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High-speed in-line cold laminating unit

Abstract

A high-speed, cold laminating system includes a lamination unit for inline use connected with a paper feeder supplying at least 30 ppm. The lamination unit further includes a set of unheated motor-driven laminating pressure rollers along a laminating path, and a cutter between the rollers and an exit. A diverter gate passes the paper sheets to the laminating path or to the exit without passing along the laminating path. The system includes a controller to control the motor, the diverter gate, and functions of the lamination unit. The controller is programmed to control the motor to pause the pressure rollers with a leading sheet therein while a subsequent sheet moves toward the pressure rollers so a laminated spacing distance between a trailing edge of the leading sheet and a leading edge of the subsequent sheet to equal a prescribed spacing distance.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
3453165	12/1968	Isbey et al.	156/235	G03F 1/92
4780742	12/1987	Takahashi et al.	N/A	N/A
5210581	12/1992	Kuzuya	N/A	N/A
5368677	12/1993	Ueda et al.	N/A	N/A
6585366	12/2002	Nagata et al.	N/A	N/A
6663238	12/2002	Kikuchi et al.	N/A	N/A
6854903	12/2004	Wiechers et al.	N/A	N/A
6860201	12/2004	Guillen et al.	N/A	N/A
6915740	12/2004	Pozuelo et al.	N/A	N/A
6942331	12/2004	Guillen et al.	N/A	N/A
7005030	12/2005	Van Heeswijk et al.	N/A	N/A
7600934	12/2008	Guillen et al.	N/A	N/A
7638012	12/2008	Galles et al.	N/A	N/A
7771553	12/2009	Lemens et al.	N/A	N/A
8778108	12/2013	Sato et al.	N/A	N/A
8800626	12/2013	Foley, Sr. et al.	N/A	N/A
9579815	12/2016	Newell et al.	N/A	N/A
10183473	12/2018	Bar	N/A	N/A
10744794	12/2019	Shigeta et al.	N/A	N/A
10875285	12/2019	Kitzmiller et al.	N/A	N/A
11001028	12/2020	Mark et al.	N/A	N/A
2003/0079827	12/2002	Kerr et al.	N/A	N/A
2004/0221947	12/2003	Haldner et al.	N/A	N/A
2007/0102104	12/2006	Galles et al.	N/A	N/A
2008/0099123	12/2007	Lemens et al.	N/A	N/A
2008/0236728	12/2007	Meier et al.	N/A	N/A
2016/0187834	12/2015	Matsuno	N/A	N/A
2019/0083999	12/2018	Shigeta	N/A	N/A
2021/0405571	12/2020	Nozaki et al.	N/A	N/A
2022/0011697	12/2021	Kimura	N/A	N/A
2022/0118756	12/2021	Francisco	N/A	N/A
2022/0281709	12/2021	Amdahl et al.	N/A	N/A
2024/0326397	12/2023	Jinichi et al.	N/A	N/A
2024/0359449	12/2023	Newell et al.	N/A	N/A

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
101304862	12/2011	CN	N/A
202934920	12/2012	CN	N/A
102555405	12/2014	CN	N/A
110871621	12/2019	CN	N/A
108883646	12/2019	CN	N/A
211641369	12/2019	CN	N/A
114379255	12/2021	CN	N/A
216733518	12/2021	CN	N/A
119659156	12/2024	CN	N/A
119734536	12/2024	CN	N/A
102015221664	12/2018	DE	N/A
2022631	12/2008	EP	N/A
1948414	12/2013	EP	N/A
2463097	12/2014	EP	N/A
3459726	12/2019	EP	N/A
3695967	12/2021	EP	N/A
3984741	12/2021	EP	N/A
3441231	12/2022	EP	N/A
2006350069	12/2005	JP	N/A
2009069273	12/2008	JP	N/A
5796807	12/2014	JP	N/A
6619504	12/2018	JP	N/A
7638524	12/2024	JP	N/A
2007016973	12/2006	WO	N/A
2024089112	12/2023	WO	N/A

OTHER PUBLICATIONS

Nguyen, “Plasticity-Induced Bending of Aluminum-Polymer Layered Composites”, University of Pittsburgh, Swanson School of Engineering, dated Apr. 7, 2023 (55 pages). cited by applicant
European Patent Office. Extended European Search Report for Application No. 23216486.3, dated May 24, 2024 (5 pages). cited by applicant

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Background/Summary

BACKGROUND
(1) The present invention relates to lamination of sheet media, for example paper sheets from a printer, between two transparent adhesive-coated films.
SUMMARY
(2) In one aspect, the present disclose provides a high-speed cold laminating system including a lamination unit configured for inline use connected with a paper feeder. The lamination unit has an entrance configured to receive multiple individual paper sheets provided in a continuous stream from the paper feeder at a page rate of at least 30 pages per minute. The lamination unit further includes an exit, a set of unheated laminating pressure rollers along a laminating path between the

