(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
22 October 2015 (22.10.2015)

WIPO | PCT

(10) **International Publication Number**
WO 2015/160954 A1

(51) **International Patent Classification**:
A61F 13/15 (2006.01)

(21) **International Application Number**:
PCT/US2015/025976

(22) **International Filing Date**:
15 April 2015 (15.04.2015)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:
61/979,538 15 April 2014 (15.04.2014) US

(71) **Applicant**: **THE PROCTER & GAMBLE COMPANY** [US/US]; One Procter & Gamble Plaza, Cincinnati, Ohio 45202 (US).

(72) **Inventors**: **ROYCE, Daniel, Richard**; One Procter & Gamble Plaza, Cincinnati, Ohio 45202 (US). **GABER, Rene**; Industriepark AM Silberberg, Procter & Gamble Strasse, 53881 Euskirchen (DE). **SPAULDING, Charles, Jeffrey**; One Procter & Gamble Plaza, Cincinnati, Ohio 45202 (US). **CEDRONE, Louis, J.**; One Procter & Gamble Plaza, Cincinnati, Ohio 45202 (US). **KENT, Jeffrey, Michael**; One Procter & Gamble Plaza, Cincinnati, Ohio 45202 (US). **VARGA, Stephen, Michael**; One Procter & Gamble Plaza, Cincinnati, Ohio 45202 (US). **KEMBEL, Michael, Dennis**; One Procter & Gamble Plaza, Cincinnati, Ohio 45202 (US).

(74) **Agent**: **KREBS, Jay A.**; c/o THE PROCTER & GAMBLE COMPANY, Global Patent Services, One Procter & Gamble Plaza, C8-229, Cincinnati, Ohio 45202 (US).

(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, BN, 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, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,

[Continued on next page]

(54) Title: METHODS FOR INSPECTING CHANNEL REGIONS IN ABSORBENT STRUCTURES IN ABSORBENT ARTICLES

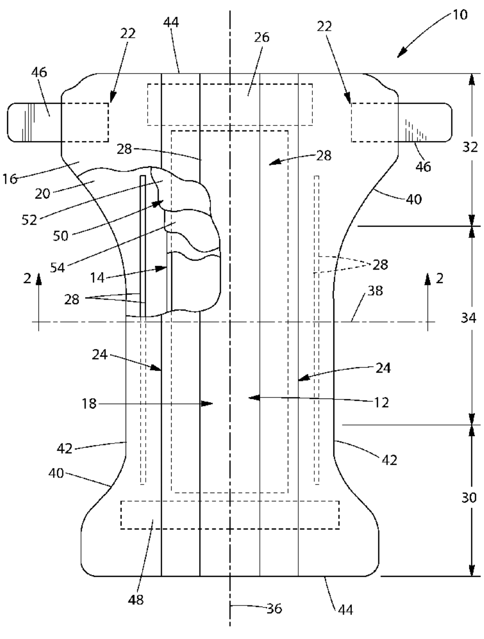

Fig. 1

(57) Abstract: The present disclosure relates to methods and apparatuses sensing emitted light caused by fluorescence of adhesive to determine characteristics of absorbent structures during the manufacture of absorbent articles. Some absorbent articles may have absorbent structures that include an absorbent core disposed between a topsheet and a backsheet. And one or more of the absorbent structure components may be assembled with adhesive that fluoresces when excited by ultraviolet light. Aspects of the present methods relate to an inspection system that may be configured to interact with, monitor, and/or control a converting line. The inspection system may include a radiation source that illuminates a surface of an absorbent structure with ultraviolet light. A sensor may be adapted to receive light caused by fluorescence of the adhesive while being irradiated with the ultraviolet light. In turn, the inspection system may determine characteristics of the absorbent structure based on the detected emitted light.

WO 2015/160954 A1

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, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, KM, ML, MR, NE, SN, TD, TG).

Published:

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

METHODS FOR INSPECTING CHANNEL REGIONS IN ABSORBENT STRUCTURES IN ABSORBENT ARTICLES

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 61/979,538, filed April 15, 2014, which is herein incorporated by reference in its entirety.

FIELD OF THE INVENTION

The present disclosure relates to methods and apparatuses for making absorbent articles with absorbent structures, and more particularly, determining characteristics of channel regions in an absorbent structure by detecting emitted light caused by fluorescence of adhesive in the channel regions while being irradiated with the ultraviolet light.

BACKGROUND OF THE INVENTION

Along an assembly line, various types of articles, such as for example, diapers and other absorbent articles, may be assembled by adding components to and/or otherwise modifying an advancing, continuous web of material. For example, in some processes, advancing webs of material are combined with other advancing webs of material. In other examples, individual components created from advancing webs of material are combined with advancing webs of material, which in turn, are then combined with other advancing webs of material. In some cases, individual components created from advancing web or webs are combined with other individual components created from other advancing web or webs. Webs of material and component parts used to manufacture diapers may include: backsheets, topsheets, leg cuffs, waist bands, acquisition layers, absorbent core components, front and/or back ears, fastening components, and various types of elastic webs and components such as leg elastics, barrier leg cuff elastics, stretch side panels, and waist elastics. Once the desired component parts are assembled, the advancing web(s) and component parts are subjected to a final knife cut to separate the web(s) into discrete diapers or other absorbent articles.

In some configurations, absorbent articles may include absorbent structures positioned between the topsheets and backsheets. In addition, absorbent structures may include acquisition layers and absorbent cores, wherein the acquisition layers may be positioned between the absorbent cores and topsheets. As such, the topsheets, backsheets, and absorbent structures of such absorbent articles may function to absorb and/or contain the discharged materials and also to isolate bodily exudates from the wearer's skin and from the wearer's garments and bed clothing. For quality control purposes, absorbent article manufacturing lines may utilize various types of sensor technology to detect various types of characteristics of webs and discrete components added to the webs along the converting line as absorbent articles are constructed. Example sensor technology may include vision systems, photoelectric sensors, proximity sensors, laser or sonic distance detectors, and the like. In turn, sensor data may be communicated to a controller in various ways. In some configurations, the controller may be programmed to utilize sensor data to make operational adjustments; communicate converting line operating information; and/or reject defective diapers.

Although the previously mentioned sensor technology may be configured to provide information about the presence or absence of various components as well as relative positions and/or perimeter shapes of such components, such sensor technology may not be configured to provide desired information about absorbent structures. Absorbent structures may be constructed in various ways in an attempt to improve wearer fit and comfort and/or the manner in which absorbent structures absorb and/or transport liquid discharged onto and through a topsheet. For example, the absorbent structures may be constructed in various shapes and/or with varying amounts of absorbent material arranged along a width and/or length. In some instances, absorbent cores may be constructed with regions having no absorbent material or relatively small amounts of absorbent material. Such regions may provide improved core bending flexibility in use. In addition, some acquisition layers may be constructed with channel regions defined by varying thicknesses along the length and/or width. In some configurations, absorbent structures may be configured with acquisition layers having correspondingly shaped channel regions. In efforts to improve and control quality of manufactured absorbent articles, it may be desirable to obtain additional detailed information about the construction of such absorbent cores and/or acquisition layers during the assembly process. Consequently, it would be beneficial to obtain information about the construction of various components during the assembly process, such as for example, the channel regions of absorbent cores and/or acquisition layers.

SUMMARY OF THE INVENTION

The present disclosure relates to methods and apparatuses sensing emitted light caused by fluorescence of adhesive to determine characteristics of absorbent structures during the manufacture of absorbent articles. Some absorbent articles may have absorbent structures that include an absorbent core disposed between a topsheet and a backsheet. And one or more of the absorbent structure components may be assembled with adhesive that fluoresces when excited by ultraviolet light. Aspects of the present methods relate to an inspection system that may be configured to interact with, monitor, and/or control a converting line. The inspection system may include a radiation source that illuminates a surface of an absorbent structure with ultraviolet light. A sensor may be adapted to receive light caused by fluorescence of the adhesive while being irradiated with the ultraviolet light. In turn, the inspection system may determine characteristics of the absorbent structure based on the detected emitted light.

In one form, a method for assembling disposable absorbent articles, wherein each absorbent article comprises a topsheet, a backsheet, and a substantially cellulose free absorbent core disposed between the topsheet and the backsheet, comprises the steps of: advancing a first continuous substrate in a machine direction, the first continuous substrate having a first surface and an opposing second surface, and defining a width in a cross direction; applying adhesive to the first surface of the first continuous substrate, wherein the adhesive fluoresces when excited by ultraviolet light; depositing absorbent particulate polymer material on the first surface of the first continuous substrate so as to define first regions of absorbent particulate polymer material surrounding second regions that are substantially free of absorbent particulate polymer material; advancing a second continuous substrate in the machine direction, the second continuous substrate having a first surface and an opposing second surface, and defining a width in the cross direction; combining the first continuous substrate with the second continuous substrate to create a continuous length of substantially cellulose free absorbent cores, wherein the second regions on the first continuous substrate are placed in facing relationships with the first surface of the second continuous substrate to define channel regions that are substantially free of absorbent particulate polymer material, and wherein the adhesive bonds the first surfaces of the first and second continuous substrates directly together in the channel regions; advancing the continuous length of substantially cellulose free absorbent cores past a sensor; irradiating at least one of the second surfaces of the first or second continuous substrates of the continuous length of substantially cellulose free absorbent cores with ultraviolet light; filtering reflected ultraviolet light from the continuous length of substantially cellulose free absorbent cores to prevent detection of the reflected ultraviolet light with the sensor; detecting with the sensor emitted light caused by fluorescence of the adhesive while being irradiated with the ultraviolet light; and determining a characteristic of a channel region based on the detected emitted light, the at least one characteristic selected from the group consisting of: a presence of the adhesive in the channel region; a presence absorbent particulate polymer material in the channel region, a shape of the channel region, bond strength, and position of the channel region.

In another form, a method for assembling disposable absorbent articles, wherein each absorbent article comprises a topsheet, a backsheet, and a substantially cellulose free absorbent core disposed between the topsheet and the backsheet, the method comprises the steps of: advancing a first continuous substrate in a machine direction, the first continuous substrate having a first surface and an opposing second surface, and defining a width in a cross direction; applying adhesive to the first surface of the first continuous substrate, wherein the adhesive fluoresces when excited by ultraviolet light; advancing the first continuous substrate and adhesive past a sensor; irradiating the first surface of the first continuous substrate and adhesive with ultraviolet light; filtering reflected ultraviolet light from the first surface of the first continuous substrate to prevent detection of the reflected ultraviolet light with the sensor; detecting with the sensor emitted light caused by fluorescence of the adhesive while being irradiated with the ultraviolet light; depositing absorbent particulate polymer material on the first surface of the first continuous substrate so as to define first regions of absorbent particulate polymer material surrounding second regions that are substantially free of absorbent particulate polymer material; advancing a second continuous substrate in the machine direction, the second continuous substrate having a first surface and an opposing second surface, and defining a width in the cross direction; combining the first continuous substrate with the second continuous substrate to create a continuous length of substantially cellulose free absorbent cores, wherein the second regions on the first continuous substrate are placed in facing relationships with the first surface of the second continuous substrate to define channel regions that are substantially free of absorbent particulate polymer material, and wherein the adhesive bonds the first surfaces of the first and second continuous substrates directly together in the channel regions; determining a characteristic of a channel region based on the detected emitted light, the at least one characteristic selected from the group consisting of: a presence of the adhesive in the channel region and bond strength.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a plan view of a diaper.

Figure 2 is a cross sectional view of the diaper shown in Figure 1 taken along the sectional line 2-2 of FIG. 1.

Figure 3 is a partial cross sectional view of an absorbent core layer.

Figure 4 is a partial cross sectional view of an absorbent core layer.

Figure 5 is a plan view of the absorbent core layer illustrated in Figure 3.

Figure 6 is a plan view of a second absorbent core layer.

Figure 7A is a partial sectional view of an absorbent core comprising a combination of the first and second absorbent core layers illustrated in Figures 5 and 6.

Figure 7B is a partial sectional view of an absorbent core comprising a combination of the first and second absorbent core layers illustrated in Figures 5 and 6.

Figure 8 is a plan view of the absorbent core illustrated in Figures 7A and 7B.

Figure 9 is a plan view of an absorbent core with channels.

Figure 10 is a cross sectional view of the absorbent core shown in Figure 9 taken along the sectional line 10-10.

Figure 11 is a schematic illustration of a process for making an absorbent core.

Figure 12 is a partial sectional view of an apparatus for making an absorbent core.

Figure 13 is a perspective view of a printing roll and supporting roll.

Figure 14 is a schematic side view of an apparatus for assembling components of an absorbent article.

Figure 14A is a schematic side view of an apparatus for assembling components of an absorbent article.

Figure 14B is a schematic side view of an apparatus for assembling components of an absorbent article.

Figure 15 is a detailed plan view of a channel region of an absorbent core.

Figure 16 is a cross sectional view of the channel region shown in Figure 15 taken along the sectional line 16-16.

DETAILED DESCRIPTION OF THE INVENTION

The following term explanations may be useful in understanding the present disclosure:

"Absorbent article" refers to devices that absorb and contain body exudates, and, more specifically, refers to devices that are placed against or in proximity to the body of the wearer to absorb and contain the various exudates discharged from the body. Absorbent articles may include diapers, training pants, adult incontinence undergarments, feminine hygiene products, breast pads, care mats, bibs, wound dressing products, and the like. As used herein, the term "body fluids" or "body exudates" includes, but is not limited to, urine, blood, vaginal discharges, breast milk, sweat and fecal matter.

“Absorbent core” means a structure that may be disposed between a topsheet and backsheet of an absorbent article for absorbing and containing liquid received by the absorbent article and may comprise one or more substrates, absorbent polymer material disposed on the one or more substrates, and a thermoplastic composition on the absorbent particulate polymer material and at least a portion of the one or more substrates for immobilizing the absorbent particulate polymer material on the one or more substrates. In a multilayer absorbent core, the absorbent core may also include a cover layer. The one or more substrates and the cover layer may comprise a nonwoven. Further, the absorbent core may be substantially cellulose free. The absorbent core does not include an acquisition system, a topsheet, or a backsheet of the absorbent article. In some embodiments, the absorbent core may consist essentially of the one or more substrates, the absorbent polymer material, the thermoplastic composition, and optionally the cover layer.

“Absorbent polymer material,” “absorbent gelling material,” “AGM,” “superabsorbent,” and “superabsorbent material” are used herein interchangeably and refer to cross linked polymeric materials that can absorb at least 5 times their weight of an aqueous 0.9% saline solution as measured using the Centrifuge Retention Capacity test (Edana 441.2-01).

“Absorbent particulate polymer material” is used herein to refer to an absorbent polymer material which is in particulate form so as to be flowable in the dry state.

“Absorbent particulate polymer material area” as used herein refers to the area of the core wherein a first substrate and a second substrate are separated by a multiplicity of superabsorbent particles.

“Airfelt” is used herein to refer to comminuted wood pulp, which is a form of cellulosic fiber.

The term “body facing surface” and “body facing side” refer to surfaces of absorbent articles and/or components thereof which face a wearer’s body when the absorbent articles are worn, and the term “garment facing surface” and “garment facing side” refer to surfaces of absorbent articles and/or components thereof that face away from a wearer’s body when the absorbent articles are worn. Absorbent articles and components thereof, including the topsheet, backsheet, absorbent core, and any individual materials of their components, have a body facing surface and/or side and a garment facing surface and/or side.

“Diaper” refers to an absorbent article generally worn by infants and incontinent persons about the lower torso so as to encircle the waist and legs of the wearer and that is specifically adapted to receive and contain urinary and fecal waste. As used herein, term “diaper” also includes a “pant” which is defined below.

“Fiber” and “filament” are used interchangeably.

As used herein, the term “joined” encompasses configurations whereby an element is directly secured to another element by affixing the element directly to the other element, and configurations whereby an element is indirectly secured to another element by affixing the element to intermediate member(s) which in turn are affixed to the other element.

“Longitudinal” means a direction running substantially perpendicular from a waist edge to a longitudinally opposing waist edge of an absorbent article when the article is in a flat out, uncontracted state, or from a waist edge to the bottom of the crotch, i.e. the fold line, in a bi-folded article. Directions within 45 degrees of the longitudinal direction are considered to be “longitudinal.” “Lateral” refers to a direction running from a longitudinally extending side edge to a laterally opposing longitudinally extending side edge of an article and generally at a right angle to the longitudinal direction. Directions within 45 degrees of the lateral direction are considered to be “lateral.”

The term “machine direction” (MD) is used herein to refer to the direction of material flow through a process. In addition, relative placement and movement of material can be described as flowing in the machine direction through a process from upstream in the process to downstream in the process. The term “cross direction” (CD) is used herein to refer to a direction that is generally perpendicular to the machine direction.

A “nonwoven” is a manufactured sheet, web or batt of directionally or randomly orientated fibers, bonded by friction, and/or cohesion and/or adhesion, excluding paper and products which are woven, knitted, tufted, stitch-bonded incorporating binding yarns or filaments, or felted by wet-milling, whether or not additionally needled. The fibers may be of natural or man-made origin and may be staple or continuous filaments or be formed in situ. Commercially available fibers have diameters ranging from less than about 0.001 mm to more than about 0.2 mm and they come in several different forms: short fibers (known as staple, or chopped), continuous single fibers (filaments or monofilaments), untwisted bundles of continuous filaments (tow), and twisted bundles of continuous filaments (yarn). Nonwoven fabrics can be formed by many processes such as meltblowing, spunbonding, solvent spinning, electrospinning, and carding. The basis weight of nonwoven fabrics is usually expressed in grams per square meter (gsm).

