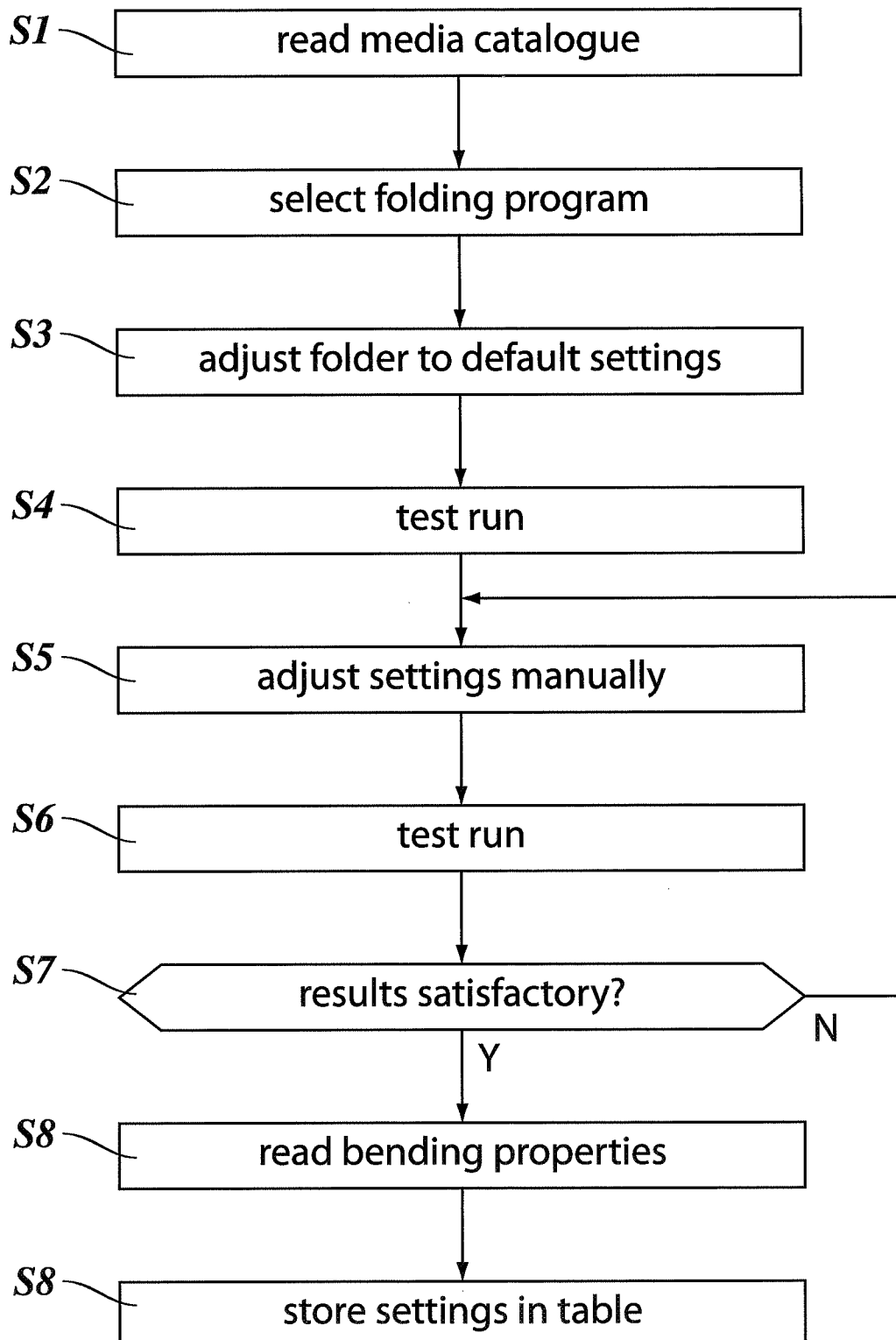
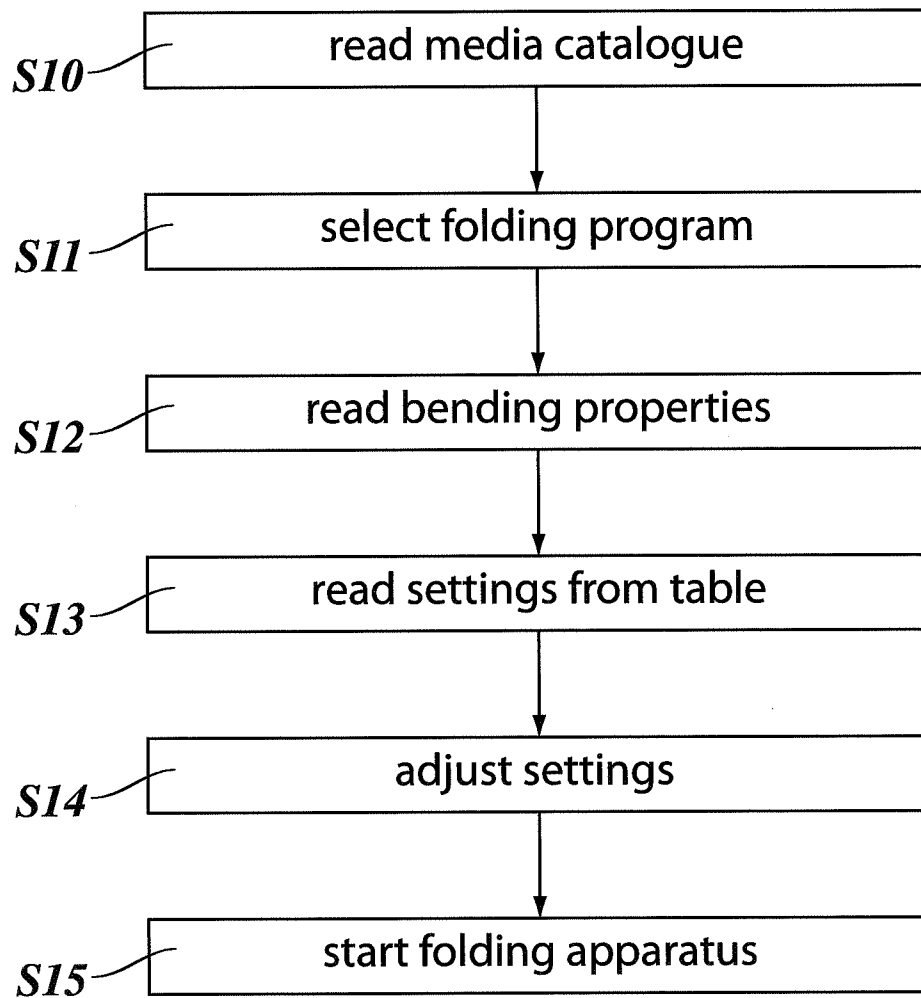
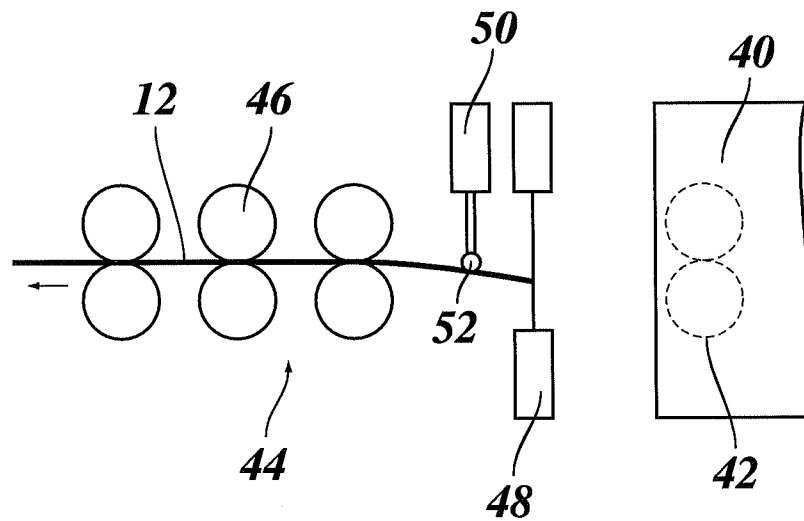
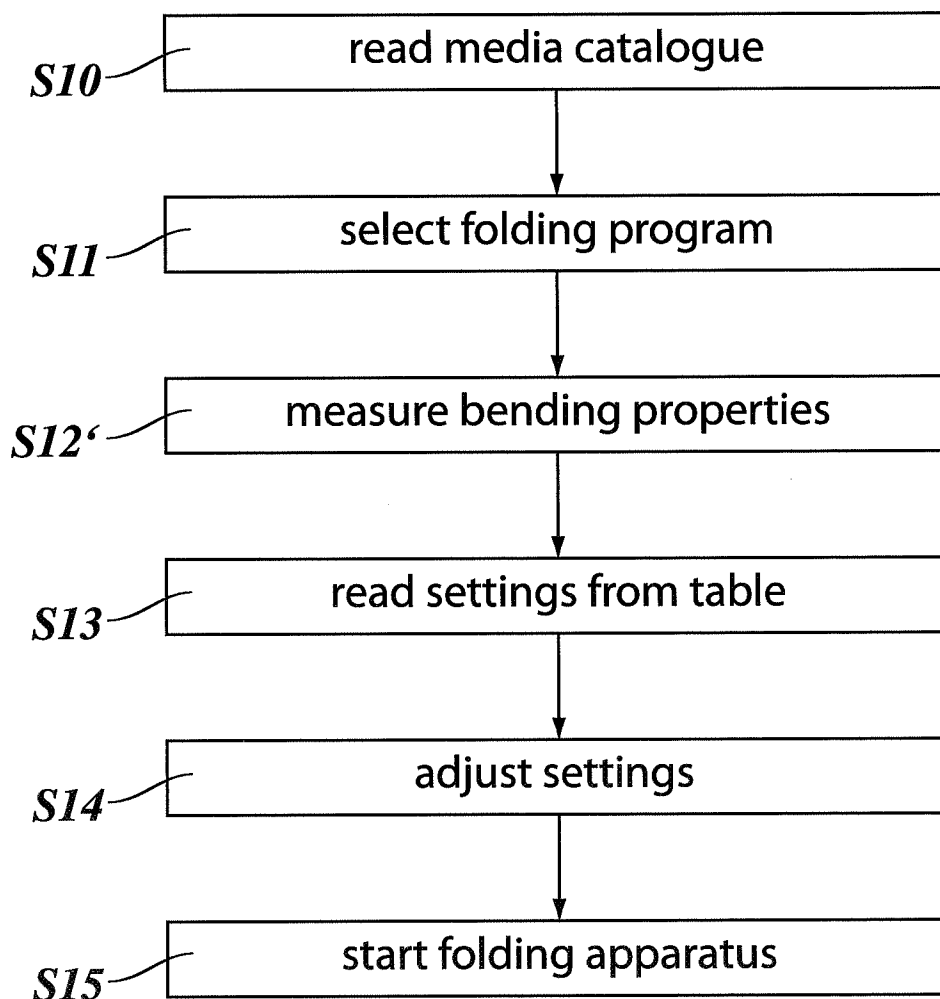
Fig. 3

Fig. 4

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Fig. 5**Fig. 6**

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/070256

A. CLASSIFICATION OF SUBJECT MATTER
INV. B65H45/14
ADD.

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)
B65H

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	----- DE 92 03 930 U1 (MATHIAS BÄUERLE GMBH) 2 July 1992 (1992-07-02) the whole document	1-13
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A	----- -/-	2,4-9, 12,13



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

14 December 2011

Date of mailing of the international search report

23/12/2011

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/070256

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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