entrance and the exit, and a cutter between the set of laminating pressure rollers and the exit. The system also includes a motor to drive rotation of the set of laminating pressure rollers. The system also includes a diverter gate that passes sheets of the plurality of individual paper sheets to the laminating path or to the exit without passing along the laminating path. The system includes a controller to control the motor, the diverter gate, and a plurality of functions of the lamination unit. The controller is programmed to control the motor to pause the set of pressure rollers with a leading sheet of the plurality of individual paper sheets therein while a subsequent sheet of the plurality of individual paper sheets is conveyed along the laminating path toward the set of laminating pressure rollers. This allows a laminated spacing distance between a trailing edge of the leading sheet and a leading edge of the subsequent sheet to be equal to a prescribed spacing distance.
(3) In another aspect, the present disclose provides a high-speed cold laminating system including a paper feeder operable to output individual paper sheets at a page rate of at least 30 pages per minute. The system also includes a lamination unit connected in-line with an outlet of the paper feeder to receive the individual paper sheets at the page rate of the paper feeder. The lamination unit includes a set of unheated laminating pressure rollers, a steering module upstream of the set of laminating pressure rollers, and a cutter downstream of the set of laminating pressure rollers. The steering module positions and orients each individual paper sheet with respect to a directional path through the lamination unit. The lamination unit further includes a laminating film cartridge receptacle with a replaceable laminating film cartridge and a motor for driving the paper sheets through the laminating film cartridge for lamination with pressure-sensitive film. The laminating film cartridge is insertable into the laminating film cartridge receptacle through a wall of the lamination unit along an insertion axis that is perpendicular to the directional path and parallel to an axis of a film roll of the laminating film cartridge. The wall includes a cutout shaped and sized for passage of the laminating film cartridge. The wall further includes an adjacent slot in aligned with the set of laminating pressure rollers and a tapered guide to direct a film tail of the laminating film cartridge into the slot and between the set of laminating pressure rollers.
(4) In another aspect, the present disclose provides high-speed cold laminating system including a laminating film cartridge having two rolls of pressure-sensitive laminating film. The laminating film cartridge receivable into a cartridge receptacle of the laminating system. The system further includes a steering module upstream of the set of laminating pressure rollers and a cutter downstream of the set of laminating pressure rollers. The steering module and operable to orients and positions individual paper sheets with respect to a directional path. The cutter severs a length of the laminating film containing an individual paper sheet from the remaining laminating film on the rolls. The system includes a controller to control the conveyance of individual paper sheets through the laminating system and programmed for bi-directional communication with an EEPROM of the laminating film cartridge. The EEPROM provides information to the controller regarding the laminating film, and the controller tracks laminating film consumption within the laminating system. The controller is further programmed to periodically update the EEPROM of the laminating film cartridge with a current remaining film length during use within the laminating system based on the laminating film consumption tracked by the controller.
(5) Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a partial perspective view of a printing system including an in-line lamination unit according to one construction of the invention.

(2) FIG. **2** is a partial perspective view of the lamination unit of FIG. **1**.
(3) FIG. **3** is a perspective view of a portion of a guide member of the lamination unit of FIG. **2**, illustrating first, second, and third trailing edge sensor elements.
(4) FIG. **4** is a is a perspective view of a side wall cutout of the lamination unit and a laminating film cartridge receptacle.
(5) FIG. **5** is a perspective view of the lamination unit, the laminating film cartridge receptacle, and a replaceable laminating film cartridge sliding into the unit.
(6) FIG. **6** is a perspective view of the lamination unit, the laminating film cartridge receptacle, and the replaceable laminating film cartridge in the unit.
(7) FIG. **7** is a partial front view of the lamination unit.
(8) FIG. **8** is a perspective view of the replaceable laminating film cartridge.
(9) FIG. **8**A is an exploded assembly view of the replaceable laminating film cartridge of FIG. **8**.
(10) FIG. **9** is a front view of a cutter unit.
(11) FIG. **9**A is a front view of a cutter unit according to another embodiment.
(12) FIG. **10**A is a schematic, side view of the set of pressure rollers with a leading sheet while a subsequent sheet is conveyed along the laminating path so that a laminated spacing distance between a trailing edge of the leading sheet and a leading edge of the subsequent sheet is equal to a prescribed spacing distance.
(13) FIG. **10**B is another schematic, side view of the set of pressure rollers with a leading sheet while a subsequent sheet is conveyed along the laminating path so that a laminated spacing distance between a trailing edge of the leading sheet and a leading edge of the subsequent sheet is equal to a prescribed spacing distance.
(14) FIG. **11** is a top view of the leading and trailing sheets of FIGS. **10**A, **10**B laminated together by the pressure rollers.
(15) FIG. **12** is a perspective view of the replaceable laminating film cartridge roll, including a laminating film roll with an end of roll flag.

DETAILED DESCRIPTION OF THE DRAWINGS

(16) With reference to FIG. **1**, a printing system **1** includes a lamination unit **10** coupled to a printing device **2**. As described in further detail below, the printing device **2** acts as an automatic paper feeder, and the lamination unit **10** may process a continuous stream of individual paper sheets from the printing device **2** while maintaining a page rate set by the printing device **2**. The printing system **1** further includes a first controller **3**, one or a plurality of material input receptacles **4**, a photocopier or scanner **6**, and a material output **8**. The material input receptacles **4** contain a plurality of material varying in dimension and type (e.g., paper styles and color). The first controller **3** can be configured to control at least some aspects of all devices of the printing system **1**, as well as optionally communicating with additional dedicated device controllers. The first controller **3** operably connects to the printing device **2** to control the material released by the material input receptacle **4** to be printed. The printing device **2** can be connected to an information network to receive various print jobs or tasks, although the printing device **2** may have alternate means for receiving data corresponding to print jobs. The printing system **1** may include a variety of devices coupled to the printing device **2** for post-processing (e.g., hole puncher, cutter, laminator, labeler). The devices, including the lamination unit **10**, couple to the material output **8**. One example of an in-line hole puncher is provided in applicant's prior U.S. Pat. No. 9,579,815, the entire contents of which are incorporated by reference herein. As an in-line connected post-processing device, the lamination unit **10** obviates the need for transporting, buffering, or loading sheets from the printer to be laminated. Rather, the sheets for a particular job are automatically processed and continuously fed from the printing device **2** to the lamination unit **10**, and then arrive for pickup at the material output **8** of the printing system **1**. The material output **8** may receive printed sheets that are not laminated, printed sheets that are laminated, and printed sheets that are processed in at least one additional in-line connected post-processing device (not shown).