"Pant" or "training pant", as used herein, refer to disposable garments having a waist opening and leg openings designed for infant or adult wearers. A pant may be placed in position on the wearer by inserting the wearer's legs into the leg openings and sliding the pant into position about a wearer's lower torso. A pant may be preformed by any suitable technique including, but not limited to, joining together portions of the article using refastenable and/or non-refastenable bonds (e.g., seam, weld, adhesive, cohesive bond, fastener, etc.). A pant may be preformed anywhere along the circumference of the article (e.g., side fastened, front waist fastened). While the terms "pant" or "pants" are used herein, pants are also commonly referred to as "closed diapers," "prefastened diapers," "pull-on diapers," "training pants," and "diaper-pants". Example pants are disclosed in U.S. Patent Nos. 4,940,464; 5,092,861; 5,246,433; 5,569,234; 5,897,545; 5,957,908; 6,120,487; and 6,120,489 and U.S. Patent Publication No. 2003/0233082 A1.

"Substantially cellulose free" is used herein to describe an article, such as an absorbent core, that contains less than 10% by weight cellulosic fibers, less than 5% cellulosic fibers, less than 1% cellulosic fibers, no cellulosic fibers, or no more than an immaterial amount of cellulosic fibers. An immaterial amount of cellulosic material would not materially affect the thinness, flexibility, or absorbency of an absorbent core.

"Substantially continuously distributed" as used herein indicates that within the absorbent particulate polymer material area wherein a first substrate and second substrate are separated by a multiplicity of superabsorbent particles. It is recognized that there may be minor incidental contact areas between the first substrate and second substrate within the absorbent particulate polymer material area.

"Thermoplastic adhesive material" as used herein is understood to comprise a polymer composition from which fibers are formed and applied to the superabsorbent material with the intent to immobilize the superabsorbent material in both the dry and wet state. The thermoplastic adhesive material of the present disclosure forms a fibrous network over the superabsorbent material.

"Thickness" and "caliper" are used herein interchangeably.

The present disclosure relates to methods and apparatuses for making absorbent articles with absorbent structures, and in particular, sensing emitted light caused by fluorescence of the adhesive to determine characteristics of channel regions of absorbent structures during the manufacture of absorbent articles. As discussed in more detail below, absorbent articles, such as diapers may have absorbent structures that include a liquid acquisition layer and a substantially cellulose free absorbent core disposed between a topsheet and a backsheet. One or more of the absorbent article components may be assembled with adhesive that fluoresces when excited by ultraviolet light. Aspects of the methods according to the present disclosure relate to the fabrication of absorbent articles wherein an inspection system may be configured to interact with, monitor, and/or control the converting line. The inspection system may include sensors arranged adjacent an advancing absorbent structure on a converting line and may communicate with the controller. Based on such communications, the controller may monitor and affect various operations on the converting line. The inspection systems herein may also include a radiation source that illuminates a surface of an absorbent structure with ultraviolet light. The sensor may include a lens adapted to receive light caused by fluorescence of the adhesive while being irradiated with the ultraviolet light. In addition, the sensor may include a filter to prevent detection of the reflected or transmitted ultraviolet light with the sensor. In turn, the inspection system may determine one or more characteristics of a channel region in the absorbent structure based on the detected emitted light. Such characteristics may include presence of the adhesive in the channel region, presence absorbent particulate polymer material in the channel region, shape of the channel region, bond strength, and position of the channel region.

The following provides a general description of various types of absorbent articles that may be produced with the methods and apparatuses disclosed herein to help provide additional context to the subsequent discussion of the process embodiments.

Figure 1 is a plan view of a diaper 10 is shown in a flat out, uncontracted state (i.e., without elastic induced contraction) and with portions of the diaper 10 are cut away to more clearly show the underlying structure of the diaper 10. A portion of the diaper 10 that contacts a wearer is facing the viewer in Figure 1.

As shown in Figure 1, the diaper 10 may include a chassis 12 having an outer covering 16 including a topsheet 18, which may be liquid pervious, and/or a backsheet 20, which may be liquid impervious. An absorbent core 14 may be encased between the topsheet 18 and the backsheet 20. The chassis 12 may also include side panels 22, elasticized leg cuffs 24, and an elastic waist feature 26. The leg cuffs 24 and the elastic waist feature 26 may each include elastic members 28. One end portion of the diaper 10 may be configured as a first waist region 30 of the diaper 10, and an opposite end portion of the diaper 10 may be configured as a second waist region 32 of the diaper 10. An intermediate portion of the diaper 10 may be configured as a crotch region 34, which extends longitudinally between the first and second waist regions 30 and 32. The waist regions 30 and 32 may include elastic elements such that they gather about the waist of the wearer to provide improved fit and containment (elastic waist feature 26). The crotch region 34 is that portion of the diaper 10 which, when the diaper 10 is worn, is generally positioned between the wearer's legs.

The diaper 10 is depicted in Figure 1 with a longitudinal axis 36 and a lateral axis 38. The periphery 40 of the diaper 10 is defined by the outer edges of the diaper 10 in which the longitudinal edges 42 run generally parallel to the longitudinal axis 36 of the diaper 10 and the end edges 44 run between the longitudinal edges 42 generally parallel to the lateral axis 38 of the diaper 10. The chassis 12 may also comprise a fastening system, which may include at least one fastening member 46 and at least one stored landing zone 48. The diaper 20 may also include such other features such as front and rear ear panels, waist cap features, elastics and the like to provide better fit, as well as containment and aesthetic characteristics. Such additional features are described, for example, in U.S. Patent Nos. 3,860,003 and 5,151,092.

A portion of the first waist region 30 may be attached by the fastening member 46 to at least a portion of the second waist region 32 to form leg opening(s) and an article waist opening. In some embodiments, the diaper 10 may be provided with a re-closable fastening system. In some embodiments, the diaper 10 may include a re-closable fastening system joined to the chassis for securing the diaper to a wearer. In some embodiments, the diaper 10 may include at least two side panels joined to the chassis and to each other to form a pant.

It is to be appreciated that the topsheet 18, the backsheet 20, and the absorbent core 14 may be assembled in a variety of configurations, such as for example as described generally in U.S. Patent Nos. 5,554,145; 5,569,234; and 6,004,306. The topsheet 18 in Figure 1 may be fully or partially elasticized or may be foreshortened to provide a void space between the topsheet 18 and the absorbent core 14. Exemplary structures including elasticized or foreshortened topsheets are described in more detail in U.S. Patent Nos. 5,037,416 and 5,269,775. The backsheet 20 may be joined with the topsheet 18. The backsheet 20 may prevent the exudates absorbed by the absorbent core 14 and contained within the diaper 10 from soiling other external articles that may contact the diaper 10, such as bed sheets and undergarments. In certain embodiments, the backsheet 20 may be substantially impervious to liquids (e.g., urine) and comprise a laminate of a nonwoven and a thin plastic film such as a thermoplastic film having a thickness of about 0.012 mm (0.5 mil) to about 0.051 mm (2.0 mils). Suitable backsheet films include those manufactured by Tredegar Industries Inc. of Terre Haute, Ind. and sold under the trade names X15306, X10962, and X10964. Other suitable backsheet materials may include breathable materials that permit vapors to escape from the diaper 10 while still preventing liquid exudates from passing through the backsheet 10. Exemplary breathable materials may include materials such as woven webs, nonwoven webs, composite materials such as film-coated nonwoven webs, and microporous films such as manufactured by Mitsui Toatsu Co., of Japan under the designation ESPOIR NO and by EXXON Chemical Co., of Bay City, Tex., under the designation EXXAIRE. Suitable breathable composite materials comprising polymer blends are available from Clopay Corporation, Cincinnati, Ohio under the name HYTREL blend P18-3097. Such breathable composite materials are described in greater detail in PCT Application No. WO 95/16746. Other breathable backsheets including nonwoven webs and apertured formed films are described in U.S. Patent No. 5,571,096.

Figure 2 is a cross sectional view of the diaper in Figure 1 taken along the line 2-2. As shown in Figure 2, the topsheet 18 may define an inner, body facing surface, and the backsheet may define an outer, garment facing surface of the diaper 10. And the absorbent core 14 may be positioned between the topsheet and the backsheet. The diaper 10 may also include an acquisition system 50 disposed between the liquid permeable topsheet 18 and a wearer facing side of the absorbent core 14. The acquisition system 50 may be in direct contact with the absorbent core. The acquisition system 50 (also referred to herein as a liquid acquisition layer 50) may comprise a single layer or multiple layers, such as an upper acquisition layer 52 (also referred to herein as a first acquisition layer 52) facing towards the wearer's skin and a lower acquisition layer 54 (also referred to herein as a second acquisition layer 54) facing the garment of the wearer. In some embodiments, the acquisition system 50 may function to receive a surge of liquid, such as a gush of urine. In other words, the acquisition system 50 may serve as a temporary reservoir for liquid until the absorbent core 14 can absorb the liquid. Exemplary acquisition systems and associated manufacturing processes are described in U.S. Patent Nos. 8,603,277 and 8,568,566; U.S. Patent Publication No. US2012/0316046 A1; and U.S. Patent Application Serial No. 14/100,083, filed on December 9, 2013, all of which are hereby incorporated by reference herein.

In some embodiments, the acquisition system 50 may include chemically cross-linked cellulosic fibers. Such cross-linked cellulosic fibers may have various absorbency properties. Exemplary chemically cross-linked cellulosic fibers are disclosed in U.S. Patent No. 5,137,537. Citric acid is an exemplary cross-linking agent. In some embodiments, polyacrylic acids may be used. In some embodiments, the cross-linked cellulosic fibers may be crimped, twisted, or curled, or a combination thereof including crimped, twisted, and curled.

In some embodiments, one or both of the upper acquisition layer 52 and lower acquisition layer 54 may include a nonwoven, which may be hydrophilic. Further, according to some embodiments, one or both of the upper acquisition layer 52 and lower acquisition layer 54 may comprise chemically cross-linked cellulosic fibers, which may or may not form part of a nonwoven material. In some embodiments, the upper acquisition layer 52 may comprise a nonwoven, without the cross-linked cellulosic fibers, and the lower acquisition layer 54 may comprise the chemically cross-linked cellulosic fibers. Further, in some embodiments, the lower acquisition layer 54 may comprise the chemically cross-linked cellulosic fibers mixed with other fibers such as natural or synthetic polymeric fibers. According to some embodiments, such other natural or synthetic polymeric fibers may include high surface area fibers, thermoplastic binding fibers, polyethylene fibers, polypropylene fibers, PET fibers, rayon fibers, lyocell fibers, and mixtures thereof.

Suitable nonwoven materials for the upper acquisition layer 52 and lower acquisition layer 54 include, but are not limited to SMS material, comprising a spunbonded, a melt-blown and a further spunbonded layer. In certain embodiments, permanently hydrophilic nonwovens, and in particular, nonwovens with durably hydrophilic coatings are desirable. Another suitable embodiment comprises a SMMS-structure. In certain embodiments, the nonwovens are porous.

In certain embodiments, suitable nonwoven materials may include, but are not limited to synthetic fibers, such as PE, PET, and PP. As polymers used for nonwoven production may be inherently hydrophobic, they may be coated with hydrophilic coatings. One way to produce nonwovens with durably hydrophilic coatings, is via applying a hydrophilic monomer and a radical polymerization initiator onto the nonwoven, and conducting a polymerization activated via UV light resulting in monomer chemically bound to the surface of the nonwoven as described in U.S. Patent Publication No. 2005/0159720. Another way to produce nonwovens with durably hydrophilic coatings is to coat the nonwoven with hydrophilic nanoparticles as described in U.S. Patent No. 7,112,621; U.S. Patent Publication No. US2004/0158212A1; and PCT Publication No. WO 02/064877. Other nonwovens are described in U.S. Patent Nos. 6,645,569; 6,863,933; and 7,112,621 as well as U.S. Patent Publication Nos. US2003/0148684A1 and US2005/0008839A1.

In some embodiments, the upper acquisition layer 52 may include a material that provides recovery when external pressure is applied and removed. Further, according to some embodiments, the upper acquisition layer 52 may comprise a blend of different fibers selected, for example from the types of polymeric fibers described above. In some embodiments, at least a portion of the fibers may exhibit a spiral-crimp which has a helical shape. In some embodiments, the upper acquisition layer 52 may comprise fibers having different degrees or types of crimping, or both. Different types of crimps include, but are not limited to a 2D crimp or "flat crimp" and a 3D or spiral-crimp. According to some embodiments, the fibers may include bi-component fibers, which are individual fibers each comprising different materials, such as a first and a second polymeric material.

The upper acquisition layer 52 may be stabilized by a latex binder, for example a styrene-butadiene latex binder (SB latex), in a certain embodiment. Processes for obtaining such lattices are described, for example, in EP Patent Publication No. EP0149880A2 and U.S. Patent Publication No. US2003/0105190. In some embodiments, SB latex is available under the trade name GENFLO™ 3160 (OMNOVA Solutions Inc.; Akron, Ohio).

The absorbent core 14, such as shown in Figures 1-8 may be disposed between the topsheet 18 and the backsheet 20 and may include two layers, a first absorbent layer 60 and a second absorbent layer 62. As shown in Figure 3, the first absorbent layer 60 of the absorbent core 14 may include a substrate 64, an absorbent particular polymer material 66 on the substrate 64, and a thermoplastic composition 68 on the absorbent particulate polymer material 66 and at least portions of the first substrate 64 as an adhesive for covering and immobilizing the absorbent particulate polymer material 66 on the first substrate 64. In some embodiments, such as illustrated in Figure 4, the first absorbent layer 60 of the absorbent core 14 may also include a cover layer 70 on the thermoplastic composition 68. The cover layer 70 shown in Figure 4 may include the same material as the substrates 64 and 72, or may include a different material. In certain embodiments, the materials of the cover layer 70 are the nonwoven materials, such as the materials described above as useful for the substrates 64 and 72. Exemplary absorbent cores and associated manufacturing processes are described in U.S. Patent Nos. 8,603,277 and 8,568,566; U.S. Patent Publication No. US2012/0316046 A1; and U.S. Patent Application Serial No. 14/100,083, filed on December 9, 2013, all of which are hereby incorporated by reference herein.

As shown in Figure 2, the second absorbent layer 62 of the absorbent core 14 may also include a substrate 72, an absorbent particulate polymer material 74 on the second substrate 72, and a thermoplastic composition 76 on the absorbent particulate polymer material 74 and at least a portion of the second substrate 72 for immobilizing the absorbent particulate polymer material 74 on the second substrate 72. Although not illustrated, the second absorbent layer 62 may also include a cover layer such as the cover layer 70 illustrated in Figure 4.

The substrate 64 of the first absorbent layer 60 may be referred to as a dusting layer and has a first surface 78 which faces the backsheet 20 of the diaper 10 and a second surface 80 which faces the absorbent particulate polymer material 66. The substrate 72 of the second absorbent layer 62 may be referred to as a core cover and has a first surface 82 facing the topsheet 18 of the diaper 10 and a second surface 84 facing the absorbent particulate polymer material 74. The first and second substrates 64 and 72 may be adhered to one another with adhesive about the periphery to form an envelope about the absorbent particulate polymer materials 66 and 74 to hold the absorbent particulate polymer material 66 and 74 within the absorbent core 14. In some embodiments, the substrates 64 and 72 of the first and second absorbent layers 60 and 62 may be a nonwoven material, such as those nonwoven materials described above.

As shown in Figures 1-8, the absorbent particulate polymer material 66 and 74 may be deposited on the respective substrates 64 and 72 of the first and second absorbent layers 60 and 62 in clusters 90 of particles to form a grid pattern 92 comprising land areas 94 and junction areas 96 between the land areas 94. As defined herein, land areas 94 are areas where the thermoplastic adhesive material does not contact the nonwoven substrate or the auxiliary adhesive directly; junction areas 96 are areas where the thermoplastic adhesive material does contact the nonwoven substrate or the auxiliary adhesive directly. The junction areas 96 in the grid pattern 92 contain little or no absorbent particulate polymer material 66 and 74. The land areas 94 and junction areas 96 can have a variety of shapes including, but not limited to, circular, oval, square, rectangular, triangular, and the like.

The grid pattern shown in Figure 8 is a square grid with regular spacing and size of the land areas. Other grid patterns including hexagonal, rhombic, orthorhombic, parallelogram, triangular, rectangular, and combinations thereof may also be used. The spacing between the grid lines may be regular or irregular.

As shown in Figure 8, the absorbent core 14 has a longitudinal axis 100 extending from a rear end 102 to a front end 104 and a lateral axis 106 perpendicular to the longitudinal axis 100 extending from a first edge 108 to a second edge 110. The grid pattern 92 of absorbent particulate polymer material clusters 90 is arranged on the substrates 64 and 72 of the respective absorbent layers 60 and 62 such that the grid pattern 92 formed by the arrangement of land areas 94 and junction areas 96 forms a pattern angle 112. The pattern angle 112 may be 0, greater than 0, or 15 to 30 degrees, or from about 5 to about 85 degrees, or from about 10 to about 60 degrees, or from about 15 to about 30 degrees.

As shown in Figures 7*a*, 7*b*, and 8, the first and second layers 60 and 62 may be combined to form the absorbent core 14. The absorbent core 14 has an absorbent particulate polymer material area 114 bounded by a pattern length 116 and a pattern width 118. The extent and shape of the absorbent particulate polymer material area 114 may vary depending on the desired application of the absorbent core 14 and the particular absorbent article in which it may be incorporated. In some embodiments, the absorbent particulate polymer material area 114 extends substantially entirely across the absorbent core 14, such as is illustrated in Figure 8.

The first and second absorbent layers 60 and 62 may be combined together to form the absorbent core 14 such that the grid patterns 92 of the respective first and second absorbent layers 62 and 64 are offset from one another along the length and/or width of the absorbent core 14. The respective grid patterns 92 may be offset such that the absorbent particulate polymer material 66 and 74 is substantially continuously distributed across the absorbent particulate polymer area 114. In some embodiments, absorbent particulate polymer material 66 and 74 may be substantially continuously distributed across the absorbent particulate polymer material area 114 despite the individual grid patterns 92 comprising absorbent particulate polymer material 66 and 74 discontinuously distributed across the first and second substrates 64 and 72 in clusters 90. In some embodiments, the grid patterns may be offset such that the land areas 94 of the first absorbent layer 60 face the junction areas 96 of the second absorbent layer 62 and the land areas of the second absorbent layer 62 face the junction areas 96 of the first absorbent layer 60. When the land areas 94 and junction areas 96 are appropriately sized and arranged, the resulting combination of absorbent particulate polymer material 66 and 74 is a substantially continuous layer of absorbent particular polymer material across the absorbent particulate polymer material area 114 of the absorbent core 14. In some embodiments, respective grid patterns 92 of the first and second absorbent layer 60 and 62 may be substantially the same.

In some embodiments, such as shown in Figure 8, the amount of absorbent particulate polymer material 66 and 74 may vary along the length 116 of the grid pattern 92. The grid pattern may be divided into absorbent zones 120, 122, 124, and 126, in which the amount of absorbent particulate polymer material 66 and 74 varies from zone to zone. As used herein, “absorbent zone” refers to a region of the absorbent particulate polymer material area having boundaries that are perpendicular to the longitudinal axis shown in Figure 8. The amount of absorbent particulate polymer material 66 and 74 may, in a certain embodiment, gradually transition from one of the plurality of absorbent zones 120, 122, 124, and 126 to another.

The amount of absorbent particulate polymer material 66 and 74 present in the absorbent core 14 may vary, but in certain embodiments, is present in the absorbent core in an amount greater than about 80% by weight of the absorbent core, or greater than about 85% by weight of the absorbent core, or greater than about 90% by weight of the absorbent core, or greater than about 95% by weight of the core. In some embodiments, the absorbent core 14 consists essentially of the first and second substrates 64 and 72, the absorbent particulate polymer material 66 and 74, and the thermoplastic adhesive composition 68 and 76. In some embodiments, the absorbent core 14 may be substantially cellulose free.

The absorbent particulate polymer material area may have a relatively narrow width in the crotch area of the absorbent article for increased wearing comfort.

It some absorbent articles, such as diapers, liquid discharge from the wearer may occur predominately in the front half of the diaper. The front half of the absorbent core 14 may therefore comprise most of the absorbent capacity of the core. Thus, according to certain embodiments, the front half of said absorbent core 14 may comprise more than about 60% of the superabsorbent material, or more than about 65%, 70%, 75%, 80%, 85%, or 90% of the superabsorbent material.

In certain embodiments, the absorbent core 14 may further comprise any absorbent material that is generally compressible, conformable, non-irritating to the wearer's skin, and capable of absorbing and retaining liquids such as urine and other certain body exudates. In such embodiments, the absorbent core 14 may comprise a wide variety of liquid-absorbent materials commonly used in disposable diapers and other absorbent articles such as comminuted wood pulp, which is generally referred to as airfelt, creped cellulose wadding, melt blown polymers, including co-form, chemically stiffened, modified or cross-linked cellulosic fibers, tissue, including tissue wraps and tissue laminates, absorbent foams, absorbent sponges, or any other known absorbent material or combinations of materials. The absorbent core 14 may further comprise minor amounts (typically less than about 10%) of materials, such as adhesives, waxes, oils and the like. Exemplary absorbent structures for use as the absorbent assemblies are described in U.S. Patent Nos. 4,610,678; 4,834,735; 4,888,231; 5,260,345; 5,387,207; 5,397,316; and 5,625,222.

The thermoplastic adhesive material 68 and 76 may cover and at least partially immobilize the absorbent particulate polymer material 66 and 74. In some embodiments, the thermoplastic adhesive material 68 and 76 can be disposed essentially uniformly within the absorbent particulate polymer material 66 and 74, between the polymers. In some embodiments, the thermoplastic adhesive material 68 and 76 may be provided as a fibrous layer which is at least partially in contact with the absorbent particulate polymer material 66 and 74 and partially in contact with the substrate layers 64 and 72 of the first and second absorbent layers 60 and 62. Figures 3, 4, and 7 show such a structure wherein the absorbent particulate polymer material 66 and 74 is provided as a discontinuous layer, and a layer of fibrous thermoplastic adhesive material 68 and 76 is laid down onto the layer of absorbent particulate polymer material 66 and 74, such that the thermoplastic adhesive material 68 and 76 is in direct contact with the absorbent particulate polymer material 66 and 74, but also in direct contact with the second surfaces 80 and 84 of the substrates 64 and 72, where the substrates are not covered by the absorbent particulate polymer material 66 and 74. This imparts an essentially three-dimensional structure to the fibrous layer of thermoplastic adhesive material 68 and 76, which in itself is essentially a two-dimensional structure of relatively small thickness, as compared to the dimension in length and width directions. In other words, the thermoplastic adhesive material 68 and 76 undulates between the absorbent particulate polymer material 68 and 76 and the second surfaces of the substrates 64 and 72.

Thereby, the thermoplastic adhesive material 68 and 76 may provide cavities to cover the absorbent particulate polymer material 66 and 74, and thereby immobilizes this material. In a further aspect, the thermoplastic adhesive material 68 and 76 bonds to the substrates 64 and 72 and thus affixes the absorbent particulate polymer material 66 and 74 to the substrates 64 and 72. Thus, in accordance with certain embodiments, the thermoplastic adhesive material 68 and 76 immobilizes the absorbent particulate polymer material 66 and 74 when wet. Some thermoplastic adhesive materials will also penetrate into both the absorbent particulate polymer material 66 and 74 and the substrates 64 and 72, thus providing for further immobilization and affixation. Of course, while the thermoplastic adhesive materials disclosed herein provide a much improved wet immobilization (i.e., immobilization of absorbent material when the article is wet or at least partially loaded), these thermoplastic adhesive materials may also provide a very good immobilization of absorbent material when the absorbent core 14 is dry. The thermoplastic adhesive material 68 and 76 may also be referred to as a hot melt adhesive.

The absorbent core 14 may also include an auxiliary adhesive 137 which is discussed in more detail below with reference to Figure 11. The auxiliary adhesive 137 may be deposited on the first substrate 64 and/or second substrate 72 of the respective first and second absorbent layers 60 and 62 before application of the absorbent particulate polymer material 66 and 74 for enhancing adhesion of the absorbent particulate polymer materials 66 and 74 and the thermoplastic adhesive material 68 and 76 to the respective substrates 64 and 72. The auxiliary adhesive 137 may also aid in immobilizing the absorbent particulate polymer material 66 and 74 and may comprise the same thermoplastic adhesive material as described hereinabove or may also comprise other adhesives including but not limited to sprayable hot melt adhesives, such as H.B. Fuller Co. (St. Paul, Minn.) Product No. HL-1620-B.

As shown in Figures 9 and 10, the absorbent core 14 may also be configured with one or more channel regions 115. In some embodiments, the channel regions 115 may be regions of the absorbent core 14 that are substantially free of absorbent particulate polymer material 66, 74 surround by absorbent particulate polymer material areas 114. In some embodiments, the substrates 64, 72 may be bonded with directly each other in the channel regions 115. In some embodiments, the channel regions 115 may have a first thickness T1 surrounded by absorbent particulate polymer material areas 114 having a second thickness T2, wherein first thickness T1 is less than the second thickness T2. It is to be appreciated that the absorbent core 14 may include various quantities of channel regions 115 having various shapes, widths, and/or lengths. It is to be appreciated that the acquisition system 50 may also include channels that may or not correspond with the channels 115 in the absorbent core 14. For example, the first acquisition layer 52 and/or the second acquisition layer 54 may include channels that may or not correspond each other and/or with the channels 115 in the absorbent core 14.

It is to be appreciated that the absorbent core may be constructed in various ways. For example, a converting apparatus 300 may including a printing system 130 for making an absorbent core 14 is shown in Figure 11 and may include a first printing unit 132 for forming the first absorbent layer 60 of the absorbent core 14 and a second printing unit 134 for forming the second absorbent layer 62 of the absorbent core 14. The first printing unit 132 may include a first auxiliary adhesive applicator 136 for applying an auxiliary adhesive 137 to the first substrate 64; a first rotatable support roll 140 for receiving the substrate 64; a hopper 142 for holding absorbent particulate polymer material 66; a printing roll 144 for transferring the absorbent particulate polymer material 66 to the substrate 64; and a thermoplastic adhesive material applicator 146 for applying the thermoplastic adhesive material 68 to the substrate 64 and the absorbent particulate polymer 66 material thereon. The second printing unit 134 may include a second auxiliary adhesive applicator 148 for applying an auxiliary adhesive to the second substrate 72, a second rotatable support roll 152 for receiving the second substrate 72, a second hopper 154 for holding the absorbent particulate polymer material 74, a second printing roll 156 for transferring the absorbent particulate polymer material 74 from the hopper 154 to the second substrate 72, and a second thermoplastic adhesive material applicator 158 for applying the thermoplastic adhesive material 76 to the second substrate 72 and the absorbent particulate polymer material 74 thereon.

The first and second auxiliary applicators 136 and 148 and/or the first and second thermoplastic adhesive material applicators 146 and 158 may apply adhesive in various ways. For example, the first and second auxiliary applicators 136 and 148 and/or the first and second thermoplastic adhesive material applicators 146 and 158 may include nozzle systems that can provide a relatively thin but wide curtain of thermoplastic adhesive material. In some embodiments, the first and second auxiliary applicators 136 and 148 may be slot coat applicators that apply the auxiliary glue 137 to the first and/or second substrates 64, 72 in strips extending along the machine direction MD. In some embodiments, the auxiliary glue strips may be about 0.5 to about 1 mm wide that are spaced about 0.5 to about 2 mm apart from each other along the cross direction CD. The printing system 130 may also include a guide roller 160 for guiding the formed absorbent core from a nip 162 between the first and second rotatable support rolls 140 and 152.

Figures 12 and 13 show portions of the first hopper 142, first support roll 140, and first printing roll 144. The first rotatable support roll 140, which may have the same structure as the second rotatable support roll 152, includes a rotatable drum 164 and a peripheral vented support grid 166 for receiving the first substrate 64. As also shown in Figures 12 and 13, the first printing roll 144, which may have the same structure as the second printing roll 156, comprises a rotatable drum 168 and a plurality of absorbent particulate polymer material reservoirs 170 in a peripheral surface 172 of the drum 168. The reservoirs 170, such as shown in Figures 12 and 13, may have a variety of shapes, including cylindrical, conical, or any other shape. The reservoirs 170 may lead to an air passage 174 in the drum 168 and include a vented cover for holding absorbent particulate polymer material 66 in the reservoir and preventing the absorbent particulate polymer material 66 from falling or being pulled into the air passage 174.

As shown in Figure 13 the first printing roll 144, which may have the same structure as the second printing roll 156, may include one or more strips 171 that have no void volume, and as such, do not pick up and/or hold absorbent particulate polymer material 66. In addition, the first rotatable support roll 140, which may have the same structure as the second rotatable support roll 152, may include one or more mating strips 153. The strips 171 may be configured to substantially coincide with the mating strips 153. As such, the absorbent particulate polymer material 66, 74 may be deposited selectively on the substrates 64, 72 except for areas that coincide with the mating strips 153 to form absorbent layers on the substrates 64, 72 having regions 115a that are substantially free of absorbent material.

Referring to Figures 11-13, in operation, a first continuous substrate 64 advances in a machine direction MD, and a second continuous substrate 72 advances in a machine direction MD. The first continuous substrate 64 includes a first surface 64a and an opposing second surface 64b, and defines a width in a cross direction CD. And the second continuous substrate 72 includes a first surface 72a and an opposing second surface 72b, and defines a width in a cross direction CD. The printing system 130 receives the first and second substrates 64 and 72 into the first and second printing units 132 and 134, respectively. The first substrate 64 advances on the rotating first support roll 140 past the first auxiliary adhesive applicator 136 that applies auxiliary adhesive 137 to the first surface 64a of the first substrate 64 in a pattern such as described hereinabove. A vacuum within the first support roll 140 may draw the first substrate 64 against the vertical support grid 166 and hold the first substrate 64 against the first support roll 140. The first support roll 140 then advances the first substrate 64 past the rotating first printing roll 144 that transfers the absorbent particulate polymer material 66 from the first hopper 142 to the first surface 64a of the first substrate 64. The first printing roll 144 may hold the absorbent particulate polymer material 66 in the reservoirs 170 and then deliver the absorbent particulate polymer material 66 to the first substrate 64. The support roll 140 then advances the printed first substrate 64 past the thermoplastic adhesive material applicator 146 which applies the thermoplastic adhesive material 68 to cover the absorbent particulate polymer material 66 on the first surface 64a of the first substrate 64. With continued reference to Figures 11-13, the second rotatable support roll 152 advances the second substrate 72 past the second auxiliary adhesive applicator 148 that applies auxiliary adhesive 137 to the first surface 72a of the second substrate 72 in a pattern such as is described hereinabove. The second rotatable support roll 152 then advances the second substrate 72 past the second printing roll 156 which transfers the absorbent particulate polymer material 74 from the second hopper 154 to the first surface 72a of the second substrate 72. The second thermoplastic adhesive material applicator 158 then applies the thermoplastic adhesive material 76 to cover the absorbent particulate polymer material 74 on the second substrate 72. The printed first and second substrates 64 and 72 then pass through the nip 162 between the first and second support rolls 140 and 152 for compressing the first absorbent layer 60 and second absorbent layer 62 together to form a continuous length of absorbent cores 14.

It is to be appreciated that various embodiments of diapers can be manufactured according various methods disclosed herein, such as for example disclosed in U.S. Patent Nos.

8,603,277 and 8,568,566; U.S. Patent Publication Nos. US2008/031621A1 and US2012/0316046 A1; and U.S. Patent Application Serial No. 14/100,083, filed on December 9, 2013, all of which are hereby incorporated by reference herein. In some configurations, a cover layer 70 may be placed upon the substrates 64 and 72, the absorbent particulate polymer material 66 and 74, and the thermoplastic adhesive material 68 and 76. In another embodiment, the cover layer 70 and the respective substrate 64 and 72 may be provided from a unitary sheet of material. The placing of the cover layer 70 onto the respective substrate 64 and 72 may then involve the folding of the unitary piece of material.

As previously mentioned, the apparatuses and methods according to the present disclosure may be utilized to assemble various components of absorbent articles. For example, Figure 14 shows a schematic view of a converting apparatus 300 adapted to manufacture diapers 10 having absorbent cores 14 and acquisition layers 50 as discussed above. As such, the method of operation of the converting apparatus 300 may described with reference to the various components of diapers 10 described above and shown in Figures 1-10. As described in more detail below, the converting apparatus 300 shown in Figure 14 operates to advance a continuous topsheet web 18 in a machine direction. A liquid acquisition layer 50 and an absorbent core 14 are combined with the advancing topsheet web 18. The combined continuous topsheet web 18, liquid acquisition layer 50, and absorbent core 14 are then advanced to subsequent converting operations to complete assembly of absorbent articles 10. As shown in Figure 14, a continuous topsheet web 18 having a first surface 302 and an opposing second surface 304 is combined with a liquid acquisition system or layer 50. More particularly, the topsheet web 18 is advanced in a machine direction MD to a nip 306 defined between a carrier apparatus 308 and roll 310, where the topsheet web 18 and liquid acquisition layer 50 are combined. Before entering the nip 306, adhesive 312 may be applied to the second surface 304 of the topsheet web 18.

It is to be appreciated that the liquid acquisition layer 50 may be formed in various ways before being combined with the topsheet web 18. As discussed above, the liquid acquisition layer 50 may include one or more layers of material. For example, as shown in Figure 14, the liquid acquisition layer 50 may include a first acquisition layer 52 and a second acquisition layer 54. During assembly, adhesive 314 may applied to the first acquisition layer 52 advancing in a machine direction MD. And discrete patches of second acquisition layers 54 may be assembled on a forming drum 339 and deposited on a continuous length of a first acquisition layer substrate 52 advancing in a machine direction MD. As shown in Figure 14, each discrete patch of second acquisition layer 54 may comprise two or more regions having different thicknesses extending in the cross direction and the machine direction. For example, the each discrete patch of second acquisition layer 54 may include a first region 54-1 and a second region 54-2, wherein the first region 54-1 defines a first thickness T1 and the second region 54-2 defines a second thickness T2. In some embodiments, the second thickness T2 may be greater than the first thickness T1.