(17) In the in-line printing system **1** as illustrated, the printing device **2** is configured to selectively feed paper sheets into the lamination unit **10**, which is incapable of receiving sheets to be laminated from another source. However, in other embodiments, the printing system **1** is provided with an additional separate paper feeder, referred to as an interposer, connected upstream of the lamination unit **10** to provide paper to the system. The interposer is a device added after the printing device **2** to allow paper sheets to be sent direct to the lamination unit **10** without traveling through the printing device **2**. In yet other embodiments, the lamination unit **10** can be configured for standalone use (without the printing device **2**) and can be fed by an automated feeder of any suitable construction.

(18) The printing system **1** including the lamination unit **10** and optionally additional in-line devices constitutes a continuous sequence of devices connected along a single workflow, with certain decision controls to determine the path that each sheet travels. The in-line printing system **1** embodies a production line of various devices, each operable to modify sheets processed therethrough. Each device can also be configured to include a bypass pathway where sheets may not receive any modifications, but rather exit the device in the same form in which they entered. In practice, many sheets may be printed by the printing device **2** and passed through the rest of the printing system **1** unchanged from the printing device **2**.

(19) FIGS. **2-7** illustrate the lamination unit **10** in further detail. The lamination unit **10** is a device operable to laminate sheets of paper or other material as the material passes through the lamination unit **10**. The lamination unit **10** may be used with and couple to a variety of upstream devices, such as the printing device **2** of the printing system **1** of FIG. **1**, to laminate a sequence of automatically fed sheets by bonding each sheet between two plies of transparent or translucent film. As noted below, the lamination unit **10** is also configured to separate laminated sheets from each other so that individual laminated products are output.

(20) With reference to FIGS. **2** and **3**, the lamination unit **10** includes an entrance **15** configured to receive a plurality of individual paper sheets provided in a continuous stream from the printing device **2** (or other paper feeder) at a high-speed page rate. The page rate can be set by the printing device **2**, without special consideration for the lamination unit **10**. In particular, the page rate output by the printing device **2** can be the same whether the sheets of the job are to be laminated in the lamination unit **10** or not. The page rate can be at least 30 pages per minute. In some constructions, the lamination unit **10** can operate at a page rate of at least 90 pages per minute. In some constructions, the lamination unit **10** can operate at a page rate of at least 140 pages per minute. Page rate is the number of sheets of letter (US) or A4 size processed per minute. However, the lamination unit **10** is not limited to these particular sheet sizes and can operate on sheets of other sizes, including but not limited to 11-inch×17-inch sheets or size A3 sheets. In some constructions, the lamination unit **10** can operate on banner length sheets, up to and including 1300 mm length. The lamination unit **10** further includes a laminating path **16** between the entrance **15** and an exit **17** of the lamination unit **10**, and the page rates mentioned above can be achieved through the laminating path **16**. Along the laminating path **16**, the lamination line speed may vary in certain portions, including speeding up, slowing down, or even briefly pausing, while keeping the page rate at the exit **17** to be equal to the page rate at the entrance **15**. All sheets passing through the lamination unit **10**, whether laminated or not, leave the lamination unit **10** via the same exit **17**. In other constructions, the lamination unit **10** can have multiple exits or output trays. Downstream of the lamination unit **10**, sheets may take a plurality of different paths before reaching the material output **8** of the printing system **1**.

(21) The printing system **1** continuously operates with a consistent page rate within each station or device of the printing system **1**. This obviates the need for buffering or stacking up sheets between tasks. As such, the overall page rate of the lamination unit **10** matches that of the printing device **2** when connected in-line with no immediate buffer. Despite this, the sheets may be laminated at a page rate lower than, or higher than, the overall page rate as measured at the entrance **15** and the

exit **17**, as will be explained in further detail below.

(22) With reference to FIG. **2**, the lamination unit **10** includes a housing **14** that at least partially surrounds a guide member **18**. The illustrated guide member **18** is a U-shaped guide member **18**, although other constructions include different shapes and sizes than the illustrated. With reference to FIGS. **2** and **3**, the guide member **18** includes a first U-shaped member **22** and a second U-shaped member **26** that together define the laminating path **16** therebetween. The guide member **18** includes multiple sets of rollers that guide one or more sheets through the guide member **18** along a direction of travel as illustrated by the arrows in FIG. **3**. The sets of rollers includes an acceleration roller **35**U operable to accelerate or decelerate each of the sheets to a designated speed between the entrance **15** and the point where lamination occurs. The upstream acceleration roller **35**U ensures continuous flow, which allows gaps between material. Particularly, a sheet may be accelerated from the entrance **15** to a speed in excess of the speed corresponding to the overall page rate. This enables a subsequent deceleration and possible pause during lamination, followed by a re-acceleration between the point of lamination and the exit **17** (e.g., by a downstream acceleration roller **35**D) up to the speed corresponding to the page rate of sheet supply to the lamination unit **10**.

(23) The guide member **18** includes a diverter gate **36** operable between a first position that passes sheets of the plurality of individual paper sheets to the laminating path **16**, and a second position that passes sheets of the plurality of individual paper sheets to the exit **17** without passing along the laminating path **16** (i.e., avoiding lamination of those sheets). The diverter gate **36** can be solenoid-operated in some constructions.

(24) The guide member **18** further includes a material receiving portion **38** and a material discharge portion **42** disposed at upper ends of the U-shaped guide member **18**. The material receiving portion **38** receives the one or more sheets of paper (e.g., from a printer or other device), and the material discharge portion **42** discharges the one or more sheets of paper (e.g., into a tray or other storage medium, or to another post-processing device, such as a cutting and/or binding machine) after the one or more sheets of paper have been moved through the laminating path **16**. While the illustrated construction illustrates a particular direction of travel (i.e., moving right to left through a U-shaped path), in other constructions the direction of travel may be different from that illustrated.