With continued reference to Figure 14, the first acquisition layer substrate 52 includes a first surface 52a and an opposing second surface 52b, and defines a width in a cross direction CD. And the discrete patches of second acquisition layers 54 each include a first surface 54a and an opposing second surface 54b, and define a width in a cross direction CD. As such, the second surface 54b of each discrete patch 54 may be in a facing relationship with the first surface 52a of the continuous length of the first acquisition layer substrate 52 to form a liquid acquisition layer 50 having a first surface 324 and an opposing second surface 326. The liquid acquisition layer may also advance through a nip 316 between rolls 318, 320 before advancing to the carrier apparatus 308. As shown in Figure 14, the first acquisition layer substrate 52 may be cut into discrete lengths or patches by a knife roll 322 on the carrier apparatus 308 to form discrete lengths of acquisition layers 50 before being combined with the topsheet web 18.

The carrier apparatus 308 and the knife roll 322 may utilize a cut and slip technique to space sequential discrete lengths of the acquisition layer 50 about the carrier apparatus 308. A cut and slip technique is an operation for achieving spacing between discrete components. An example operation for achieving spacing between discrete components is disclosed in U.S. Pat. No. 5,702,551, which is incorporated by reference herein. Other types of operations and equipment that may be used to cut and space discrete lengths of components are disclosed in U.S. Pat. Nos. 6,620,276; 6,811,019; and 7,587,966, which are incorporated by reference herein. The discrete lengths of acquisition layer 50 are then combined with the topsheet web 18 at nip 306. In particular, the first surface 324 of the acquisition layer 50 may be adhered to the second surface 304 of the topsheet web 18 at nip 306, and as such, the first acquisition layer 52 may be positioned between the topsheet web 18 and the second acquisition layer 54. Although the acquisition layer 50 is shown in Figure 14 as being cut into discrete lengths before being combined with the topsheet web 18, it is to be appreciated that in some embodiments a continuous length of acquisition layer 50 may be combined with the topsheet web 18. From the nip 306, the combined topsheet web 18 and liquid acquisition layer 50 advance in the machine direction MD to a nip 328 defined between a carrier apparatus 330 and roll 332, where the topsheet web 18 and acquisition layer are combined with an absorbent core 14. Before entering the nip 328, adhesive 333 may be applied to the second surface 304 of the acquisition layer 50 and/or topsheet web 18.

It is to be appreciated that the absorbent core 14 may be formed in various ways before being combined with the topsheet web 18 and acquisition layer 50. For example, as shown in Figure 14, the absorbent core 14 has a first surface 334 and an opposing second surface 336 and may be formed in accordance with the process description provided above with reference to Figures 1-13. As such, the absorbent core may include various components discussed above with reference to Figures 1-10, such as a first absorbent layer 60 and a second absorbent layer 62, wherein the first absorbent layer 60 of the absorbent core 14 may include a substrate 64, an absorbent particular polymer material 66 on the substrate 64, and a thermoplastic composition 68 on the absorbent particulate polymer material 66. And the second absorbent layer 62 of the absorbent core 14 may include a substrate 72, an absorbent particulate polymer material 74 on the second substrate 72, and a thermoplastic composition 66 on the absorbent particulate polymer material 74. As such, with reference to Figures 2 and 14, the substrate 72 may define the first surface 334 of the absorbent core 14, and the substrate 64 may define the second surface 336 of the absorbent core 14. As shown in Figure 14, the absorbent core 14 may also be cut into discrete lengths by a knife roll 338 on the carrier apparatus 330 before being combined with the acquisition layer 50 and topsheet web 18.

The carrier apparatus 330 and the knife roll 338 may also utilize a cut and slip technique to space sequential discrete lengths of the absorbent core 14 about the carrier apparatus 330. A cut and slip technique is an operation for achieving spacing between discrete components. An example operation for achieving spacing between discrete components is disclosed in U.S. Pat. No. 5,702,551, which is incorporated by reference herein. Other types of operations and equipment that may be used to cut and space discrete lengths of components are disclosed in U.S. Pat. Nos. 6,620,276; 6,811,019; and 7,587,966, which are incorporated by reference herein. The discrete lengths of absorbent core 14 are then combined with the acquisition layer 50 and topsheet web 18 at nip 328. In particular, the first surface 334 of the absorbent core 14 may be adhered to the second surface 326 of the acquisition layer 50 at nip 328. Although the absorbent core 14 is shown in Figure 14 as being cut into discrete lengths before being combined with the acquisition layer 50 and topsheet web 18, it is to be appreciated that in some embodiments a continuous length of absorbent core 14 may be combined with the acquisition layer 50 and topsheet web 18.

From the nip 328, the combined topsheet web 18, acquisition layer 50, and absorbent core 14 advance in the machine direction MD to additional converting operations that complete assembly of the diapers 10. For example, as shown in Figure 14, a backsheet web 20 having a first surface 358 and an opposing second surface 360 may be advanced in a machine direction MD to a nip 350 defined between drums 352, 354. At the nip 350, the backsheet web 20 may be combined with the advancing topsheet web 18, liquid acquisition layer 50, and absorbent core 14. Before entering the nip 350, adhesive 356 may be applied to a second surface 304 of the topsheet web 18. It is to be appreciated that the topsheet web 18, backsheet web 20, acquisition layer 50, absorbent core 14 can be combined with other absorbent article components as described above, such as for example, fastening components, leg cuffs, and elasticated features.

In some configurations, the converting apparatus 300 may also include embossing processes that may be applied to various components of absorbent articles during manufacture, such as disclosed in U.S. Patent Nos. 8,603,277 and 8,658,852 as well as U.S. Patent Publication No. US2006/0116653A1, which are all incorporated by reference herein. For example, as shown in Figure 14A, the combined topsheet web 18, acquisition layer 50, and absorbent core 14 advance from the nip 328 in the machine direction MD to an embossing apparatus 340, where a pattern is embossed into the topsheet web 18. The embossing apparatus may include an embossing nip 342 defined between a patterned embossing roll 344 and an anvil roll 346. As shown in Figure 14A, the combined topsheet web 18, acquisition layer 50, and absorbent core 14 advance in the machine direction MD through the embossing nip 342 such that the outer surface of the patterned embossing roll 344 engages the first surface 302 of the topsheet web and the outer surface of the anvil roll engages the second surface 336 of the absorbent core 14. The topsheet web 18, acquisition layer 50, and absorbent core 14 are compressed while advancing through the embossing nip 342, and the embossing roll 344 embosses a pattern of embossments into the topsheet web 18. It is to be appreciated that the topsheet web 18, acquisition layer 50, and absorbent core 14 can be combined with other absorbent article components as described above in an assembly process, such as for example, a backsheet, fastening components, leg cuffs, and elasticated features. As such, an inspection system 600 utilizing sensors 602 and radiation sources 606 described above may be configured and positioned downstream of the embossing apparatus 340 adjacent the embossed components to create profiles representing surface topographies of embossed topsheet web 18 in combination with acquisition layers 50 and/or absorbent cores 14.

Further to the above discussion, it is to be appreciated the embossing processes may be carried out in various stages of the assembly process. For example, as shown in Figure 14B, the embossing apparatus 340 is positioned upstream of the nip 328. As such, the combined topsheet web 18 and acquisition layer 50 advance from the nip 306 in the machine direction MD to the embossing apparatus 340, where a pattern is embossed into the topsheet web 18. The embossing apparatus may include an embossing nip 342 defined between a patterned embossing roll 344 and an anvil roll 346. As shown in Figure 14B, the combined topsheet web 18 and acquisition layer 50 advance in the machine direction MD through the embossing nip 342 such that the outer surface of the patterned embossing roll 344 engages the first surface 302 of the topsheet web and the outer surface of the anvil roll engages the second surface 326 of the acquisition layer 50. The topsheet web 18 and acquisition layer 50 are compressed while advancing through the embossing nip 342, and the embossing roll 344 embosses a pattern of embossments into the topsheet web 18. From the embossing apparatus 340, the combined topsheet web 18 and acquisition layer 50 may then advance in the machine direction MD to the nip 328 defined between a carrier apparatus 330 and roll 332, where the topsheet web 18 and acquisition layer are combined with an absorbent core 14. Before entering the nip 328, adhesive 333 may be applied to the second surface 304 of the acquisition layer 50 and/or topsheet web 18.

As shown for example in Figure 11, an inspection system 600 may be configured to interact with, monitor, and/or control the converting line 300. In some configurations, sensors 602 may be arranged adjacent the converting line 300 and may communicate with a controller 604. Based on such communications, the controller 604 may monitor and affect various operations on the converting line 300. For example, the controller may send various types of control commands to the converter line based on communications with the sensors 602. In some embodiments, the control commands may be in the form of reject commands communicated to a reject system.

It is to be appreciated that the controller 604 may include one or more computer systems. The computer system may, for example, include one or more types of programmable logic controller (PLC) and/or personal computer (PC) running software and adapted to communicate on an EthernetIP network. Some embodiments may utilize industrial programmable controllers such as the Siemens S7 series, Rockwell ControlLogix, SLC or PLC 5 series, or Mitsubishi Q series. The aforementioned embodiments may use a personal computer or server running a control algorithm such as Rockwell SoftLogix or National Instruments Labview or may be any other device capable of receiving inputs from sensors, performing calculations based on such inputs and generating control actions through servomotor controls, electrical actuators or electro-pneumatic, electrohydraulic, and other actuators. Process and product data may be stored directly in the controller or may be located in a separate data historian. In some embodiments, the historian is a simple data table in the controller, In other embodiments, the historian may be a relational or simple database. Common historian applications include Rockwell Automation Factory Talk Historian, General Electric Proficy Historian, OSI PI, or any custom historian that may be configured from Oracle, SQL or any of a number of database applications. It is also to be appreciated that various types of controllers and inspection sensors can be configured in various ways and with various algorithms to provide various types of data and perform various functions, for example, such as disclosed in U.S. Patent Nos. 5,286,543; 5,359,525; 6,801,828; 6,820,022; 7,123,981; 8,145,343; 8,145,344; and 8,244,393; and European Patent No. EP 1528907B1, all of which are incorporated by reference herein.

In some embodiments, the sensors 602 may be configured to detect emitted light 610 caused by fluorescence of adhesive in absorbent structures while being irradiated with the ultraviolet light. For example, as shown in Figure 11, the inspection system 600 may include a radiation source 606 that illuminates a surface of an absorbent structure with ultraviolet light 608 extending in the cross direction CD. Example radiation sources 606 may include mercury vapor lamps, incandescent bulbs, mercury vapor gas discharge lamps, and light emitting diode lamps. It is to be appreciated that the radiation source 606 and the sensor 602 may be separate stand-alone units or may be incorporated together into a single unit, such as for example, machine vision bar lamps. An example machine vision bar lamp is a linear 395 nanometer LED array lamp, Model LL146-395, available from the Spectrum Illumination Company of Montague, MI, USA. Such radiation sources may illuminate absorbent structures with ultraviolet light having various wavelengths. For example, in some embodiments, a radiation source 606 may illuminate with ultraviolet light. In some embodiments, the ultraviolet light may include light having a peak wavelength from about 10 nanometers to about 400 nanometers. Some embodiments may utilize ultraviolet light having a peak wavelength from about 300 nanometers to about 400 nanometers. And some embodiments may utilize ultraviolet light having a peak wavelength from 350 nanometers to 400 nanometers. In some embodiments, the ultraviolet light may have a wavelength of 365 nanometers, 385 nanometers, or 395 nanometers. In turn, the sensor 602 detects emitted light 610 caused by fluorescence of the adhesive while being irradiated with the ultraviolet light. It is to be appreciated that the emitted light 610 may have various wavelengths. For example, in some embodiments, the emitted light 610 may be blue light having wavelength of about 450 nanometers. In addition, the sensor 602 may be configured with a filter that prevents detection of reflected ultraviolet light from the illuminated absorbent structure. It is to be recognized that neither the light from the radiation source 606 nor the light emitted as a result of fluorescence 610 are monochromatic, and that the wavelengths described herein represent the peak intensities of each light. Further, filters described herein attenuate the light outside a specified range of wavelengths.

As previously mentioned, the substrates and/or components inspected with the methods and apparatuses herein may include adhesive that fluoresces when excited by ultraviolet light. It is to be appreciated that various types of adhesives may be used, such as for example, Technomelt DM526 and Dispomelt 519A, both available from Henkel Technologies. In some configurations, adhesives may include a material additive that causes the adhesive to fluoresce when excited by ultraviolet light. In some configurations, chemical properties of the adhesive may cause the adhesive to fluoresce when excited by ultraviolet light.

It is to be appreciated that various different types of sensors 602 may be used in the methods disclosed herein. For example, sensors 602 may be configured as photo-optic sensors that receive emitted light 610 and serve to determine the presence or absence of a specific material, such as adhesive. Sensors 602 may also be configured as vision systems and other sub-processing devices to perform detection and, in some cases, logic to more accurately determine the status of an inspected product. Particular examples of such sensors 602 may include Cognex Insight, DVT Legend or Keyence smart cameras, component vision systems such as National Instruments PXI or PC based vision system such as Cognex VisionPro or any other vision system software which can run on a PC platform. Based on the ability to detect emitted light 610 as discussed above, the sensors 602 may be configured to detect the presence or absence of adhesives on substrates and/or components, and may be configured to detect the relative placement of such adhesives on substrates and/or components. In turn, based on the detections of the sensors 602, feedback signals from the sensors 602 in the form of inspection parameters may be communicated to the controller 604.

It is to be appreciated that inspection parameters may be provided from the sensors 602 in various forms. In some embodiments, inspection parameters may be in the form of "results," such as for example, provided from a sensor state change resulting in a binary input corresponding with the detected presence or absence of emitted light. For example, inspection parameters may indicate the presence or absence of adhesive in various locations on a substrates and/or components. In another embodiment, inspection parameters may be provided in the form of measurements and/or numerical indications of detected positions of adhesives on components and/or substrates; numerical indications of the positions of adhesives on components and/or substrates relative to adhesives on other components and/or substrate; and/or numerical indications of positions adhesives on components and/or substrates relative to another physical or virtual reference.

Building on the discussion above, inspection parameters generated based on detected emitted light 610 may be used to determine various characteristics of components and/or substrates during the assembly process. For example, inspection parameters may indicate the relative position of one feature, such as a channel region 115, with respect to a measured width of an absorbent core 14 compared to the desired width. In some embodiments, measurements may be correlated with quality or performance parameters, such as for example, bond strengths of the adhesives or absorptive performance of an inspected product. In some embodiments, inspection parameters may be in the form of images transferred via a standard protocol such as ftp (File Transfer Protocol), DDE (Dynamic Data Exchange), or OPC (Object Linking and Embedding for Process Control), which are stored in a database or stored in a specified directory on an image server for the purpose of either operator visualization, offline image processing or claim support.

It is to be appreciated that the sensor 602 and/or radiation source 606 may be configured and arranged in various ways relative to advancing substrates or laminates that are being monitored. For example, Figure 11 shows an inspection system 600 including a sensor 602, controller 604, and radiations source 606 adjacent a continuous length of absorbent cores 14 advancing in a machine direction MD. In particular, the inspection system 600 may be configured to illuminate the second surface 72b of the second continuous substrate 72 of the continuous length of substantially cellulose free absorbent cores 14 with ultraviolet light 608 extending in the cross direction CD. The absorbent cores 14 may include adhesive that fluoresces to emit light 610 detectable by the sensor 602 when excited by ultraviolet light 608.

In a particular example with continued reference to Figure 11, the auxiliary adhesive 137 may be configured to fluoresce when excited by ultraviolet light 608, and thus, may be used to determine various characteristics of channel regions 115 in the absorbent cores 14. As discussed above with reference to Figures 9 and 10, the channel regions 115 of the absorbent cores 14 may be regions that are substantially free of absorbent particulate polymer material 66, 74 surrounded by absorbent particulate polymer material areas 114. And in some embodiments, the substrates 64, 72 may be bonded with directly each other in the channel regions 115. As such, the ultraviolet light 608 shown in Figure 11 may penetrate the second continuous substrate 72 in the channel regions 115 to the auxiliary adhesive in the channel regions 115. In turn, auxiliary adhesive 137 located in the channel regions 115 will fluoresce and emit light 610 that is detectable by the sensor 602. For example, Figures 15 and 16 are detailed views of a channel region 115 with an auxiliary adhesive 137. As mentioned above, the auxiliary adhesive 137 may be applied one or both substrates 64, 72 with a slot coating device in the form of strips 139. With continued reference to Figures 15 and 16, the strips 139 of auxiliary adhesive 137 have been applied to only the first surface 64a of the first substrate 64. In addition, the strips 139 of auxiliary adhesive 137 are separated from each other along the cross direction CD and extend along the machine direction MD through the channel region 115.

As shown in Figure 16, the absorbent particulate polymer material 66, 74 in the absorbent particulate polymer material area 114 may be substantially opaque to ultraviolet light 608. As such, the ultraviolet light 608 is depicted as not penetrating through absorbent particulate polymer material 66, 74 to reach the strips 139 of auxiliary adhesive 137 on the first substrate 64 opposite the absorbent particulate polymer material area 114. However, the ultraviolet light 608 is depicted as penetrating through the second substrate 72 to reach the strips 139 of auxiliary adhesive 137 on the first substrate 64 in the channel region 115. In turn, the strips 139 of auxiliary adhesive 137 on the first substrate 64 in the channel region 115 fluoresce and emit light 610 that may be detected by a sensor 602. It is to be appreciated that materials that fluoresce generate light that is detected by the sensor, while materials that do not fluoresce will not generate light. Thus, materials that do not fluoresce may appear relatively darker in an image. Further, materials that do not fluoresce and that have varying measures of opacity to the transmitted or emitted light may also appear relatively darker in an image. As such, the inspection system 600 may determine various characteristics of the channel regions 115 based on detected emitted light 610 or the absence of emitted light 610 from auxiliary adhesive in the channel regions 115. Such characteristics may include, for example, may include a presence or absence of strips 139 of auxiliary adhesive 137 in the channel region 115; a quantity of strips 139 of auxiliary adhesive 137 in the channel region 115; dimensions of the strips 139 of auxiliary adhesive 137 along the machine direction MD and/or cross direction CD in the channel region 115; positions of the strips 139 of auxiliary adhesive 137 along the machine direction MD and/or cross direction CD in the channel region 115; separation distances between strips 139 of auxiliary adhesive 137 in cross direction CD in the channel region 115; a presence absorbent particulate polymer material 66, 74 in the channel region 115; a shape of the channel region; bond strength between the substrates 64, 72 in the channel region 115; position of the channel region 115; and/or orientation of the channel region 115.

It is to be appreciated that the inspection systems 600 may include more than one sensor and/or radiation source positioned to monitor the same or opposing sides of an advancing absorbent structure. For example, referring back to Figure 11, it is to be appreciated the radiation source 606 may be positioned on an opposing side of the absorbent cores 14 from the sensor 602 in a backlighting configuration. As such, the radiation source 606 may be positioned to illuminate the second surface 64b of the first continuous substrate 64 of the continuous length of substantially cellulose free absorbent cores 14 with ultraviolet light 608 extending in the cross direction CD, and the sensor 602 may be positioned such to detect light 610 emitted from adhesive through the second continuous substrate 72. It is also to be appreciated that the sensor 602 and radiation device may both be positioned adjacent the first continuous substrate 64 of the continuous length of substantially cellulose free absorbent cores 14. In addition, the inspection system 600 may include a sensor 602 and a radiation source 606 adjacent the first continuous substrate 64 and may include a second sensor 62 and a second radiation source 606 adjacent the second continuous substrate 72. With continued reference to Figure 11, it is to be appreciated that one or more sensors 602 and/or radiation sources 606 may be located in various positions relative to different stages of the assembly process. For example, one or more sensors 602 and/or radiation sources 606 may be positioned downstream of the first and/or second auxiliary adhesive applicators 136, 148 and upstream of printing rolls 144, 156, such as generally indicated by locations A and B in Figure 11. In another example, one or more sensors 602 and/or radiation sources 606 may be positioned downstream of the printing rolls 144, 156 and upstream of nip 162, such as generally indicated by locations C and D in Figure 11.

It is to be appreciated that the inspection systems 600 may be arranged and/or configured to monitor other components of absorbent structures during the assembly process. For example, as shown in Figures 14-14B, an inspection system 600 may be configured with a radiation device 606 to illuminate the second surface 52b of the first acquisition layer 52 with ultraviolet light 608. As such, the adhesive 314 between the first acquisition layer 52 and second acquisition layer 54 may be configured to fluoresce and emit light 610 detectable by the sensor 602 when excited by ultraviolet light 608.

Although the methods and apparatuses herein have been presented and described in the context of using ultraviolet light to detect adhesives in absorbent structures, such as acquisition layers and absorbent cores, it is to be to be appreciated that the methods and apparatuses herein may be applied to other absorbent article components at various stages of manufacture. As such, inspections systems utilizing sensors and radiation sources as described above may be configured and positioned adjacent to converting apparatuses to detect the presence or absence of adhesives on various absorbent article components. In some embodiments, inspections systems may detect the presence, absence, position, and/or quantity of other adhesives used to attach various components, such as a landing zone, a front ear, a back ear, a leg cuff, and/or topsheet materials, whether the adhesives are applied through slot coating, pressure nozzles, or other application methods. Further, inspection systems may be configured to inspect for the presence or absence of elastics attached to a product with adhesive.

Although various methods and apparatuses are discussed above to determine various characteristics of various components and/or substrates during the assembly of absorbent articles based on detected light emitted from adhesives that fluoresce when excited by ultraviolet light, it is to be appreciated that the configurations herein may be modified to operate in other ways. For example, components and/or substrates may be configured to fluoresce when excited by ultraviolet light, while adhesive on such components and/or substrates absorbs ultraviolet light.

The dimensions and values disclosed herein are not to be understood as being strictly limited to the exact numerical values recited. Instead, unless otherwise specified, each such dimension is intended to mean both the recited value and a functionally equivalent range surrounding that value. For example, a dimension disclosed as “40 mm” is intended to mean “about 40 mm.”

Every document cited herein, including any cross referenced or related patent or application and any patent application or patent to which this application claims priority or benefit thereof, is hereby incorporated herein by reference in its entirety unless expressly excluded or otherwise limited. The citation of any document is not an admission that it is prior art with respect to any invention disclosed or claimed herein or that it alone, or in any combination with any other reference or references, teaches, suggests or discloses any such invention. Further, to the extent that any meaning or definition of a term in this document conflicts with any meaning or definition of the same term in a document incorporated by reference, the meaning or definition assigned to that term in this document shall govern.

While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

CLAIMS

What is claimed is:

1. A method for assembling disposable absorbent articles, each absorbent article comprising a topsheet (18), a backsheet (20), and a substantially cellulose free absorbent core (14) disposed between the topsheet (18) and the backsheet (20), the method comprising the steps of:

advancing a first continuous substrate (64) in a machine direction, the first continuous substrate (64) having a first surface (64a) and an opposing second surface (64b), and defining a width in a cross direction;

applying adhesive to the first surface of the first continuous substrate (137), wherein the adhesive fluoresces when excited by ultraviolet light;

depositing absorbent particulate polymer material (66) on the first surface (64a) of the first continuous substrate (64) so as to define first regions (114) of absorbent particulate polymer material surrounding second regions (115) that are substantially free of absorbent particulate polymer material (66);

advancing a second continuous substrate (72) in the machine direction, the second continuous substrate (72) having a first surface (72a) and an opposing second surface (72b), and defining a width in the cross direction;

combining the first continuous substrate (64) with the second continuous substrate (72) to create a continuous length of substantially cellulose free absorbent cores (14), wherein the second regions (115) on the first continuous substrate (64) are placed in facing relationships with the first surface (72a) of the second continuous substrate (72) to define channel regions (115) that are substantially free of absorbent particulate polymer material, and wherein the adhesive bonds (137) the first surfaces of the first and second continuous substrates (64, 72) directly together in the channel regions (115);

advancing the continuous length of substantially cellulose free absorbent cores (14) past a sensor (602);

irradiating at least one of the second surfaces of the first or second continuous substrates (64, 72) of the continuous length of substantially cellulose free absorbent cores (14) with ultraviolet light (608);

filtering reflected ultraviolet light (610) from the continuous length of substantially cellulose free absorbent cores (14) to prevent detection of the reflected ultraviolet light with the sensor;

detecting with the sensor (602) emitted light caused by fluorescence of the adhesive (137) while being irradiated with the ultraviolet light (608); and

determining a characteristic of a channel region (115) based on the detected emitted light, the at least one characteristic selected from the group consisting of: a presence of the adhesive in the channel region; a presence absorbent particulate polymer material in the channel region, a shape of the channel region, bond strength, and position of the channel region.

2. The method of claim 1, wherein the first continuous substrate (64) is between the sensor (602) and the second continuous substrate (72).

3. The method of claim 2, wherein the step of irradiating further comprises advancing the continuous length of substantially cellulose free absorbent cores (14) past a radiation source (606) such that the first continuous substrate (64) is between the radiation source (606) and the second continuous substrate (72).

4. The method of claim 2, wherein the step of irradiating further comprises advancing the continuous length of substantially cellulose free absorbent cores (14) past a radiation source (606) such that the second continuous substrate (72) is between the radiation source (606) and the first continuous substrate (64).

5. The method of claim 1, wherein the step of applying adhesive (137) further comprises applying the adhesive in a plurality of strips (139) extending the machine direction and separated from each other in the cross direction.

6. The method of claim 5, wherein the step of determining a characteristic of a channel region (115) based on the detected emitted light (610) further comprises detecting a quantity of strips (139) extending through the channel region (115).

7. The method according to any of the preceding claims, further comprising the step of depositing absorbent particulate polymer material (74) on the first surface (72a) of the second continuous substrate (72) so as to define first regions (114) of absorbent particulate polymer material surrounding second regions (115) that are substantially free of absorbent particulate polymer material.

8. The method of claim 7, wherein the step of combining the first continuous substrate (64) with the second continuous substrate (72) to create a continuous length of substantially cellulose free absorbent cores (14) further comprises placing the second regions on the first continuous substrate (64) and the second continuous substrate (72) in facing relationships to define channel regions (115) that are substantially free of absorbent particulate polymer material (66, 74), and wherein the adhesive bonds (137) the first surfaces of the first and second continuous substrates directly together in the channel regions (115).

9. The method according to any of the preceding claims, wherein the ultraviolet light (608) comprises a wavelength of about 350 nanometers to about 400 nanometers.

10. The method according to any of the preceding claims, wherein the emitted light (610) comprises blue light.

11. The method of claim 10, wherein the blue light comprises a wavelength of about 450 nanometers.

12. The method according to any of the preceding claims, wherein the adhesive (137) comprises a material additive that causes the adhesive to fluoresce when excited by ultraviolet light.

13. The method according to any of the preceding claims, wherein chemical properties of the adhesive (137) causes the adhesive to fluoresce when excited by ultraviolet light (608).

14. The method according to any of the preceding claims, further comprising the step of: applying adhesive (148) to the first surface (72a) of the second continuous substrate (72), wherein the adhesive (148) fluoresces when excited by ultraviolet light (608).

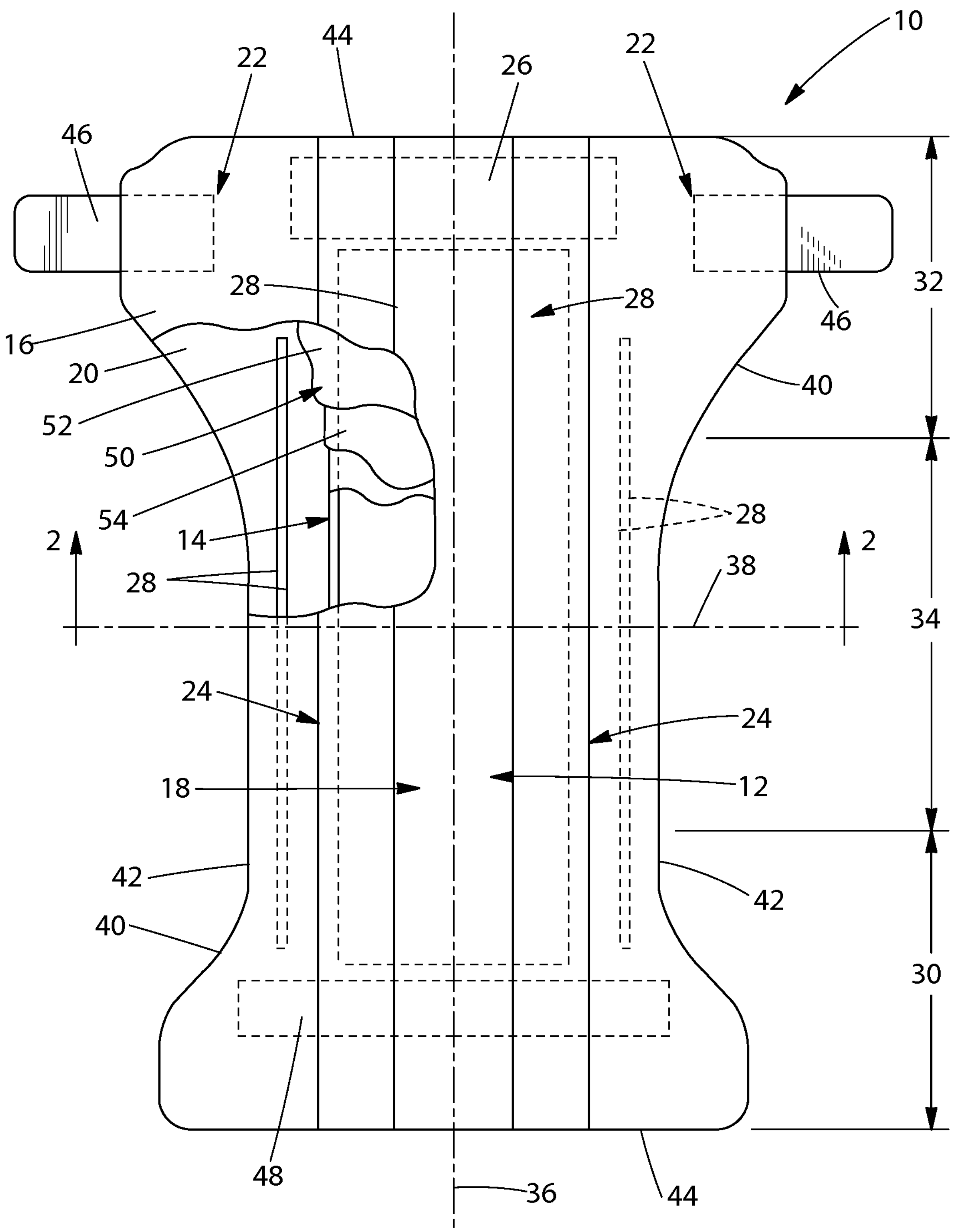
10
22
44
26
22
46
28
28
32
16
46
20
40
52
50
54
28
2
14
2
28
38
34
24
24
18
12
42
42
40
30
48
36
44

Fig. 1

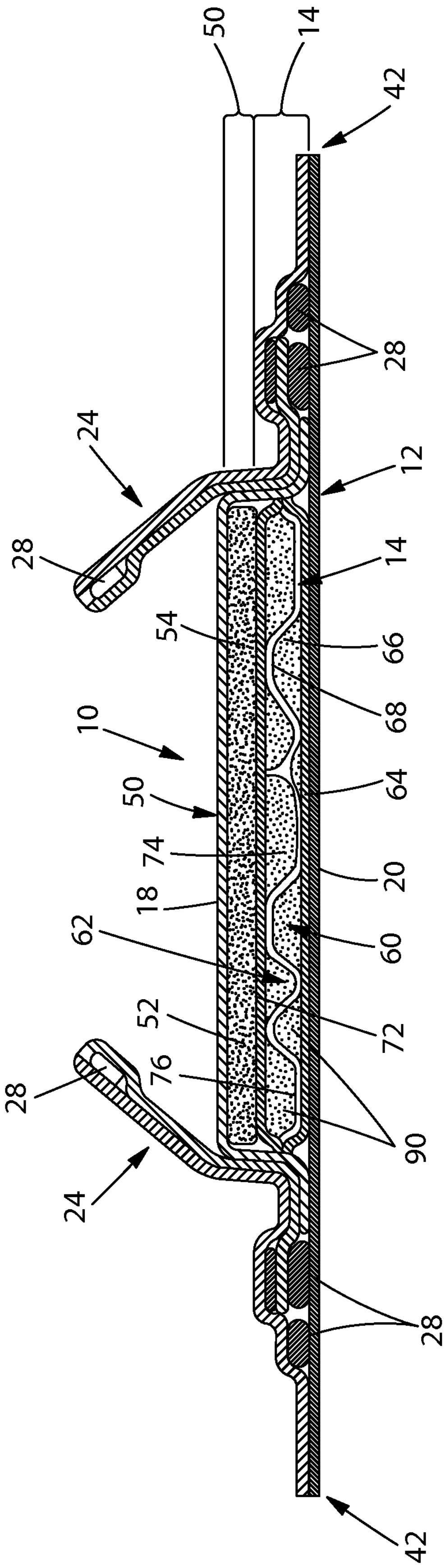
50
14
42
28
24
12
28
14
54
66
68
10
64
50
74
18
20
62
60
52
72
76
28
90
24
28
42