(25) The material receiving portion **38** further includes a path entry sensor **44** to sense the material length thus determine the material size. The path entry sensor **44** is configured to send the material size to the lamination unit **10**.

(26) As material passes through the lamination unit **10**, its overall throughout matches the output page rate of the printer can maintain its normal or full speed. However, the speed of a sheet need not remain constant throughout the lamination unit **10**. If desired to slow down at one point, the sheet must accelerate elsewhere. To ensure continuous flow, the acceleration rollers **35**U, **35**D adjust the speed of material regardless of its initial speed entering the material receiving portion **38**. In some constructions, this allows lamination to occur at a fixed page rate for a wide range of page rates as measured into/out of the lamination unit **10** (i.e., the page rate of the printing system **1**).

(27) With reference to FIGS. **3** and **7**, the lamination unit **10** includes an alignment sensor **46**. The sensor **46** is disposed adjacent the laminating path **16** and detects a position of an edge of a sheet of paper that extends parallel with the direction of travel as the sheet of paper moves through the laminating path **16**. Within the lamination unit **10**, this is considered a side edge of the sheet, although it may be the “top” or “bottom” of a sheet (i.e., according to portrait orientation). The sensor **46** provides information to the lamination unit **10** to center the sheet. In particular, the sheet may be shifted in a direction perpendicular to the direction of travel. The sensor **46** can be a sensor unit or assembly that includes a row of sensors (e.g., two sensor elements) arranged perpendicular to the direction of travel.

(28) With continued reference to FIGS. **3** and **7**, the lamination unit **10** also includes a second alignment sensor, or particularly skew sensor **50**. The skew sensor **50** is disposed adjacent the laminating path **16** and detects a leading edge of the sheet of paper as the sheet of paper moves

through the laminating path **16**. The angle of the leading edge can be determined from the sensor **50**. The sensor **50** can be a sensor unit or assembly that includes a row of sensors (e.g., three or five sensor elements) arranged perpendicular to the direction of travel.

(29) With reference to FIGS. **1** and **4-7**, the lamination unit **10** includes a set of unheated laminating pressure rollers **66** along a laminating path **16** and a laminating film cartridge **78** (FIG. **3**). The pressure rollers **66** are disposed generally at the bottom of the U-shaped guide member **18**. The sensors **44**, **46**, and **50** are disposed between the entrance **15** and the pressure rollers **66**, and one or more (e.g., a central sensor element of the skew sensor **50** alone) are used to detect positions of leading and/or trailing edges of different sheets of paper passing through the laminating path **16**. Based at least in part on the sheet edge detection, the laminating pressure rollers **66** are controlled for selective activation to control stopping/starting of the lamination unit **10** to laminate the sheet material based on the detected positions of the leading and/or trailing edges. As illustrated, all of the sensors **44**, **46**, **50** are located upstream of the laminating film cartridge **78**. The sensor(s) **44**, **46**, and **50** communicates with a lamination controller **59** of the lamination unit **10** (FIG. **1**) such that the controller **59** can receive signals from the sensor(s) **44**, **46**, and **50**, and communicate a signal to the lamination unit **10**. The controller **59** of the lamination unit **10** is in operable communication with the first controller **3** of the printing system **1**. The controller **59** is further operably connected to control a motor **61**, the diverter gate **36**, and a plurality of functions of the lamination unit **10**, including those described in further detail below.

(30) A steering module **60** of the lamination unit **10** is provided upstream of the pressure rollers **66** and cartridge **78**. The steering module **60** includes the motor **61** and a plurality of independently-driven drive rollers **62** operably connected to the skew sensor **50**. The steering module **60** is operable to orient and position each one of the individual sheets of paper with respect to a directional path through the lamination unit **10**. The skew sensor **50** sends information to the controller **59** to adjust the speeds of the drive rollers **62** to eliminate the skew angle of the sheet. The leading edge of the sheet is positioned perpendicular to the direction of travel. The motor **61** is operably connected to the controller **59** to drive the drive rollers **62** based upon a control signal generated in the controller **59**. Solenoid(s) **79** of one or more upstream sets of rollers can be actuated to release the grip of the rollers on the sheet in the event of a long sheet that is still resident at one or more upstream roller sets while being manipulated at the steering module **60**.

(31) With further reference to FIG. **7**, the lamination unit **10** further includes a laminating film cartridge receptacle **74** along the laminating path **16** (FIG. **3**). The laminating film cartridge receptacle **74** accommodates and receives the replaceable laminating film cartridge **78**. As illustrated in FIGS. **4-7**, a slide rail **80** projects into the laminating film cartridge receptacle **74** for engagement with the laminating film cartridge **78**. The slide rail **80** extends perpendicular to the laminating path **16**. As illustrated, the slide rail **80** is provided at the bottom of the cartridge receptacle **74** to engage corresponding channel(s) **109** in the laminating film cartridge **78** (FIGS. **8** and **12**), although other positions are optional depending on the configuration of the laminating film cartridge **78**. The film cartridge **78**, which is described separately below, includes a supply of pressure-sensitive laminating film **90** for use at the laminating pressure rollers **66**. The lamination unit **10** further includes a wall or access panel **82** with a cutout **86** to allow access to the cartridge **78**. The cutout **86** is shaped and sized for passage of the laminating film cartridge **78**. The shape of the cutout **86** is configured to the profile of the cartridge **78**, such that all or most of the other portions of the lamination unit **10** are concealed by the panel **82**. In some embodiments, the lamination unit **10** can be mounted slidably (e.g., on rails) within the cabinet or housing **14**, and at least a portion of the lamination unit **10** can slide out from an operational position within the housing **14** to facilitate removal of the cartridge **78** for replacement.