Fig. 2

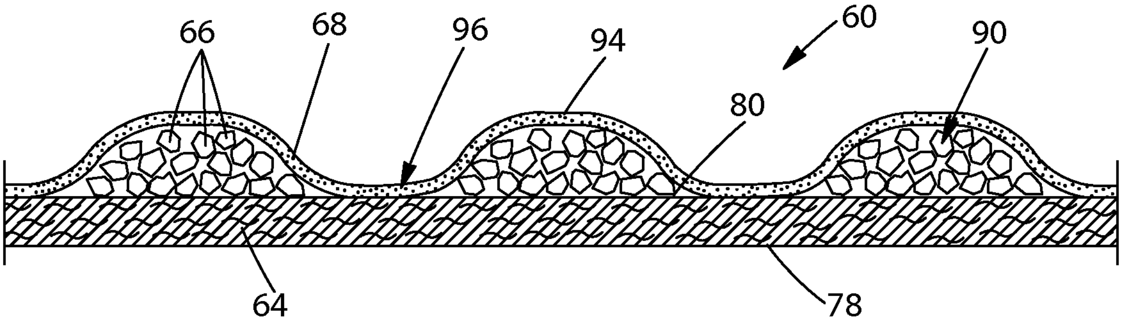

Fig. 3

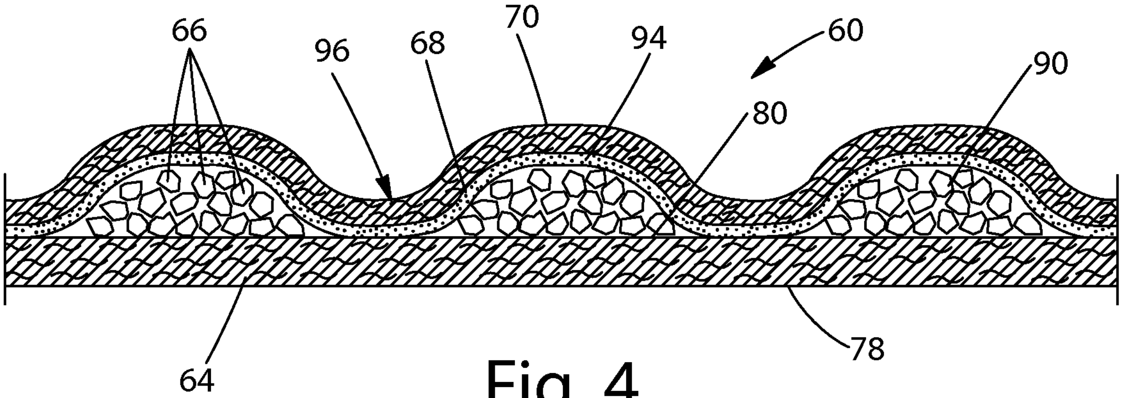

Fig. 4

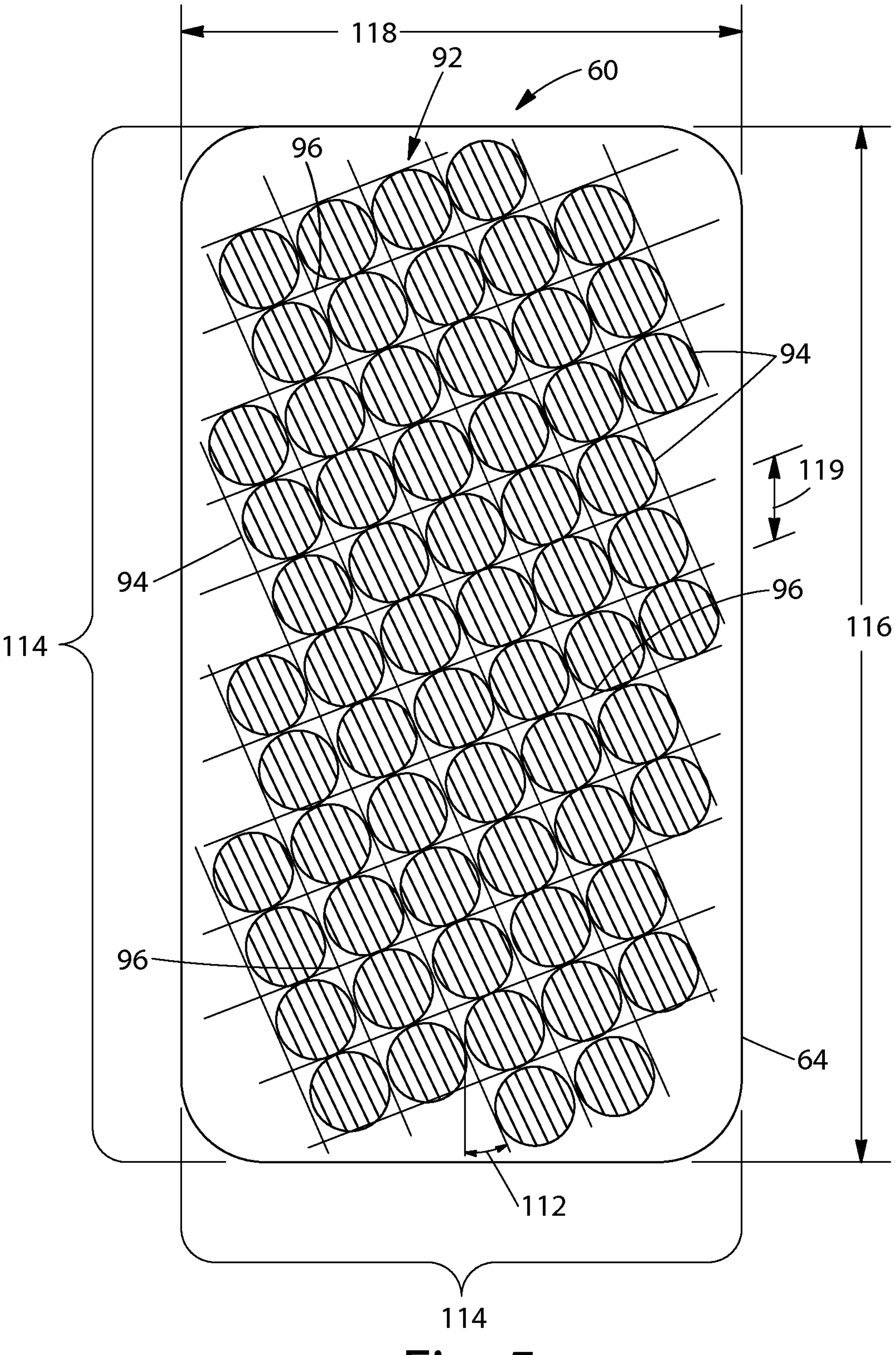

Fig. 5

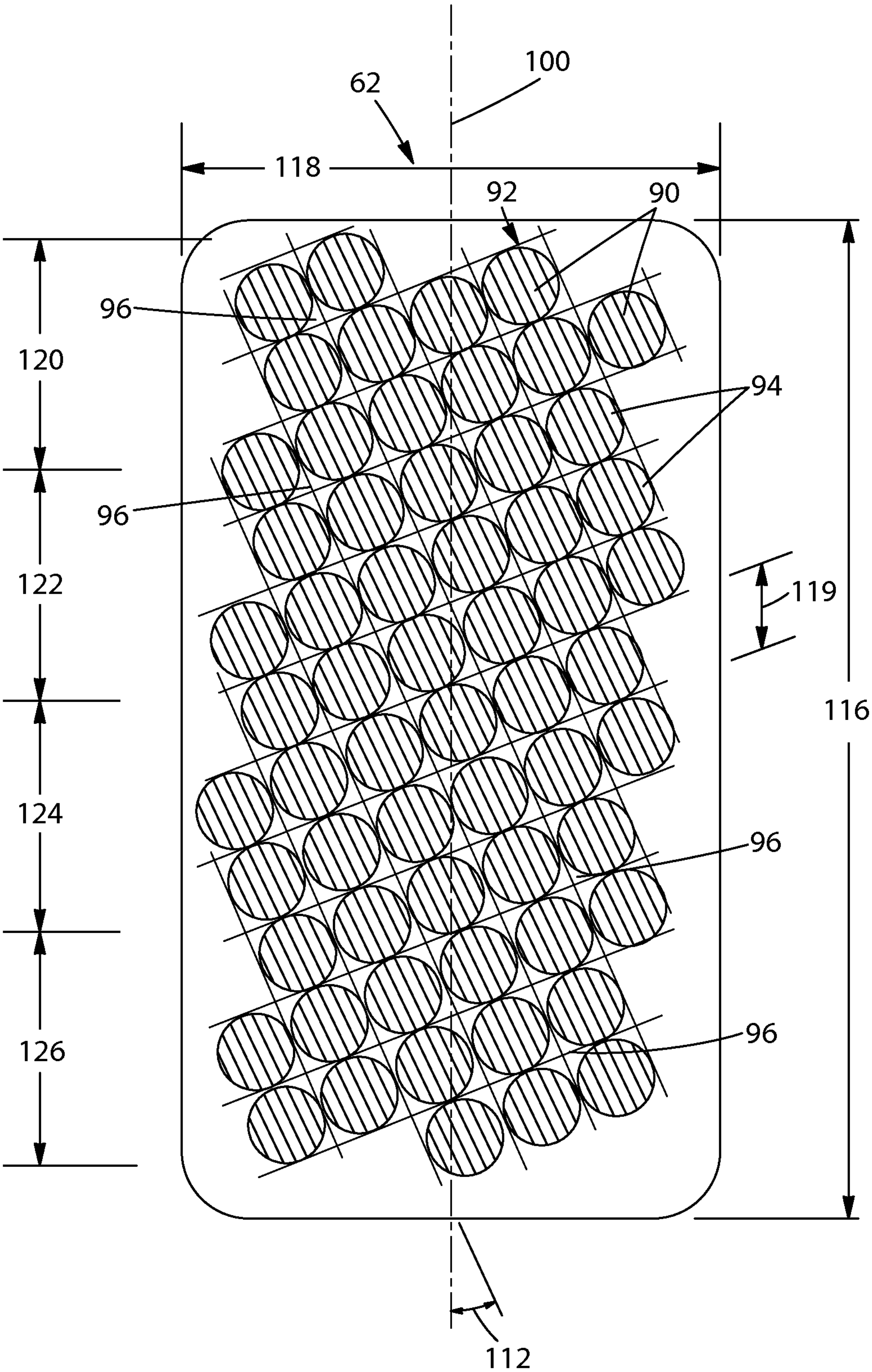

Fig. 6

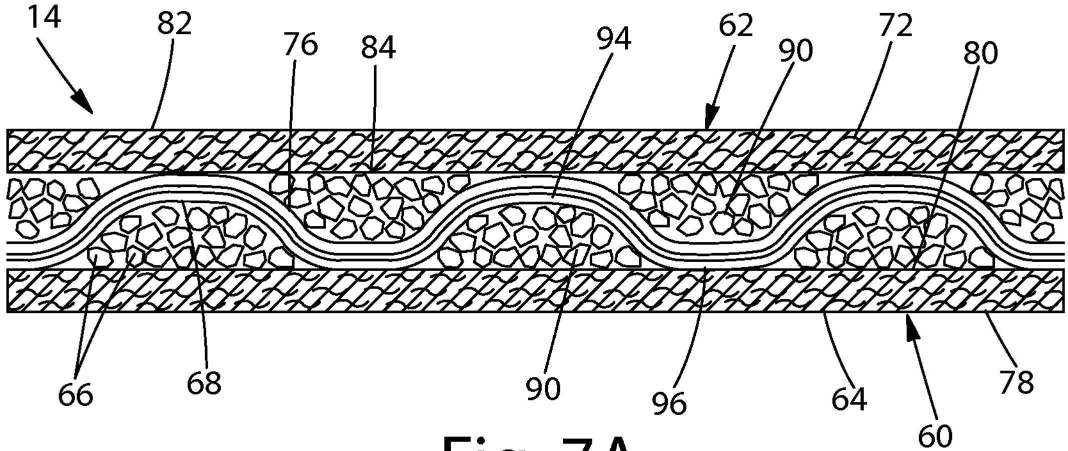
14
82
76
84
94
62
90
72
80
66
68
90
96
64
60
78

Fig. 7A

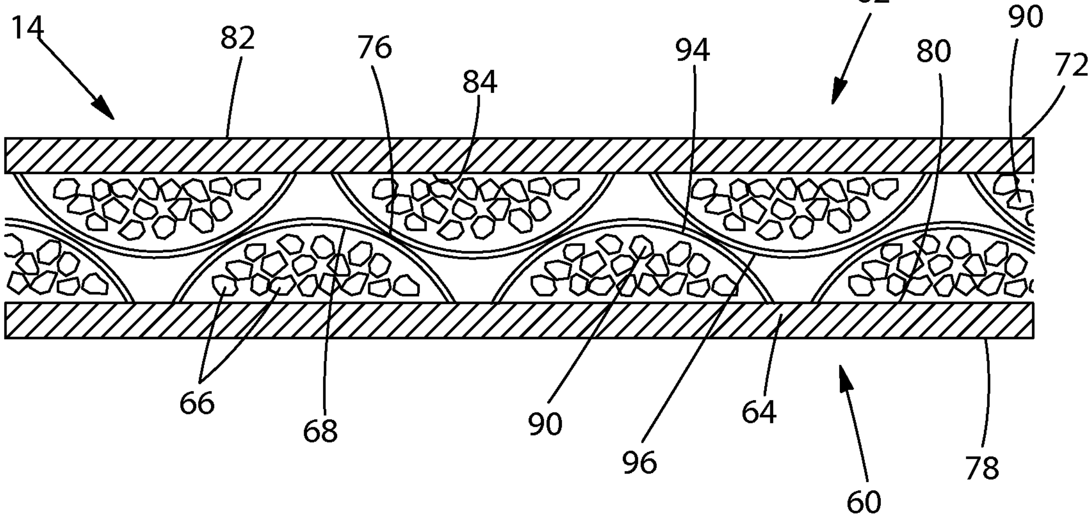
14
82
76
84
94
62
80
90
72
66
68
90
96
64
60
78

Fig. 7B

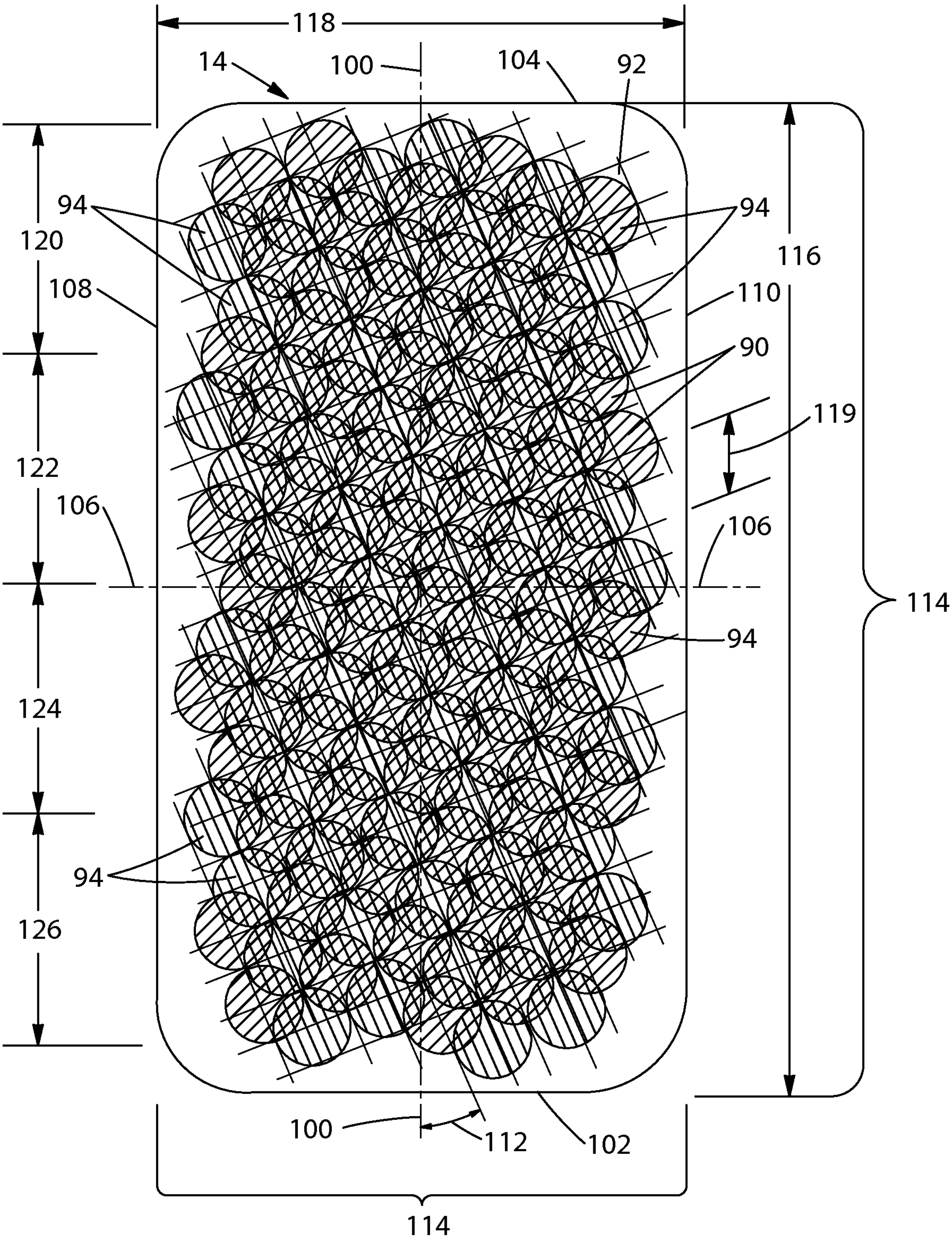
118
14
100
104
92
94
120
108
94
116
110
90
122
119
106
106
114
94
124
94
126
100
112
102
114

Fig. 8

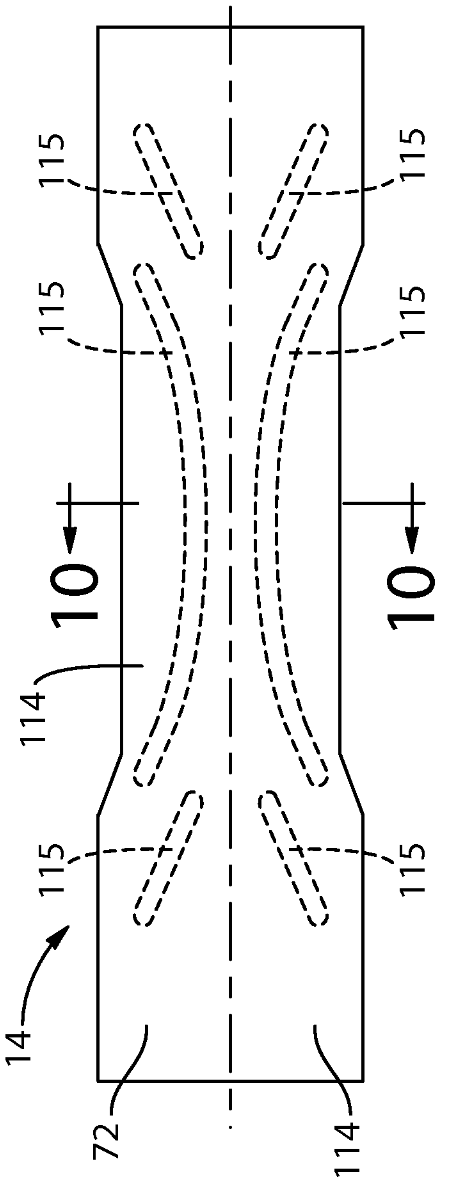
115
115
115
115
115
115
10
10
114
14
72
114

Fig. 9

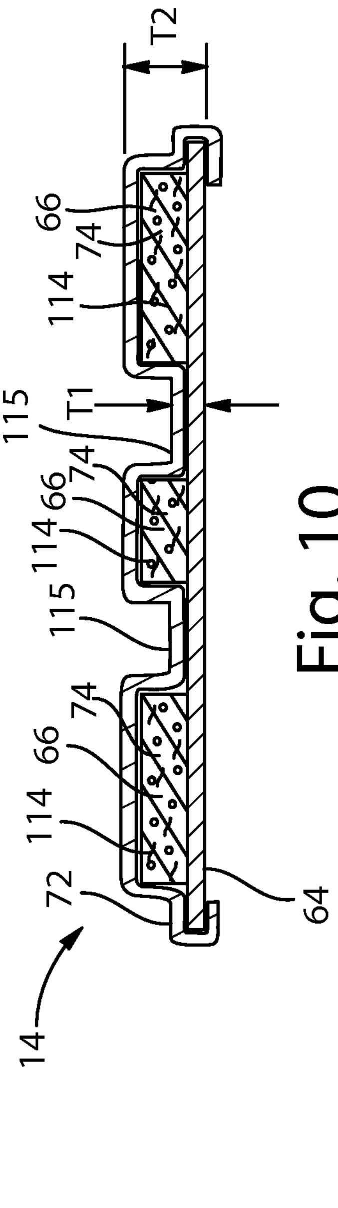
T2
66
74
114
T1
115
74
66
114
115
74
66
114
72
64
14

Fig. 10

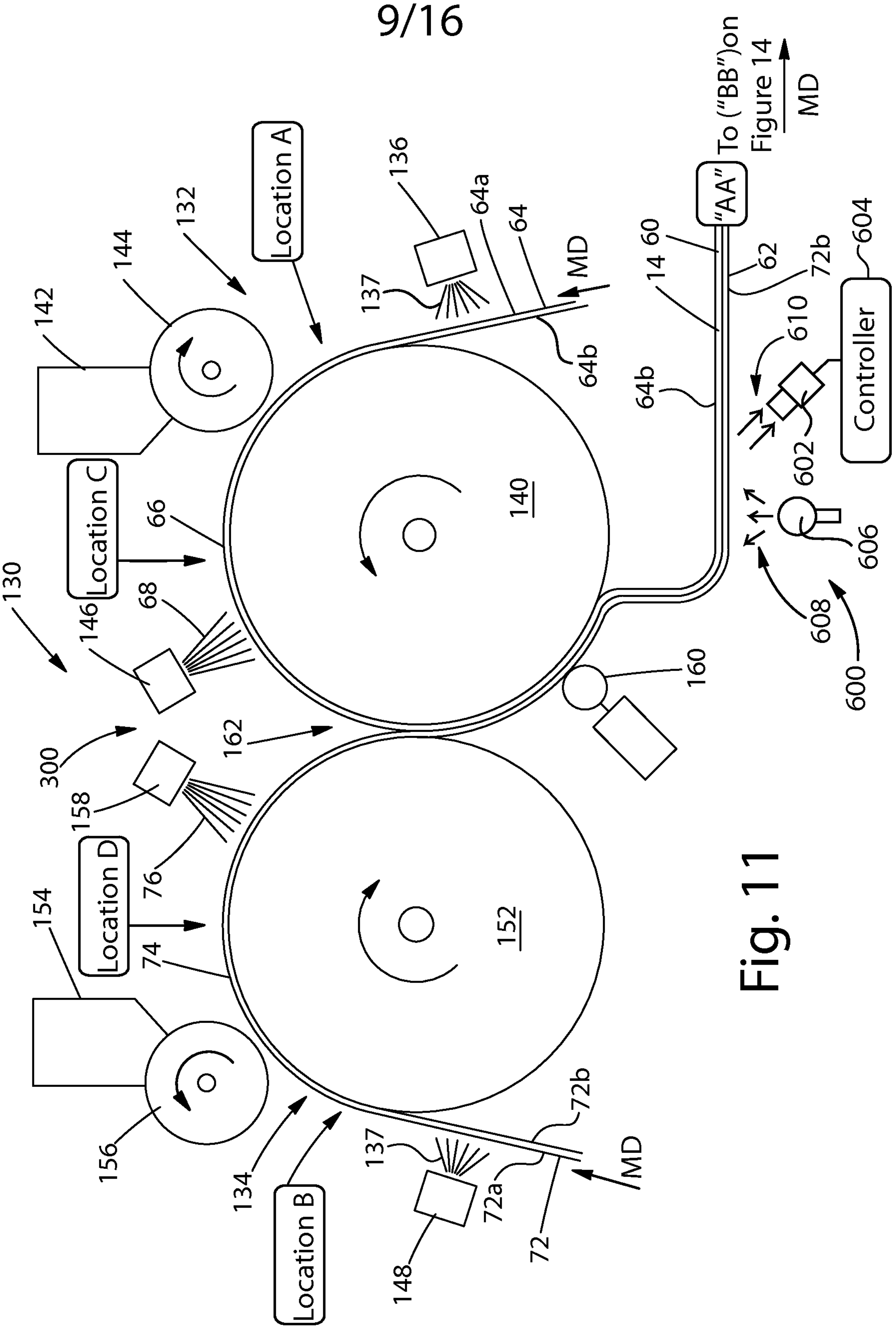
Location A
Location B
Location C
Location D
"AA"
To ("BB")on Figure 14
MD
Controller
140
152
130
132
134
136
137
142
144
146
148
154
156
158
160
162
300
14
60
62
64
64a
64b
66
68
72
72a
72b
74
76
600
602
604
606
608
610

Fig. 11

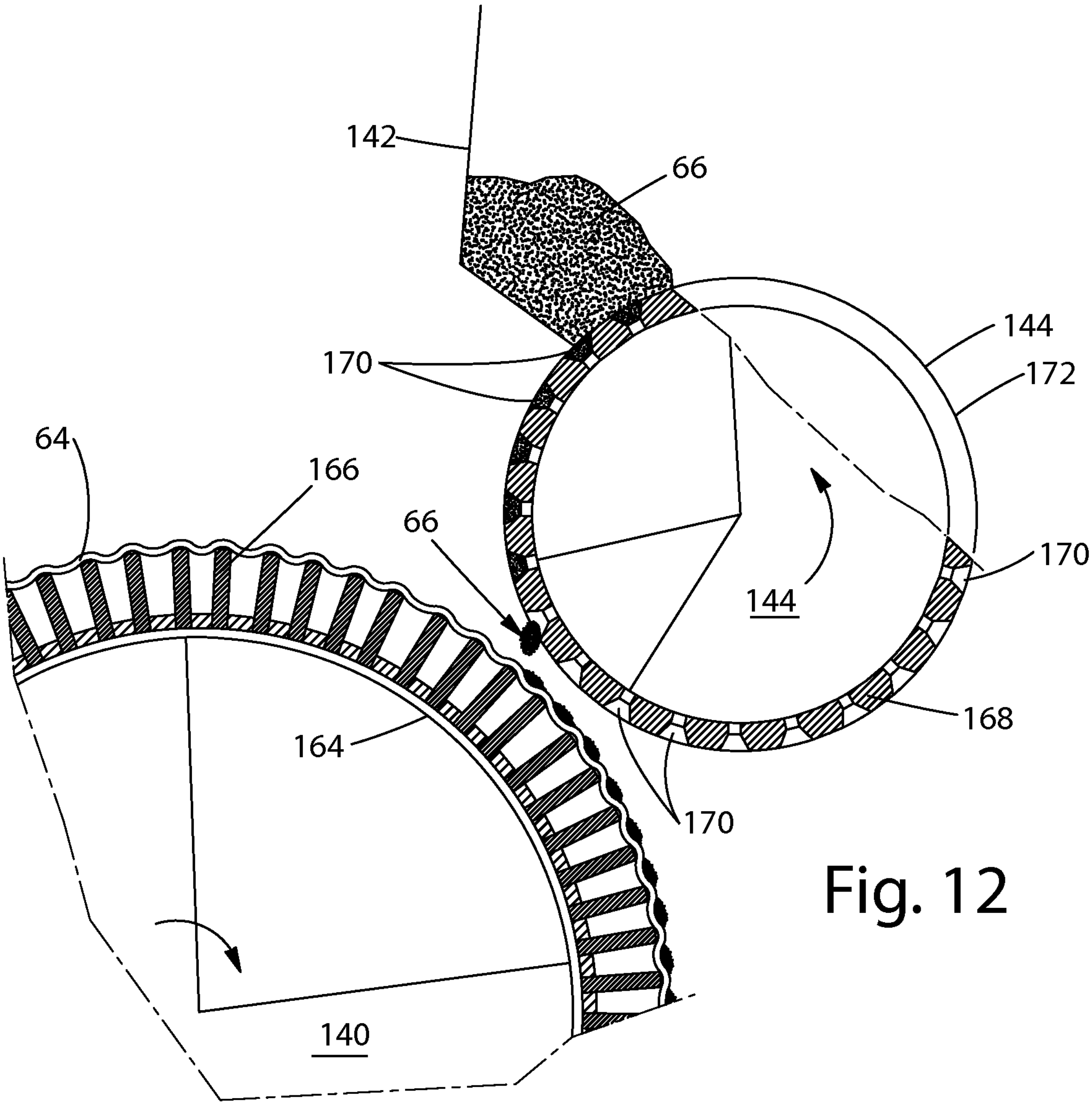

Fig. 12

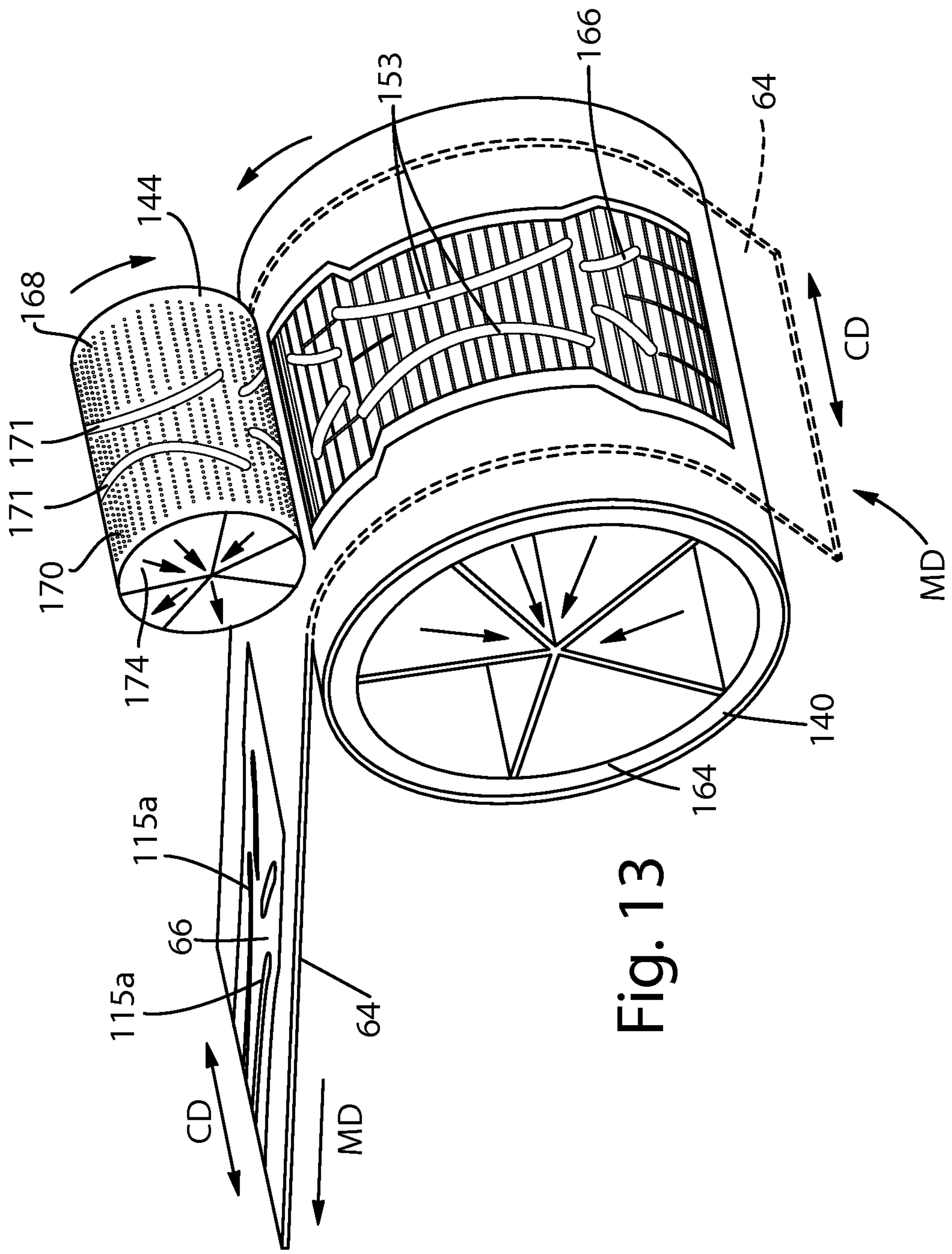
153
166
64
144
168
171
171
170
174
CD
MD
140
164
115a
66
115a
64
CD
MD