(32) The panel **82** also includes a slot **85** adjacent the cutout **86** in register with the set of laminating pressure rollers **66** for passage of a pre-sealed laminating film tail **87** of the laminating film cartridge **78** (i.e., where the films of the two rolls **90** are bonded together). The panel **82**

further includes a tapered guide **88** configured to direct the film tail **87** into the slot **85** and between the set of laminating pressure rollers **66**. The tapered guide **88** includes two flanges coupled to the panel **82** with a gap between to allow the film tail **87** to be guided through.

(33) A lever **89** is supported movable with respect to the panel **82**. As shown in FIGS. **5** and **6**, the lever **89** can be at least partially exposed and accessible above the panel **82**. The lever **89** is coupled to a linkage **91** operable to close and open the pressure rollers **66**. The linkage **91** can include an adjustable biasing device **91**A (FIGS. **3** and **7**) that sets the pressure applied between the laminating pressure rollers **66** when the linkage **91** is in the closed or operational laminating position. With reference to FIGS. **5** and **6**, the cartridge **78** is enabled to be removed by moving the lever **89** from a closed or latching position to an open or unlatching position. For example, the linkage **91** operated by the lever **89** can include or actuate a link **91**B that engages with one or more contact surfaces **78**A of the cartridge **78** as shown in FIGS. **5-7** to retain the cartridge **78** whenever the lever is closed. The cartridge contact surfaces **78**A can be configured to provide inter-engagement of complementary shaped features with the link **91**B, or simply provide a frictional engagement therewith as shown. The lever **89** is operable with one release motion to release the laminating film cartridge **78** from a latched position and separate the set of laminating pressure rollers **66**. With the pressure rollers **66** in the open or gapped position, the film tail **87** is unclamped from the laminating pressure rollers **66** for removal. Likewise, a user can use the tapered guide **88** to direct the film tail **87** of the new or refilled film cartridge **78** between the pressure rollers **66**. Movement of the laminating film cartridge **78** out of or into the cartridge receptacle **74** is guided by engagement of the channel(s) **109** with the slide rail **80**. Following the insertion of the cartridge **78**, the lever **89** is operated back to the closed or latching position to secure the cartridge **78** into the operational position and clamp the film tail **87** between the laminating pressure rollers **66**.

(34) As shown in FIGS. **5** and **6**, the lever **89** can be biased by a spring **89**A (e.g., over-center tension spring). For example, the spring **89** extends between a first end secured on the lever **89** (which is operable by the user as the handle or input of the linkage **91**), and a second end on the panel **82**. Due to the over-center relationship of the spring **89**A with respect to the pivot of the lever **89**, the spring **89** can bias the lever to the two different limit positions, the open and closed positions, depending on the position of the lever **89**. Closing the lever **89** enables the spring **89**A to apply bias force in the closing or latching direction that actuates the link **91**B from the upwardly-biased position of FIG. **5** to the downward position of FIG. **6**. As shown, the link **91**B can be provided in the form of a plate and can be upwardly-biased by one or more springs **91**C that are provided at the outboard ends and arranged to bear against an angled portion of the link **91**B. In the same closing motion, the lever **89** also drives the upper pressure roller **66** downward toward and against the lower pressure roller **66**. The upper pressure roller **66** is driven by the adjustable biasing device **91**A, which is length adjustable and includes a spring (not shown) that exerts downward force on a bearing block **91**D that rotatably supports the upper pressure roller. The same mechanism is provided on both ends supporting the upper pressure roller **66**. When the lever **89** is opened, spring pressure is relieved in the adjustable biasing device **91**A, and the linkage **91** further pulls the upper pressure roller **66** away from the lower pressure roller **66** as shown in FIG. **4**. In some constructions, the spring **89**A is eliminated, and the lever **89** may be unbiased (i.e., biased by gravity alone).

(35) With further reference to FIG. **8**, the cartridge **78** includes a pair of rolls of pressure-sensitive laminating film **90** positioned along parallel spool axes **92**. Each film roll includes a spool or core about which the laminating film **90** is wound to form the roll. The film of the first laminating film roll **90** is released on a top side of the laminating path traveled by the sheets, and the film of the second laminating film roll **90** is released on the bottom side. As shown in FIG. **7**, the laminating film from the rolls **90** extends directly to the laminating pressure rollers **66** immediately downstream of the cartridge **78**. Each sheet to be laminated passes through a gap at the center of the cartridge **78** between the film rolls **90** and is directed into a nip formed by the laminating

pressure rollers **66**. As shown, the cartridge **78** can include a tapered sheet guide. At the laminating pressure rollers **66**, the sheet meets the adhesive-coated co-facing sides of the two laminating films. A laminating motor **93** is operably connected to the pressure rollers **66** to rotate them, which also pulls the required amount of film from the laminating film rolls **90**. The laminating film from the two rolls **90** adhere together around the sheet thus laminating the sheet.

(36) With further reference to FIGS. **7** and **10**, a sheet sensor **94** tracks the movement of each sheet (by detection of leading and/or trailing edges) along the laminating path **16**, downstream of the laminating nip formed by the rollers **66**. The controller **59** is programmed to receive information from the sheet sensor **94** about the position of the sheet as it exits the laminating pressure rollers **66**. The sheet sensor **94** can be used to detect the trailing edge of the laminated sheet, data upon which the controller **59** determines when to stop and cut a laminated product, for example, counting a prescribed number of steps of the motor **93** following detection of the trailing edge of the sheet, wherein the prescribed number of steps corresponds to the distance between the sheet sensor **94** and the cutting point established by a cutter assembly **120**, plus a prescribed excess or border. In some constructions, the motor **93** can be controlled to stop for cutting based on other information, including detection of the trailing sheet edge further upstream (and a corresponding greater number of motor steps). Also, once sheet length is detected, by leading and trailing edges passing the path entry sensor **44** or the skew sensor **50**, control of the motor **93** may be handled in relation to leading edge detection, plus the sheet length for a given sheet.

(37) FIGS. **10**A and **10**B present a detail schematic view of two sequential sheets **96***a*, **96***b* encountering the laminating pressure rollers **66**, illustrating one optional feature for controlling sheet-to-sheet spacing prior to cutting laminated sheets apart. As described above, the laminating pressure rollers **66** rotate to pull the sheet through and bond it between the laminating film from the rolls **90**. The controller **59** is programmed to control the motor **93**, based on one or more detected sheet edges, to pause the set of pressure rollers **66** while a portion of the leading sheet **96***a* remains therein. For example, the controller **59** can direct stoppage of the motor **93** upon a prescribed number of motor steps following detection of the trailing edge **97***a* of the leading sheet **96***a* by the skew sensor **50** or another appropriate sheet sensor. The remaining sheet(s) along the laminating path **16** continue moving, so that the subsequent sheet **96***b* following the leading sheet **96***a* closes the sheet-to-sheet gap with the leading sheet **96***a*. Based on the position of a leading edge **97***b* of the subsequent sheet **96***b* in relation to the stopped trailing edge **97***a* of the leading sheet **96***a* (e.g., calculated by the controller **59** by counting steps of the upstream motor **61** of the steering module **60** that delivers the subsequent sheet **96***b* to the laminating pressure rollers **66**), the controller **59** controls the motor **93** to restart the laminating pressure rollers **66** to set a laminated spacing distance **98** between the leading sheet trailing edge **97***a* and the subsequent sheet leading edge **97***b* equal to a prescribed spacing distance. The prescribed spacing distance **98** may be double a prescribed border **102** of the finished laminated product, as shown in FIG. **11**. The border **102** represents the bonded laminating film beyond the respective sheet edges **97***a*, **97***b*. The prescribed border **102** may be automatically set or input to one of the system controllers **3**, **59** by a user. While the illustrated construction illustrates a particular direction of travel (i.e., moving right to left), in other constructions the direction of travel may be different from that illustrated.

(38) With reference to FIGS. **8** and **8**A, the replaceable laminating film cartridge **78** can include a removable refill portion **103** selectively securable to a reusable frame portion **104**. The pressure-sensitive laminating film rolls **90** are provided as part of the removable refill portion **103**, separate from the reusable frame portion **104**. The first and second laminating film rolls **90** are connected together at a prescribed spacing distance by connector(s) that form a complementary fit with the interior of the reusable frame portion **104**. Aspects of the laminating film cartridge **78** can be similar to that disclosed in U.S. Patent Application Publication No. 2022/0281709, the entire contents of which are incorporated by reference herein. The cartridge **78** includes a first end portion **106** and a second end portion **107** arranged on opposite ends of the laminating film rolls **90**. The

first end portion **106** and second end portion **107** have respective base ends formed with the respective open-bottom channels **109** that are aligned and configured to mutually receive the slide rail **80** provided at the bottom of the laminating film cartridge receptacle **74**. Engagement with the slide rail **80** may limit the laminating film cartridge **78** to movement into and out of the operation position in the laminating film cartridge receptacle **74** by sliding movement parallel to the spool axes **92** (i.e., perpendicular to the laminating path **16**).

(39) The cartridge **78** includes a spring-loaded brake **116** configured to enable adjustment of the unrolling tension in one of the laminating film rolls **90**. Adjusting the brake **116** changes the unrolling tension differential between the two rolls **90** to correct for curl in the finished laminated products. In some constructions, the system characteristics produce an inherent amount of product curling during operation. Although the brake **116** can offset or correct this inherent curling, additional or alternative solutions can be provided in the lamination unit **10**. For example, the two laminating pressure rollers **66** can be manufactured with non-matching hardness and/or outside diameter. The difference in hardness and/or outside diameter may be relatively small, e.g., one roller's outside diameter being reduced by 10 percent or less compared to the other, or one roller's hardness on a common hardness scale being reduced by 10 percent or less compared to the other. Either or both of these solutions may reduce or completely offset the natural tendency for curl in finished laminated products. Thus, the tension brake **116** may be retained for fine adjustment or may be eliminated in some constructions.

(40) With further reference to FIGS. **8** and **12**, the removable refill portion **103** includes an electronic memory device such as an EEPROM **110** operable to store information about the laminating film rolls **90**, including any combination of its serial number, type, and remaining length. The EEPROM **110** may communicate with the controller **59** to alert the user of errors (e.g., an incompatibility between paper size/type and film size/type) and circumvent unsuccessful lamination jobs. The EEPROM **110** is provided on the removable refill portion **103** at a position that remains exposed when joined with the reusable frame portion **104** as shown in FIG. **8**. As such, a connection for electrical communication can be established between the EEPROM **110** and the controller **59** (e.g., by a Serial Peripheral Interface “SPI” connector **111**, including conductor contacts and spring pins) upon insertion of the laminating film cartridge **78** into the operational position within the receptacle **74**. The connection for electrical communication can be automatic upon insertion of the laminating film cartridge **78**, not requiring any further steps or actions. The connector **111** can be seen at the back of the lamination unit **10** in FIG. **3**, as the cartridge **78** is removed from the lamination unit **10**. The connector **111** is one exemplary means of sensing or transmitting information from the EEPROM **110** to the controller **59**, although alternative sensing and/or communication devices and protocols are also contemplated.