Fig. 13

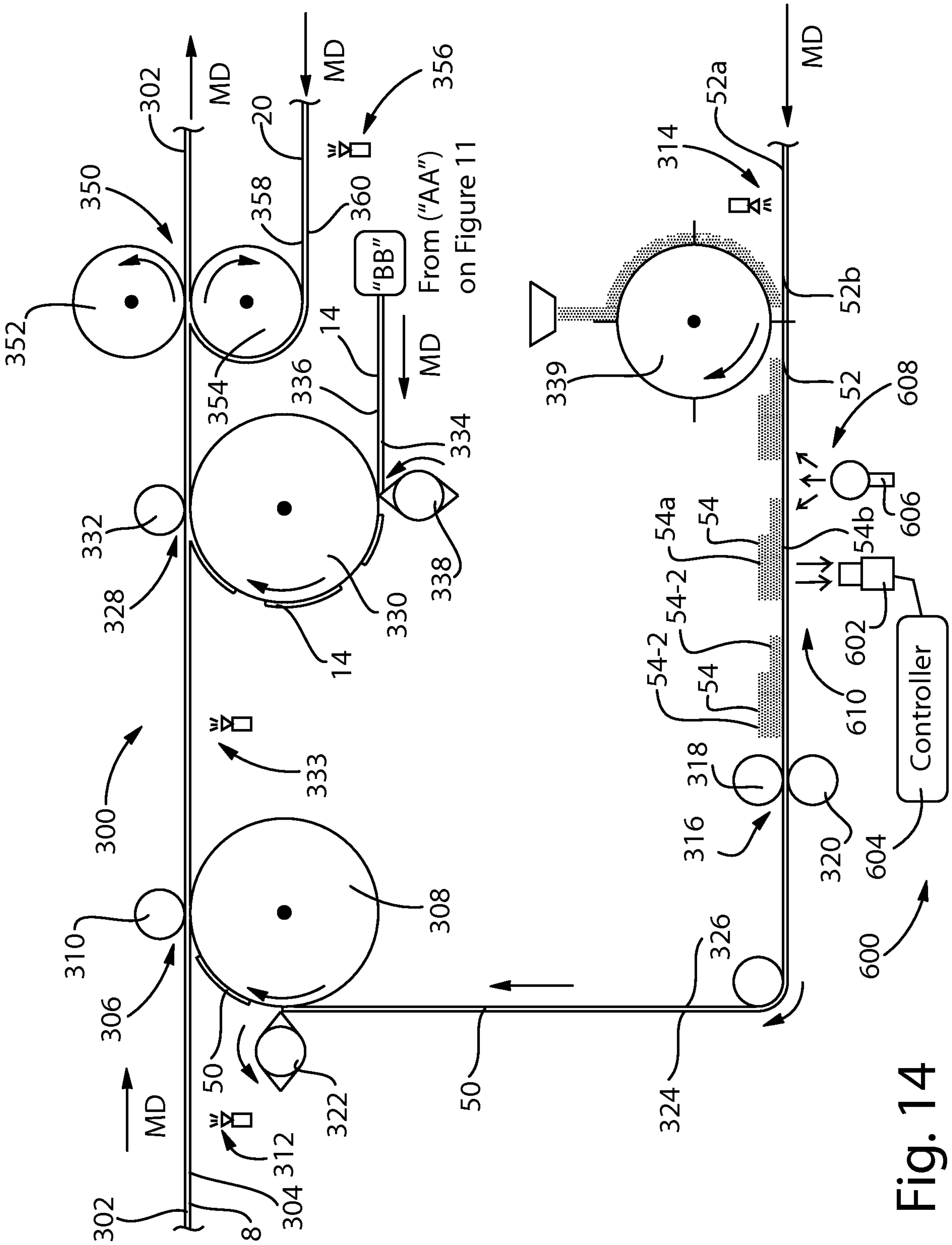
MD
302
350
352
354
358
360
20
356
"BB"
From ("AA") on Figure 11
14
336
334
332
328
330
338
300
333
310
306
308
50
322
312
304
18
324
326
314
52a
52b
52
339
608
606
54a
54
54-2
54b
602
610
Controller
604
600
316
318
320

Fig. 14

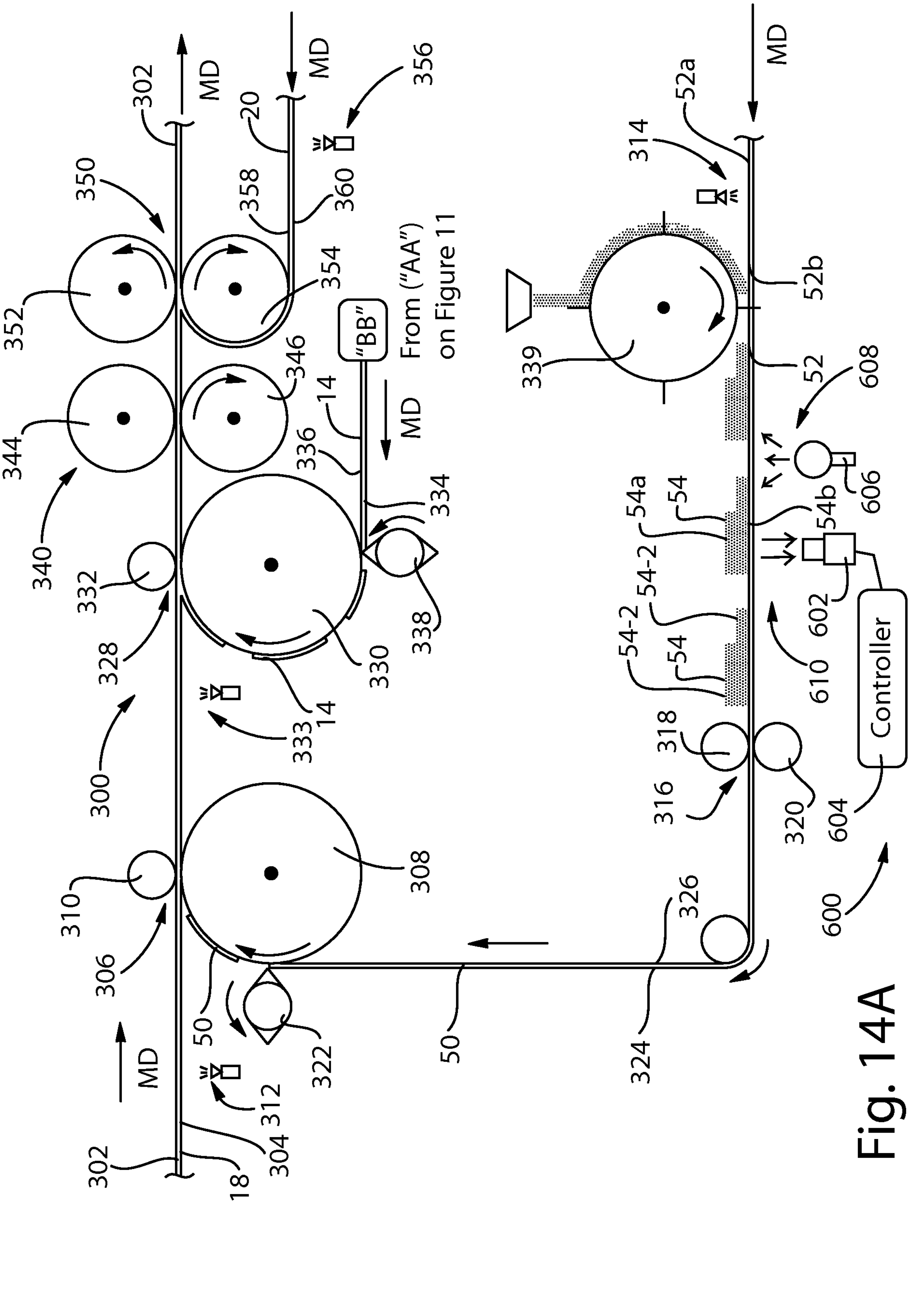
MD
MD
MD
MD
MD
"BB"
From ("AA")
on Figure 11
Controller
302
304
18
306
308
310
312
322
50
300
328
330
332
333
14
334
336
338
340
344
346
350
352
354
356
358
360
20
339
314
52a
52b
52
608
606
54a
54
54b
54-2
602
610
316
318
320
604
600
326
324

Fig. 14A

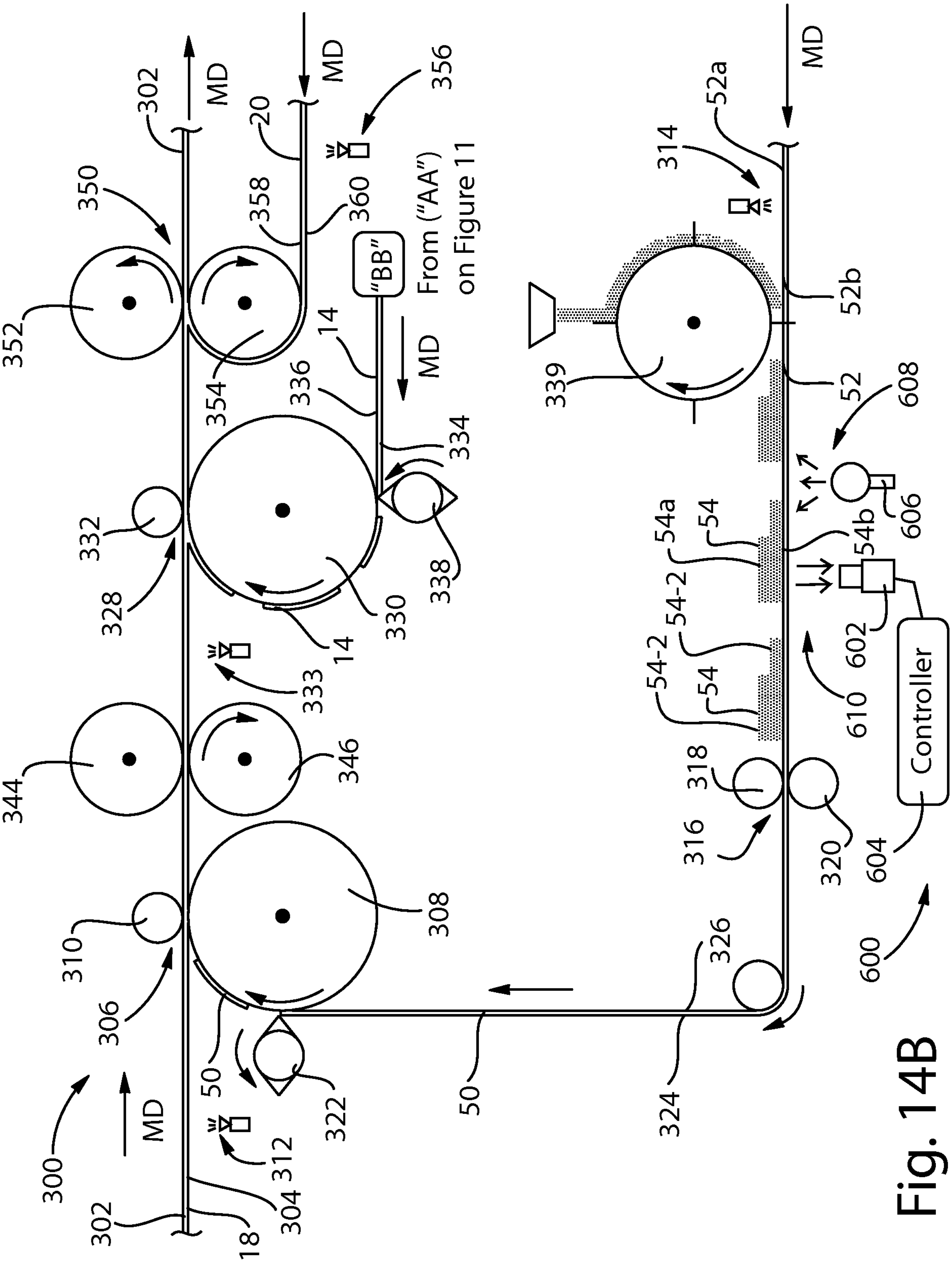
300
302
304
306
308
310
312
316
318
320
322
324
326
328
330
332
333
334
336
338
339
344
346
350
352
354
356
358
360
314
18
20
14
50
52
52a
52b
54
54a
54b
54-2
600
602
604
606
608
610
MD
"BB"
From ("AA")
on Figure 11
Controller

Fig. 14B

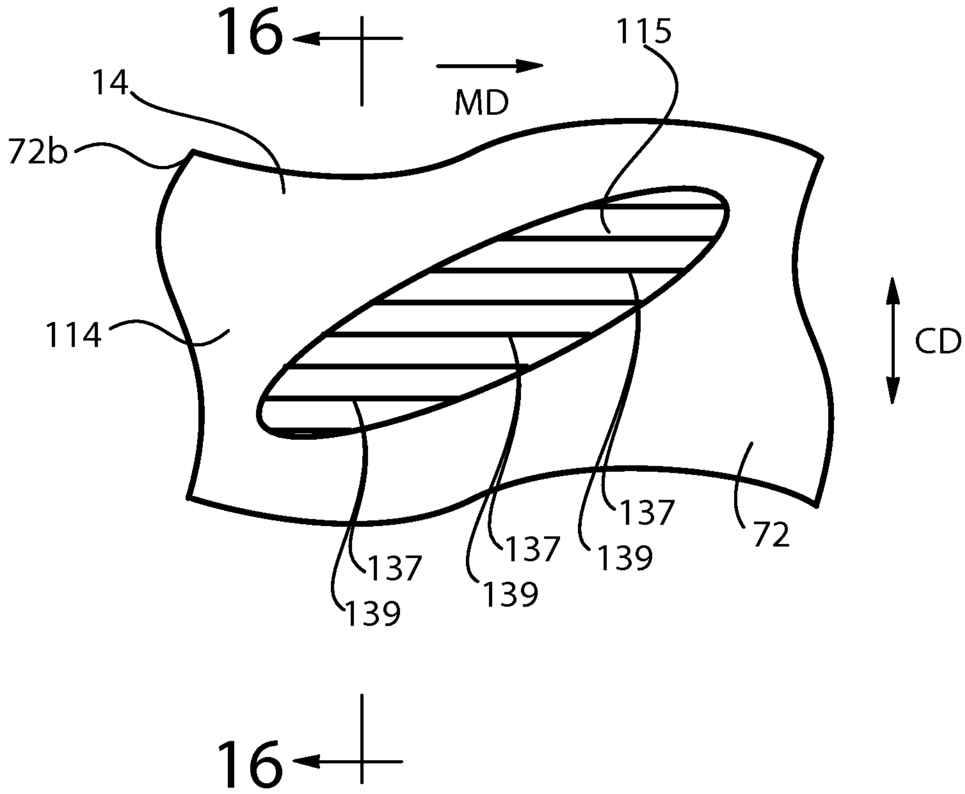

Fig. 15

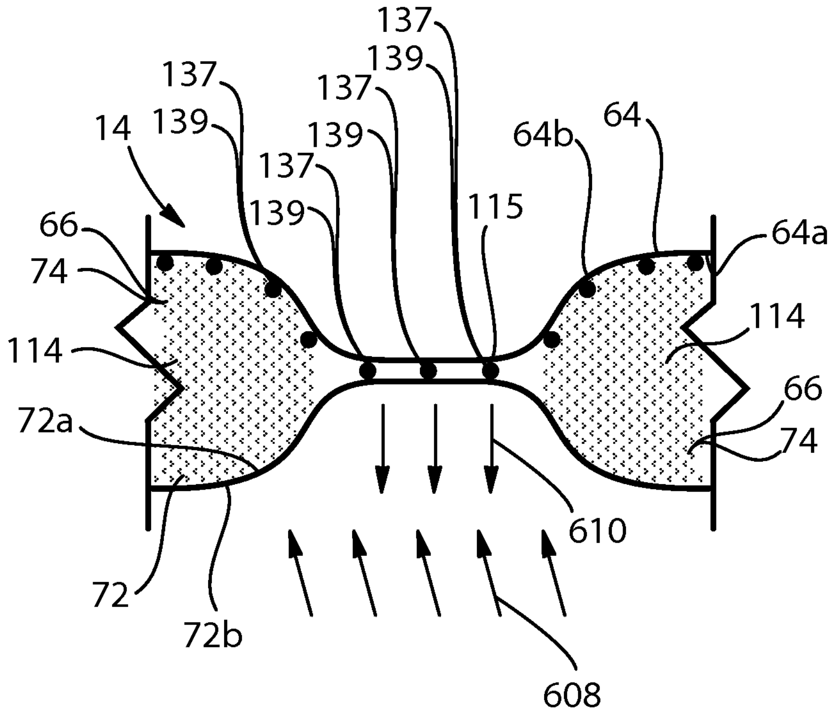
137
139
137
139
137
139
137
139
14
64b
64
115
66
64a
74
114
114
66
72a
74
610
72
72b
608

Fig. 16

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/025976

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61F13/15
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)
A61F

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2013/031143 A1 (UNICHARM CORP [JP]; OGASAWARA YOSHIKAZU [JP]; IIDA MIWA [JP]) 7 March 2013 (2013-03-07) figures 2A,2B paragraph [0042] - paragraph [0044] paragraph [0052] - paragraph [0080] -----	1-14
A	WO 2010/003038 A2 (BOSTIK INC [US]; ZHANG CHONGYAO [US]) 7 January 2010 (2010-01-07) the whole document -----	1-14
A	WO 03/034963 A2 (KORMA SPA [IT]; GERLACH HERBERT F [IT]; ZAPPA VALENTINO [IT]) 1 May 2003 (2003-05-01) the whole document -----	1-14
A	US 4 837 715 A (UNGPIYAKUL TANAKON [US] ET AL) 6 June 1989 (1989-06-06) column 3, line 37 - column 7, line 66 -----	1-14

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 July 2015	15/07/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Mauhin, Viviane

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/025976

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 2013031143	A1	07-03-2013	CN	103732193	A	16-04-2014
			EP	2750647	A1	09-07-2014
			JP	2014525274	A	29-09-2014
			TW	201333452	A	16-08-2013
			US	2014169632	A1	19-06-2014
			WO	2013031143	A1	07-03-2013
WO 2010003038	A2	07-01-2010	AU	2009266879	A1	07-01-2010
			CA	2729777	A1	07-01-2010
			CN	102105178	A	22-06-2011
			EP	2310058	A2	20-04-2011
			ES	2535459	T3	11-05-2015
			JP	5592883	B2	17-09-2014
			JP	2012506915	A	22-03-2012
			US	2010264369	A1	21-10-2010
			WO	2010003038	A2	07-01-2010
WO 03034963	A2	01-05-2003	AU	2002350548	A1	06-05-2003
			DE	10152155	A1	15-05-2003
			EP	1437995	A2	21-07-2004
			WO	03034963	A2	01-05-2003
US 4837715	A	06-06-1989	CA	1314084	C	02-03-1993
			US	4837715	A	06-06-1989