(41) The EEPROM **110** communicates with the controller **59** to allow tracking the laminating film usage by the controller **59**. Supplied with data on the original film roll lengths of the cartridge **78** and data on the usage within the lamination unit **10**, the controller **59** may calculate a remaining length of laminating film. The controller **59** is programmed for bi-directional communication with the EEPROM **110**. The EEPROM **110** provides the laminating film information to the controller **59**, and the controller **59** communicates back, continuously or periodically, to rewrite the EEPROM **110** with an updated value of remaining laminating film length. Thus, the calculated amount of remaining film from the controller **59** is stored with the cartridge **78** (particularly the refill portion **103**). As such, the information is unaffected by removal and reinsertion of the film rolls **90**. If removed and reinserted, into the same lamination unit **10** or another one like it, the controller **59** is configured to read the current remaining film length of the laminating film cartridge **78** as stored to the EEPROM **110** at the last usage prior to removal. The controller **59** can then continue to update the EEPROM **110** from an accurate starting point when the cartridge **78** is further used within the lamination unit **10**.

(42) The bi-directional communication between the EEPROM **110** and the controller **59** can be

used to provide warnings to the users of the lamination unit **10**—either at a local display on the lamination unit **10** or a display of the printing device **2**. The warnings can inform a user of low amounts of laminating film and communicate if the cartridge **78** needs to be replaced soon. In some embodiments, the laminating controller **59** can communicate to the controller **3** of the printing system **1** such that the controller **3** can issue a warning based on the remaining laminating film length. For example, the warning may indicate that the requested number of sheets to be laminated cannot be completed without replenishing the laminating film (e.g., refilling the cartridge **78**). In some cases, a laminating job (which may form a portion of an overall printing job) may be put on hold or aborted if insufficient film remains. The user may change the cartridge **78** prior to starting the print job, or the user may wait and replace mid-print when the laminating film is completely used up. Upon reaching a low film threshold, the controller **3** may trigger and maintain a low film warning until the cartridge **78** is replaced.

(43) As illustrated in FIG. **12**, at least one of the laminating film rolls **90** includes an end of roll flag **112** (e.g., adhesive flag or other indicator) at a designated distance from the end of the film, for example 3000 mm remaining or 1000 mm remaining. The end of roll flag **112** can be identified by a corresponding sensor **112**A. The end of roll flag **112** is a physical factory-set indicator, as opposed to a calculated amount (from the controller **59**), allowing a positive confirmation of an approaching end-of-roll. The end of roll flag **112** acts as a back-up or failsafe to the EEPROM **110**. For example, upon detection of the end of roll flag **112** by the sensor **112**A, the controller **59** is configured to overwrite a current remaining film length stored on the EEPROM **110** based on the preprogrammed value corresponding to the factory-set placement of the end of roll flag **112**. This may overwrite a higher value of remaining film stored on the EEPROM **110** (e.g., when some unrecorded film waste introduces error in the calculated amount). In some constructions, a signal identifying the end of film supply (e.g., a prescribed number of rotations following identification of the end of roll flag **112** by the sensor **112**A) causes the controller **59** to enact a hard stop for further laminating to prevent binding or jamming that may occur if the pressure rollers **66** attempt pulling the terminal end of laminating film off the supporting spool to which it is secured.

(44) With reference to FIG. **9**, the lamination unit **10** includes a cutter assembly **120**, or simply “cutter,” provided between the set of laminating pressure rollers **66** and the exit **17**. In some constructions, the cutter **120** includes a guillotine cutter unit **121**. The cutter **120** includes a cutting motor **122** operably connected to a clutch pulley **123** which couples to a drive link **124** and acts as a crank for the drive link **124**. The clutch pulley **123** can be operated by a solenoid **126**. The drive link **124** has an end opposite the clutch pulley **123** that is connected with a blade frame or blade arm **132** on which the cutting edge or blade **132**A is provided. The sheet sensor **94** is disposed adjacent an inlet **128** of the cutter **120** and detects a trailing edge of the laminated sheet as it moves through the inlet **128** of the cutter **120**. The sheet sensor **94** sends a signal to the controller **59**, in response to which the controller sends a signal to activate the clutch pulley **123**. Additional details and alternative triggers have been discussed in the preceding description with respect to determining when the laminated sheet is to be stopped for cutting. The drive link **124** is mechanically adjustable to adjust a cutting stroke of the blade arm **132** and blade **132**A of the guillotine cutter unit **121**. The drive link **124** has a length adjuster **133** (e.g., turnbuckle) operable to adjust the length of the drive link **124** and correspondingly adjust the cutting stroke. The blade **132** operates against a stationary cutting stick **136** on a base or frame **140** of the cutter **120**. At certain times, such as the beginning of a new cartridge **78** or the beginning of a new job after a dormant period, waste film must be trimmed from a leading edge when commencing laminating. The trimming is accommodated by operation of the cutter **120**, and disposal of the trimmed waste to a waste bin **142**, for example through a purge gate **142**A. The purge gate **142**A can be solenoid-operated.

(45) The cutter **120** further includes a plurality of support links **134** supporting the blade arm **132** from the frame **140**. The blade arm **132** is configured to hover the blade **132**A over the cutting stick

136 between cuts. One of the support links **134** is mechanically adjustable to adjust a cutting alignment of the blade arm **132** and the blade **132**A in relation to the stationary cutting stick **136**. For example, one of the support links **134** is coupled to the frame **140** via an eccentric bearing **138**. The levelness of the blade arm **132** and the blade **132**A is adjusted by adjusting (rotating) the bearing **138** within the frame **140**. The bearing **138** can be clamped into the desired orientation once adjusted. The cutting stick **136** is worn down over time and is removably coupled to the frame **140** of the cutter **120** to be easily reconfigured and eventually replaced without impact to other portions of the cutter **120**. The blade **132**A is configured to contact the cutting stick **136** off-center such that the cutting stick **136** can be flipped around and reused in a second configuration to extend its useful life. The cutting stick **136** can also be flipped over such that the bottom becomes the top for a third configuration. From the third configuration, the cutting stick **136** can be flipped around for a fourth configuration. The cutting stick **136** is removed by uncoupling mechanical fasteners and removing a removable baffle **141** with the cutting stick **136**. The cutting stick **136** is removed and reconfigured or a new one is installed. In some embodiments, the cutting stick **136** is made of plastic, but may be made of other suitable materials. Furthermore, the cutter **120** facilitates replacement of the cutting stick **136** to a different material. A second blade sensor **144**, as illustrated in FIG. **9**, is encased in a disk coupled to the clutch pulley **123**. The second blade sensor **144** rotates with the clutch pulley **123** to track the movement of the blade arm **132** with the blade **132**A to ensure it returns to a home position before allowing the next laminated product to enter the cutter **120**. Once the laminated product is cut, it leaves the lamination unit **10** through the exit **17** and onto an output tray for retrieval.

(46) FIG. **9**A illustrates a cutter **220** of another construction, which is generally similar to the cutter **120** except as specifically noted below. Therefore, reference numbers from FIG. **9** are retained where appropriate and reference is made to the above description. The cutter **220** includes a drive link **224** connecting the clutch pulley **123** to the blade arm **132**. The drive link **224** may be mechanically adjustable with a length adjuster **133** to adjust a cutting stroke of the blade arm **132** and blade **132**A of the guillotine cutter unit **121**, like that of FIG. **9**. However, the drive link **224** of FIG. **9**A is also provided with an integrated compensator **250** that allows elastic flexure within the drive link **224**. Thus, reliable cutting may be achieved with less adjustment of the drive link length or the eccentric bearing **138**, either or both of which may optionally be eliminated or provided with a smaller range of adjustment as compared to FIG. **9**. The compensator **250** can include a spring **254**, which is shown as a compression coil spring in the illustrated embodiment. The spring **254** is operable to deflect and store energy from any additional drive input from the clutch pulley **123** after the blade **132**A makes contact with the cutting stick **136**. The preload in the spring **254** is adjustable in some configurations, for example, by a nut **258** on a threaded shaft about which the spring **254** is disposed.

(47) The embodiments described above and illustrated in the figures are presented by way of example only and are not intended as a limitation upon the concepts and principles of the present invention. As such, it will be appreciated by one having ordinary skill in the art that various changes in the elements and their configuration and arrangement are possible without departing from the spirit and scope of the present invention as set forth in the appended claims. Various features of the invention are set forth in the following claims.

Claims

1. A high-speed cold laminating system comprising: a lamination unit configured for inline use connected with a paper feeder, the lamination unit having an entrance configured to receive a plurality of individual paper sheets provided in a continuous stream from the paper feeder at a page rate of at least 30 pages per minute, the lamination unit further including an exit, a set of unheated laminating pressure rollers along a laminating path between the entrance and the exit, and a cutter

provided between the set of laminating pressure rollers and the exit; a motor connected to drive rotation of the set of laminating pressure rollers; a diverter gate operable between a first position that passes sheets of the plurality of individual paper sheets to the laminating path, and a second position that passes sheets of the plurality of individual paper sheets to the exit without passing along the laminating path; and a controller operably connected to control the motor, the diverter gate, and a plurality of functions of the lamination unit, wherein the controller is programmed to control the motor to pause the set of pressure rollers with a leading sheet of the plurality of individual paper sheets therein while a subsequent sheet of the plurality of individual paper sheets is conveyed along the laminating path toward the set of laminating pressure rollers so that a laminated spacing distance between a trailing edge of the leading sheet and a leading edge of the subsequent sheet is equal to a prescribed spacing distance.

2. The high-speed cold laminating system of claim 1, wherein the prescribed spacing distance is double a prescribed border value input to the controller so as to avoid trimming and waste between the laminated leading sheet and subsequent sheet.

3. The high-speed cold laminating system of claim 1, further comprising a steering module upstream of the set of laminating rollers along the laminating path, the steering module operable to orient and position each one of the individual paper sheets with respect to a directional path through the lamination unit.

4. The high-speed cold laminating system of claim 1, wherein the lamination unit includes a laminating film cartridge receptacle directly upstream of the set of laminating pressure rollers, the laminating film cartridge receptacle accommodating a replaceable laminating film cartridge with two continuous rolls of pressure-sensitive laminating film positioned along parallel spool axes.

5. The high-speed cold laminating system of claim 4, wherein the laminating film cartridge is movable into and out of an operation position in the laminating film cartridge receptacle by sliding movement parallel to the spool axes.

6. The high-speed cold laminating system of claim 1, wherein the cutter comprises a crank-driven reciprocating guillotine cutter assembly positioned downstream of the set of pressure rollers.

7. The high-speed cold laminating system of claim 6, wherein the guillotine cutter assembly includes a drive link that is mechanically adjustable to adjust a cutting stroke of a blade of the guillotine cutter assembly, and wherein the guillotine cutter assembly includes a support link that is mechanically adjustable to adjust a cutting alignment of the blade in relation to a stationary cutting stick.

8. The high-speed cold laminating system of claim 7, wherein the cutting stick is removably coupled to a frame of the guillotine cutter assembly to facilitate reconfiguration and/or replacement of the cutting stick.

9. The high-speed cold laminating system of claim 6, wherein the guillotine cutter assembly includes a drive link with an integrated compensator operable to absorb excess input travel to a blade of the guillotine cutter assembly.

10. The high-speed cold laminating system of claim 1, wherein the controller is configured to change a line speed of sheets of the continuous stream of paper sheets between the entrance and the set of laminating pressure rollers and to change a line speed of the sheets, after lamination, between the set of laminating pressure rollers and the exit such that the controller can maintain an overall page rate through the lamination unit that matches the page rate at the entrance, up to at least 90 pages per minute, without driving the motor at a speed that matches the page rate.